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Quantitative Restrictions on the Flow of Narcotics

Supply and Demand Restraints in a
North-South Macro-model

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Abstract

This paper constructs a macroeconomic model of North-South interaction where the flow of narcotics from the South to the North is restricted. Their economic effects are akin to quantitative restrictions in trade policy. Two alternative policy scenarios will be considered. One involves reducing the supply of drugs at source, accompanied by aid. Supply side restrictions have negative aggregate supply side effects in the producing region, because of the monopoly rents generated from that type of control. This makes them a second best policy, particularly if the accompanying aid is not used for poverty alleviation and fails to expand domestic aggregate demand. Alternative, demand side restrictions will be found to be superior.

Keywords: North-South interaction, trade policy, narcotics control

JEL classification: D74, F02, F41

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1 Introduction

The increase in transnational crime, particularly associated with the increased drug trade, is widely recognised as part of the negative side of increased globalization. According to the UNDCP (1998) estimates, the global production of opium by volume increased by 141% between 1986-96. In the same period there was a 24% rise in coca leaf output. There are several stages of processing before the final product sells in the developed North. More important, is the huge value added from the primary commodity to the final product. To give one example, the price of coca leaf was US\$ 1 per kilogram in Colombia in 1998, but the base for cocaine was US\$ 800. This implies an 800-fold rise in value, even before final production and shipment. Farmgate prices of opium and coca have risen, while the street value of heroin and cocaine in Europe and the USA are declining. It is clear from the volume sold that there has been a sharp rise in the demand for heroin and cocaine in the North.

Civil wars and organised crime both produce violence. The problems associated with drug production are similar to the causes of conflict, and involve the interaction of greed and grievance (Addison and Murshed 2000; Collier and Hoeffler 1999). Poverty produces grievance which can lead to drug production, which results in violence and even more grievance. Armed political groups use drug revenues to finance their wars; alternatively simply to satisfy their greed when the political-economic reasons for war have been assuaged (Northern Ireland). Thus, grievance can easily descend into banditry. Similarly, drug-barons, whose motives are purely mercenary, use armed force to further their political and economic ambitions.¹

Poverty is as central to the economics of violence as greed. It produces incentives for violent acts, and lowers the costs of fighting. Most drug producing states are low-income developing countries belonging to the South. Many of the causes of poverty are domestic in nature and are associated with bad policy choices as well as historically inherited inequities in asset ownership. But there are external factors as well. These include the effects of falling commodity prices (coffee, for example), the debt crisis and the poverty increasing effects of macro-stabilisation policies imposed by multilateral agencies.

The major drug producing nations are Peru, Bolivia and Colombia for coca²; Afghanistan, Myanmar and Laos for opium. Many of these countries are characterised by civil war as well as widespread poverty. Most of them have also experienced growth failure. The consumer of drugs is mainly in the developed North, led by the world's only remaining superpower, the USA. The USA's reach is far longer in Latin America compared to Asia. It is in that region, especially Colombia, where the USA is following a policy of drug eradication at the (farmgate) source of supply, accompanied by a policy of military assistance to the government to fight the drug trade. Colombia is in the midst

¹ It has to be admitted that both rebel groups and drug-barons occasionally provide services to the adjoining population.

² Interesting accounts of the drug industry in Bolivia and Colombia can be found in Gamarra (1999) and Thoumi (1999) respectively.

of a civil war. One side (FARC) uses coca related revenues to fight the government who receive military assistance from the USA. In the words of Duncan Campbell:

-----a civil war in which one side will be funded by the US tax-payer and the other side by the US drug-taker---

[Duncan Campbell, *Guardian*, 20th July 2000, page 7]

The purpose of this paper is to construct a macroeconomic model of North-South interaction where the flow of narcotics from the South to the North is restricted. Although the restraints are to do with law enforcement, their economic effects are akin to quantitative restrictions in trade policy (see Murshed 1992a and 1992b on tariffs, quotas and VERs in North-South models). Two alternative policy scenarios will be considered. They are to do with the supply and demand side of the problem. The first involves reducing the supply of drugs in the region of origin accompanied by aid. This is the policy being pursued by the USA with regard to Colombia, criticised by Campbell (2000). It will be postulated that supply side restrictions have negative aggregate supply side effects in the producing region because of the monopoly rents generated from that type of control. This will lead to supply side restrictions becoming a second best policy, particularly if the accompanying aid is not used for poverty alleviation and fails to expand domestic aggregate demand. Alternative, demand side restrictions will be found to be superior.

