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ON THE ECONOMIC THEORY OF SMUGGLING*

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Abstract

Earlier models of smuggling are deficient in their treatment of risk and transport costs. A model of smuggling of agricultural goods in an intra-EEC context is constructed, with due regard to such costs. Smuggling of agricultural goods is an increasing cost industry, not because of unspecified or unplausible externalities, as in earlier papers, but because of increasing transport costs as the extensive margin of source-locations for smuggled goods is expanded. In consequence, intra-marginal smugglers can earn economic rents. The theoretical model is supported by empirical studies of trade between The Republic of Ireland and Northern Ireland.

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1. Introduction

Earlier empirical studies by this author argued that the Green Currency System of the EEC's Common Agricultural Policy (CAP), combined with the complex network of Monetary Compensation Amounts (MCA's), ie. cross-border taxes and subsidies, has induced large-scale smuggling of CAP products between the Republic of Ireland and Northern Ireland, and between other contiguous national EEC territories (Norton, 1983a, b, 1984). The present paper develops a simple theoretical model of smuggling of agricultural produce within an EEC type of framework and briefly compares its predictions with earlier empirical findings.

It is argued in section 2 that previous theoretical work on smuggling involves serious misspecifications: its treatment of transport costs leaves much to be desired. As an alternative, the argument in section 3 is that the smuggling of agricultural goods is an increasing cost industry -- not because of external diseconomies of scale which cause upward shifts in the cost structures of existing smuggling firms as the smuggling industry as a whole expands, as in earlier models, but because of increasing transport costs as the economically viable distance-margin for smuggling is extended. Thus given a certain ad valorem tax reflecting international price differences in a two-country framework, smuggling will prevail from source-locations within a certain distance from the frontier. The greater the distance travelled, the greater the per unit costs of smuggling. Under perfect competition in smuggling, potential smugglers located at some particular distance would earn no economic profits or rents; however, many or all of those located at distances smaller than that would earn rents or quasi-rents. For any given tariff, and other things being equal, the closer to zero the distance to the frontier, the greater the economic rents from smuggling. If the international price differential is increased, and if the ad valorem at-frontier tax is increased to mirror the new differential the distance-margin for smuggling and its volume will be increased. New marginal smugglers at the new distance-margin for smuggling

will earn zero or negligible economic rents, but those accruing to smugglers located inside that margin will increase. Section 4 draws on empirical support for this kind of von Thünen model.

2. Earlier models of smuggling

Modern literature on the theory of smuggling goes back to Bhagwati and Hansen (1973) -- henceforth referred to as BH¹. In their two-country schema and subsequently, we refer to the country into which goods are smuggled as Home; the trading partner is Abroad.

BH considered the view that smuggling increases welfare in the case of small economies, since it is by definition the evasion of policy-induced barriers to trade which are suboptimal. Fiscal considerations aside, that view would be correct if smuggling were costless. Given their implicit assumption that legal trade has zero transport costs whereas smuggling has higher per unit costs than legal trade, BH concluded that the conventional view is false, except in very special cases. Also, with perfect competition in smuggling, the question of the residence of smugglers does not arise in BH, for under their assumptions, smugglers' economic profits or rents would be zero. BH assume that smuggling is completely riskless.

BH construct a model of trade involving two goods -- an exportable and an importable. In legal trade exportables are transformed into importables at constant terms of trade. Smuggling is an alternative way in which exportables are transformed into importables. But for reasons unexplained, BH assume that Home's rate of transformation through smuggling is at all points less favourable than in legal trade; thus smuggling in itself always involves

¹As BH indicate, an earlier model is that of Beccaria (1764). It seems that it remains unpublished in English. I can supply an English translation on request. The later papers by Bhagwati and Srinivasan (1973, 4), Johnson (1974), Falvey (1978) and Ray (1978) all rely on the BH theoretical framework.

special real resource costs².