The rest of the paper is organised as follows: section 2 outlines aggregate supply behaviour in the South, section 3 is concerned with the macroeconomics of supply side controls and transfers to the South, section 4 with the macroeconomic analysis of a tariff-type restriction on demand and finally, section 5 concludes.

2 Illicit production and aggregate supply in the South

The purpose of this section is to outline *aggregate* supply behaviour in the South within a macroeconomic context. This makes us more concerned with the process of output generation and less with sectoral demand-supply equilibrium at this stage. Output in the criminal sector is a pure exportable for the South, consumed entirely in the North. Total output or aggregate supply in the South (Y_S) can be said to be composed of production in two sectors: legal activities (S) and criminal activities (C). This can be written as

$$Y_S = f(S, C) \quad f_1 > 0, f_2 < 0. \quad (1)$$

The reasoning behind the above is that criminal activities detract from total output as there are negative externalities involved; these include complicity in crime (bribery and coercion), law enforcement, and the negative spillover effects of foreign sponsored destruction of narcotic supply. The first two costs are akin to the directly unproductive profit seeking activities (DUP) mentioned in Bhagwati (1982).³ It should also be borne in mind that DUP actually reduces total output. A good example of the last point is the US government's DEA (Drug Enforcement Agency) sponsoring the destruction of coca

³ DUP is longhand in the lexicon of economics for corruption.

plantations in Bolivia, Colombia and Peru. Although compensation is paid, there are bound to be negative effects from some of the processes used, such as the aerial spraying of coca crops.

Equation 1 may be rewritten as a function of the two alternative instruments utilised to restrict C :

$$Y_s = f(S, C(t, v)) \dots C_1 < 0, C_2 > 0 \quad (2)$$

Here t indicates the ad-valorem consumption tax equivalent of a quota in the North, and v stands for the tariff or tax equivalent of the quantitative export restraint in the South. I will refer to the former as the “tariff” and the latter as the “VER” (voluntary export restraint). It should be noted that in actual fact both the “tariff” and the VER are quantitative restrictions. The tariff is like a quota restriction on the demand side and the VER a quota type restraint in the supply side. This is because we are dealing with a contraband substance, which cannot be directly taxed, as it is illegal. But the restrictions will both have their certainty tax equivalents, which we utilise in the model in this paper. The crucial difference is that the tariff is a demand side restriction where the revenues are retained in the consuming region (North); whereas the VER is a supply side control where the monopoly rents generated are kept in the producing region (South). Therefore, the tariff has a negative impact on domestic value-added in the C sector, whereas the VER does not.

Consider the following mark-up pricing rule describing supply behaviour in the C sector:

$$P_C = aW(1 + x) \quad (3)$$

where P_C indicates the price of the criminal product, a is a labour-output coefficient, W is the wage rate, and x indicates the profit extracted by the warlord or drug baron. Let us say a quantitative restriction is placed on the sale of drugs taking the form of a domestic supply restraint (VER). This will cause the price of C to rise, and result in positive monopoly rents that are retained domestically.⁴ Note that I have omitted capital, intermediate input and other costs of enforcement from (3). Their inclusion would only complicate the algebra, and enforcement costs already enter via the DUP activities captured in (1) above. If we assume that labour productivity (a) and wages are (W) are constant, then these rents will be captured by warlords:

$$P_C(1 + v) = aW(1 + x) \quad (4)$$

Differentiating the above with respect to v , for constant values of a and W , we obtain:

$$P_C + \frac{dP_C}{dv} = aW \frac{dx}{dv} \quad (5)$$

⁴ I am assuming that the demand for C (for example addictive drugs) is highly inelastic.

In the case of the tariff, it works on the demand side and the revenues are collected in the North. It, therefore, constitutes a leakage from the domestic sector, and the differentials in (5) with t instead of v need to be evaluated with a negative sign.

Utilising the information in (2) to (4), one may rewrite (2) as:

$$Y_S = f(tP_C, vP_C) \dots f_1 > 0, f_2 < 0 \quad (6)$$

Equation 6 is the short-run aggregate supply function for the economy in the South. The two arguments inside the function above represent tariff and VER revenues respectively. The former has a positive impact on aggregate supply in the South, as it is external, and actually *diminishes DUP* and other harmful externalities. It works on the demand side. Nationals of the South residing in the North could capture some of these tariff revenues. These monies could find their way back to the domestic economy via money “laundering”. Laundering is a pure asset swap; it does not affect the total stock of assets in the economy, but merely converts illegally obtained money into an existing legally owned asset. By contrast, a VER is postulated to have negative supply-side effects. It is a domestic quantitative restriction, which is a method of restricting C from the supply side. It impacts negatively on total output because of the negative externalities arising from crop eradication, corruption and law enforcement. In principle, however, it does augment domestic demand or expenditure. Some of this will be moderated by import leakage. Also, any positive aggregate demand effects hinge crucially on income distribution. If warlords, who capture, this rent have a low propensity to consume domestic goods then the aggregate demand effects will be negligible. It is also worth noting that unlike with a VER, an import tariff on C , which is collected in the North, will have little impact on the South’s income distribution.

3 Macroeconomic effects of a VER and a transfer

Restrictions on the supply of the C sector in the South may have a welfare and microeconomic motivation, but in turn it also has macroeconomic consequences. In the macroeconomic context all income and expenditure is aggregated. In this section I also analyse the macroeconomic effects of an income transfer or “aid” from North to the South.

We begin by examining the goods market equilibrium condition in the North. This requires aggregate supply or output to be equal to aggregate demand or expenditure. Discrepancies between the two lead to adjustments in output, with output rising when there is excess demand and vice versa (see Taylor, 1983; Murshed 1992a and 1992b).

$$Y_N = E_N(Y^D_N) + X_N(Y^D_S, P_S) - P_S X_S(Y^D_N, P_S) - P_S C(Y^D_N, P_S(1+v))(1+v) \quad (7)$$

Here Y_N stands for aggregate supply or output in the North. On the right hand side we have expenditure (E_N) which is a function of disposable income (Y^D_N) plus exports (X_N) minus imports. There are two types of imports: ordinary imports are denoted by X_S , and criminal imports by C . Exports and imports are a function of disposable income and relative prices (P_S or the South’s price)). Note that we set the Northern price to unity, and by appropriate choice of units set $P_S = P_C$. Although the C sector is subject to a quantitative restriction, this has a price or tax equivalent in v . There are also VER rents

arising from the consumption of $C = vP_S C$ that are “transferred” to the South (in actual fact they remain there).

Disposable income in the North is given by:

$$Y^D_N = Y_N(1 - \tau) \quad (8)$$

where τ is the tax on income, which is then given to the South in the form of aid.

Turning to goods market equilibrium in the South:

$$P_S Y_S(tP_S, vP_S) = P_S E_S(Y^D_S) + P_S X_S(\cdot) + P_S C(\cdot) - X_N(\cdot) \quad (9)$$

Y_S is composed of the output of two sectors, S and C , where $P_S = P_C$. Note that $Y_{S1} = 0$ here, $Y_{S2} < 0$, and disposable income (Y^D_S) is given by:

$$Y^D_S = Y_S + \tau Y_N + vP_S C \quad (10)$$

It includes the transfer⁵ from the North and the rents from the supply restraint on C which will both boost income and hence expenditure. But this expenditure might be disproportionately directed towards imports or money laundering. In fact, laundering does not add to domestic demand, as it involves changes in asset portfolios. Aggregate excess demand in the South will cause output to increase in the model in this paper, although it can be easily reconciled with a rise in the terms of trade, P_S , Taylor (1983).

The details concerning the derivation of the model are contained in the appendix.

As far as the impact on the output of the North is concerned:

$$\frac{dY_N}{dv} = \frac{[P_S C(1 + \Omega) - X_{N1} P_S (Y_{S2} + C)][P_S (E_{S1} - 1) - X_{N1}]}{DET} \quad (11)$$

$$\frac{[P_S X_{S1} + P_S C_1][P_S^2 Y_{S2} (1 - E_{S1}) - P_S^2 E_{S1} C - P_S^2 C_2 + X_{N1} P_S (Y_{S2} + C)]}{DET}$$

The above expression cannot be signed unambiguously. Note that, $\Omega = P_S C_2 < 0$, the elasticity of C consumption with respect to price. I assume $\Omega < 1$ in absolute value. This is in line with the fact that the consumption of C is highly price inelastic. The necessary condition for the above expression to be negative is that $Y_{S1} > C$ in absolute terms.