BH consider two cases of perfect competition in smuggling: they allow the smuggling industry to have either a constant or an increasing rate of transformation; however they assume that an individual smuggler has a constant rate of transformation, thereby rendering his output always indeterminate. When an increasing rate of transformation for the smuggling industry is postulated, that, for reasons unexplained, is exclusively due to intra-industry, inter-firm, diseconomies of scale: an individual firm's costs shift upwards if the firm does not change the volume smuggled while other firms in aggregate do. It is argued below that the smuggling industry does indeed exhibit increasing costs, but that this is due to explicit treatment of transport costs. Also, for the same reason, intra-marginal smugglers do earn rents or quasi-rents. Furthermore, the smugglings of intra-marginal firms located at any given distance from the frontier will become determinate.

The BH welfare results depend on there always being special real resource costs attached to smuggling as distinct from legal trade. However, recognising that resource costs in the form of transportation in legal international trade are in fact positive, there may be -- and for some traders there almost surely are -- even higher real resource costs in routing goods through official points of entry than would apply in smuggling them from points quite distant from customs posts (but just across the frontier) and landing them at point of sale in Home. If, on the other hand, the only special costs of smuggling were confiscation of detected contraband and fines, then those costs would be government revenue. In that case (if both forms of import had zero, or the same, transport costs) the aggregate rate of transformation in smuggling

²Bhagwati and Srinivasan (1973) state in a footnote that this arises insofar as smuggling leads, for example, to (higher) transport costs or to higher f.o.b. import prices. However, at least in the case where the smuggling industry is assumed to have increasing costs, the latter explanation seems inconsistent with the assumption that Home is a price-taker.

would be the (transport-cost-adjusted³) terms of trade under free trade. Smuggling could then result in an unambiguous increase in welfare vis-a-vis the non-smuggling situation.

Sheikh (1974) extended BH by postulating that real resources are required for smuggling in the form of inputs to a nontraded transportation commodity T. The amount of T needed to smuggle a unit of the importable is always one unit. All commodities (an exportable, an importable and T) are produced under perfect competition with industry constant returns to scale. Let p denote the international price of the importable in terms of the exportable and let t be the ad valorem tariff. C_T is the constant unit cost of production of T, with the exportable as the numeraire. Implicitly assuming that transport costs on legal trade are zero, Sheikh postulates that the domestic price of the importable is $p(1 + t)$. The real resource cost per unit smuggled is then a constant ($p +$

Sheikh assumes that smugglers know risk costs in terms of goods confiscated, fines, etc. A smuggler takes these costs as given to him and he can smuggle any quantity without affecting risk costs per unit. But Sheikh also makes smuggling an increasing cost industry due to intra-industry, inter-firm, diseconomies of scale: the individual smuggler's risk costs increase if other firms try to smuggle more. These assumptions in regard to risk costs are implausible. Because the government in Sheikh's model spends a fixed amount on surveillance, regardless of the volume of smuggling, expenditure on law enforcement per unit of attempted smuggling decreases with volume. However, given his specification of transport costs, Sheikh (p. 360, note 11) recognises that the assumption of external diseconomies in risk is forced upon him when he adds that "our assumption of increasing risk costs is crucial in enabling us to get a determinate solution to the problem of distribution of [aggregate] imports between legal and smuggled since it generates a positively sloped supply curve". The reader is again reminded that smuggling is indeed likely to

³Conventional terms of trade notions could be adjusted to allow for transport costs in the form of shrinkage of goods in transit.

be an increasing cost industry but, as discussed below, for reasons other than those in earlier studies.

Locus AA' in Fig. 1 is Sheikh's supply curve for smuggled imports. It slopes upwards because of external diseconomies in the form of increasing risk costs. The supply curve for legal imports is infinitely elastic at $p(1 + t)$. Thus the aggregate supply curve for imports is ABC in the diagram. Assuming that the demand curve intersects the supply curve to the right of point B, market equilibrium in smuggling is attained when OD is smuggled in; legal imports are the residual⁴. However, the identity of individual smugglers, and their allocations between smuggling and non-smuggling, are again (as in BH) indeterminate. At the equilibrium level of smuggling OD, AG denotes the per unit risk cost of smuggling in terms of the exportable and, as this cost is parametric to the individual smuggler, there are again no pure profits or economic rents in smuggling equilibrium.