⁵ Although the transfer is mainly military aid, its macroeconomic effect is to increase aggregate demand, albeit mainly on imports.

Turning to the South:

$$\frac{dY_S}{dv} = \frac{[E_{N1} - 1 - P_S X_{S1} - P_S C_1] [P_S^2 Y_{S2} (1 - E_{S1}) - P_S^2 E_{S1} C - P_S^2 C_2 + X_{N1} P_S (Y_{S2} + C)]}{DET} - \frac{X_{N1} [P_S C (1 + \Omega) - X_{N1} P_S (Y_{S2} + C)]}{DET} \quad (12)$$

Again this expression cannot be signed unambiguously. The same necessary condition applies for the above expression to be negative. An additional condition which will reinforce the negative effects of the VER on equilibrium total output in the South is if $E_{S1} < 0$. This means that the propensity to consume out of VER rents is very low. But it does not imply that the overall propensity to consume is small, but rather we refer here to consumption out of the rents generated by the VER. This could be low, particularly if warlords who either launder their revenues or spend mainly abroad capture the rents.

The results above can be depicted in the diagram contained in Figure 1 in Y_N and Y_S space. The NN schedule depicts equilibrium (aggregate demand equal to aggregate supply) in the North's goods market, and the SS schedule gives the same information for the South. The NN is upward sloping (see A.3) because for given income in the South a rise in income and expenditure in the North also benefits the South via the export multiplier effect, causing income to rise in the South as well. A similar line of reasoning applies to the upward sloping SS schedule (see A.4). The initial equilibrium is at point A in Figure 1. The VER will cause both schedules to shift. There is a rightward movement in the schedules if the effect on equilibrium income is expansionary; this is shown as point C on the diagram. If, as is more likely, the VER causes a decline in equilibrium income and output in both regions, the schedules shift leftwards and the new post-VER equilibrium is at point D in Figure 1.

We now examine the impact of the transfer from North to South:

$$\frac{dY_N}{d\tau} = \frac{Y_N [(E_{N1} - X_{N1})(P_S (E_{S1} - 1) - X_{N1}) + P_S^2 X_{S1} (1 - X_{S1}) + P_S^2 C_1 (1 - 2X_{S1} - C_1)]}{DET} \quad (13)$$

The above expression is negative only if $E_{N1} > X_{N1}$. It will, however, be positive if $E_{N1} < X_{N1}$. This means that if the marginal propensity to import in the South from the North (X_{N1}) is high the North's income will increase after the transfer. This is due to the positive export multiplier effect of the transfer for the North, particularly if such a gift of aid is tied to the purchase of goods (weapons, say) and services from the North.

As far as the South is concerned:

$$\frac{dY_S}{d\tau} = \frac{Y_N [(E_{S1} - X_{S1} - C_1)(P_S (1 - E_{N1}) + P_S^2 (X_{S1} + C_1)) - X_{N1} - X_{N1}^2]}{DET} \quad (14)$$

A sufficient condition for $dY_S/d\tau < 0$ is: $E_{S1} - X_{S1} - C_1 < 0$. The transfer is then "over-effected". The condition implies that the transfer does not boost expenditure on domestic goods by much, instead increasing imports. Also, there is a reduction in the

imports of the North from the South. Once again, the distribution of income and who gets the transfer revenues matters. If the military complex and the elite capture aid, then E_{SI} will be small and Y_S will decline. The North can gain at the expense of the South, or at least the military complex in the North. Point D in Figure 1 illustrates such a new equilibrium, where we omit the NN and SS schedules to avoid clutter.

While welfare is clearly related to matters such as income distribution, as an approximation we can examine the impact of the VER-cum-transfer on the utility of a “representative” consumer. In the South this will be synonymous with $P_S Y_S$, as alterations in income determine the capacity to consume. A fall in equilibrium income lowers welfare of the representative consumer in the South. The VER will lower aggregate supply in the South via the negative externalities associated with the domestic supply restriction on the C good. Aggregate demand is also likely to decline, particularly if those who receive VER rents do not consume domestic goods, and those who capture the aid flows mainly import arms and security services from the donor country. Furthermore, if we attach a low or negative value to the income of warlords who capture VER rents, then there is an additional negative distributional effect of the VER cum aid policy.

In the North, however, we examine the utility of the non-consumer of the C good. This will take the form:

$$U = u(Y_N - C) \quad u_1 > 0. \quad (15)$$

In other words utility rises with the consumption of home and ordinary Southern goods (both contained in changes in Y_N), and declines with the consumption of C . Evaluating the above with respect to the two policy parameters will yield.

$$\frac{dU}{d(v + \tau)} = u_1 \frac{dY_N}{d(v + \tau)} - u_1 \frac{dC}{d(v + \tau)} \quad (16)$$

Since the policies reduce C consumption, the second term on the right hand side of (16) is positive. The effect on Y_N of the combined supply restraint and transfer is unclear. Thus, the net effect on welfare is also ambiguous.

4 Macroeconomic effects of a tariff

We need to redefine the notions of disposable income, as in this case the revenues are retained in the North. I postulate, however, that the revenues do not enter into the income component in the demand function for the C good in the North. Also $Y_{SI} > 0$ applies and $Y_{S2} = 0$. The definitions of disposable income become:

$$Y^D_N = Y_N(1 - \tau) + tP_S C \quad (8')$$

and

$$Y^D_S = Y_S + \tau Y_N \quad (10')$$

We substitute the two expressions above into equations (7) and (9), and also substitute t for v . See the expression for dt in the appendix.

For the North:

$$\frac{dY_N}{dT} = \frac{[P_S C(1 + \Omega) - X_{N1} P_S Y_{S1} + P_S C(-E_{N1} + X_{S1})][P_S(E_{S1} - 1) - X_{N1}]}{DET} - \frac{[P_S X_{S1} + P_S C_1][P_S^2 Y_{S1}(1 - E_{S1}) + X_{N1} P_S Y_{S1} - P_S^2(X_{S1} C + C_2)]}{DET} \quad (17)$$

As far as the South is concerned:

$$\frac{dY_S}{dt} = \frac{[E_{N1} - 1 - P_S X_{S1} - P_S C_1][P_S^2 Y_{S1}(1 - E_{S1}) + X_{N1} P_S Y_{S1} - P_S^2(X_{S1} C + C_2)]}{DET} - \frac{X_{N1}[P_S C(1 + \Omega) - X_{N1} P_S Y_{S1} + P_S C(-E_{N1} + X_{S1})]}{DET} \quad (18)$$

The necessary conditions for the tariff to have a positive impact on equilibrium output in both regions, or for the expressions in (15) and (16) to be positive are:

- i) $E_{N1} > X_{S1}$. This means a stronger propensity to consume on home goods relative to imports in the North. Note that with a tariff it is the North that gets to keep and spend the tariff revenues.
- ii) $X_{N1} Y_{S1} > P_S C(1 + \Omega)$. This implies a substantial positive supply-side effect on the South's output following the tariff. It is worthwhile reminding ourselves that the aggregate supply effect of the tariff is positive for the South, and is the opposite of the effect with a domestic restriction on the C sector (VER).
- iii) $X_{S1} C > C_2$.

The results above are depicted by point C on the diagram. The reversal of the conditions listed above are sufficient for the tariff to have a negative impact (point B in Figure 1).

The tariff, being similar to a tax on the consumption of C in the North, reduces its use in the North directly. It actually raises aggregate supply in the South as DUP-type wasteful activities and other harmful externalities are reduced. In the South, it does not lead to a redistribution of income in favour of warlords or the military sector (no special aid or transfer here). Aggregate demand and equilibrium income could also increase in both regions. Welfare in the South increases. Evaluating (16) above with respect to the tariff (t) tells us that the representative non-consumer of C will be unambiguously better off if Y_N increases.

5 Conclusions

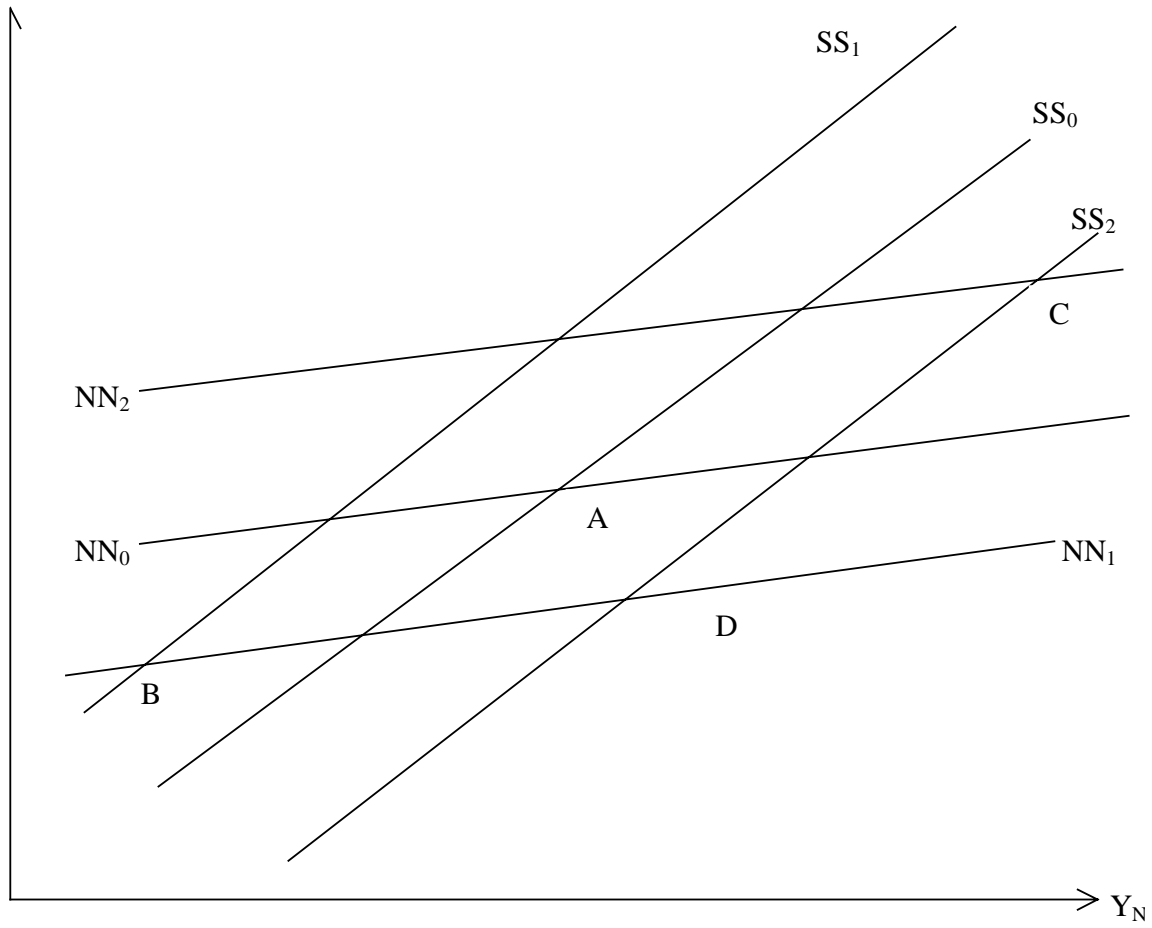
A tariff-equivalent is the first-best mode of control for the socially undesirable C good consumed in the North and produced in the South. It has a direct impact on demand. It could also increase income in both regions. It has a positive supply side effect in the South and does not have the unfavourable income distribution effects of domestic supply controls. The VER is, by contrast, a control mechanism working on the supply

side of the *C* sector in the South. It creates undesirable rents that go to warlords, lowers aggregate supply via negative externalities as well as DUP, and leads to unfavourable alterations in income distribution. It could also diminish equilibrium output in both regions. When a supply restraint is accompanied by a policy of aid, this could benefit the donor (North) at the expense of the recipient (South), especially if the latter imports a lot from the North. This is likely to be the case when the aid that accompanies the destruction of coca crops mainly goes to the military and results in imported security expenditure. The crucial hypothesis behind the results in the model rest with the nature of the aggregate supply effects of the two output restraining instruments, as well as the aggregate demand effects of aid.

The observant reader will have realised that the policy superiority of the tariff or tax equivalent on consumption will *increase* if the illegality of drugs in the consuming region is removed. But that is the point behind the dominance of a tax over a quantitative restriction or prohibition. The former implies forcing consumers to pay more for something that they are allowed to use. The latter is a regulation, which creates the necessity for evasion, extortion and other shadowy underground activities. Revenues from a tax can be better utilised in preventive and rehabilitation programmes. In the producing region, legality will help eliminate the wasteful DUP type activities that lower total output. It would also make it possible for the state to extract some of the monopoly rents associated with production, which can then be used for fiscal stabilisation and poverty alleviation.

Even if drugs continue to be illegal, a far superior policy-mix would include the taxation equivalent on the demand side of the problem. On the supply side it would be better to tackle the causes of increased drug production directly rather than simply destroy crops and arm governments. The causes include internal conflict, falling commodity prices, and state failure in social provisioning. Aid, which only goes to the military and not poverty alleviation could ultimately have disastrous consequences, as it will intensify existing civil wars. The rise in poverty, as well as the poverty-conflict nexus, is perhaps the greatest cause of increased drug production at the primary stage.

Figure 1
Restrictions on the C Sector



Appendix

Totally differentiating (7) and (9), utilising (8) and (10), arranging them in excess demand form we get:

$$\begin{bmatrix} E_{N1} - 1 - P_S X_{S1} - P_S C_1 & P_S X_{S1} + P_S C_1 \\ X_{N1} & P_S (E_{S1} - 1) - X_{N1} \end{bmatrix} \begin{bmatrix} dY_N \\ dY_S \end{bmatrix} = \begin{bmatrix} -X_{N1} P_S (Y_{S2} + C) + P_S C (1 + \Omega) & Y_N (E_{N1} - X_{N1} - P_S X_{S1} - P_S C_1) \\ P_S^2 Y_{S2} - P_S^2 E_{S1} (Y_{S2} + C) - P_S^2 C_2 + P_S X_{N1} (Y_{S2} + C) & Y_N (-P_S E_{S1} + X_{N1} + P_S X_{S1} + P_S C_1) \end{bmatrix} \begin{bmatrix} dv \\ d\tau \end{bmatrix} \quad (\text{A.1})$$

In the analysis above I have made the standard simplifying assumption that the initial values v , τ and $t = 0$; but dv , $d\tau$, and $dt \neq 0$. The various partial derivatives have the following signs: E_{N1} , E_{S1} , X_{N1} , X_{S1} , $C_1 > 0$. C_2 , $Y_{S2} < 0$. Note that, $\Omega = P_S C_2 < 0$, the elasticity of C consumption with respect to price. I assume $\Omega < 1$ in absolute value.

The trace of the Jacobian is negative. The determinant is given by:

$$DET = (E_{N1} - 1)[P_S (E_{S1} - 1) - X_{N1}] - P_S^2 (E_{S1} - 1)(X_{S1} + C_1) > 0 \quad (\text{A.2})$$

The model is therefore stable.

With the tariff the right hand side of (A.2) has an additional component:

$$\begin{bmatrix} -E_{N1} P_S C - X_{N1} Y_{S1} + P_S^2 X_{S1} C + P_S C (1 + \Omega) \\ P_S^2 Y_{S1} - P_S E_{S1} Y_{S1} - P_S^2 X_{S1} C - P_S^2 C_2 + X_{N1} Y_{S1} \end{bmatrix} dt$$

The slopes of NN and SS from the right hand side of (A.1) are:

$$\frac{dY_S}{dY_N / NN} = \frac{1 + E_{N1} + P_S X_{S1} + P_S C_1}{P_S X_{S1} + P_S C_1} > 0 \quad (\text{A.3})$$

and

$$\frac{dY_S}{dY_N / SS} = \frac{X_{N1}}{P_S (1 - E_{S1}) + X_{N1}} > 0 \quad (\text{A.4})$$

The expression in (A.3) is greater in magnitude than (A.4); thus the NN schedule is steeper than SS schedule.

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