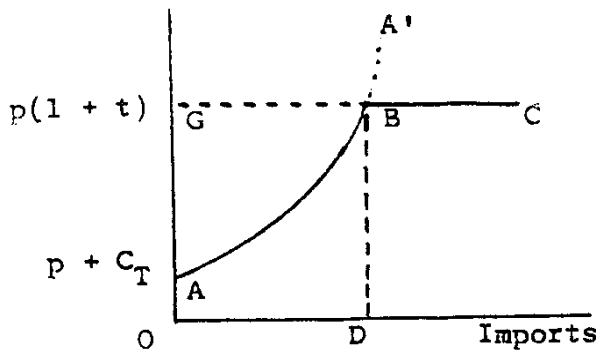


Fig. 1

⁴It follows, if there are confiscations, that AA' is the supply curve for actual rather than attempted smuggling and that the State does not sell confiscated contraband on the home market.

A more recent model of smuggling is that of Pitt (1981). It is tailor-made to explain smuggling of certain agricultural goods out of Indonesia, given export taxes. According to Pitt, an appropriate model for Indonesia must explain three things: smuggling, legal export trade and price disparity. By price disparity Pitt means the excess of the domestic market price over the tax-inclusive world price -- the export price. Thus legal exports apparently incur absolute losses. Pitt argues that the justification for such trade is its ability to reduce the costs of smuggling: to camouflage their smuggling firms engage in some legal exports. Legal exports are thus viewed as inputs to smuggling activity, as is indicated by the representative firm's smuggling function $\bar{q}^S = g(q^L, q^S)$, where \bar{q}^S is the amount successfully smuggled by a trader, L is his legal export volume and q^S is the amount of the good he tries to smuggle. Production and trade is conducted by identical firms under perfect competition thus the distance of a firm from the frontier is irrelevant in

Pitt's model is in contrast to that of BH, where there is no incentive to trade legally at an apparent loss because of their assumption that the rate of transformation in smuggling is independent of the amount of legal trade. As in earlier models, Pitt's firms earn no economic profits or rents in smuggling equilibrium. That is because each smuggler's revenue from foreign trade (legal plus illegal) is then equal to the domestic cost of the tradeables. Also, as in BH, Pitt implicitly assumes zero transport costs in legal international trade. If there is any smuggling of a good in Pitt's model, all firms trading internationally in that good engage in some smuggling; otherwise they would incur overall losses. Hence, there are no law-abiding firms in his model.

3. Smuggling, costs and economic rents

This section develops a model giving insight into smuggling of CAP products between contiguous EEC countries -- the territories particularly in mind are The Republic of Ireland and Northern Ireland (which is part of the UK). The model also gives insights into smuggling in general. Consider a trader located

within the EEC but outside the national frontier at a distance d from Home. Assume that his initial current-period holdings of the good under analysis are fixed -- these may be the inventory on his own farm. He must decide: (i) Whether to trade the goods domestically at the prevailing market price or, equivalently for present purposes, whether to maintain the goods (eg. for further processing) at the prevailing price (in which case he is trading with himself). Thus, if he engages in any form of international trade, he foregoes the opportunity to avail of the going market price in Abroad. (ii) If he engages in exporting (to, say, Home) he has to determine whether to operate legally, to smuggle, or both. Define:

q: Quantity available to trader (potential smuggler) in Abroad.

p: Price Abroad. It is assumed, due to price support policies (intervention buying and selling, aids to private storage, etc.), that this is the same in all regions of Abroad. All value magnitudes are measured in terms of a single tradeable commodity.

t: Ad valorem rate of tax, payable by the exporter, on movement of goods into Home. It is assumed that the purpose of this tax is (approximately) to bridge the gap between the higher support prices obtainable in Home and the lower prices obtainable Abroad.

$p(1 + t) + \theta$: Market price in all regions of Home. Home's market price may differ from Abroad's price plus tax by a small amount; otherwise, considerations involving smuggling aside, there would never be trade between Home and Abroad. The term $\theta \geq 0$ may reflect failure of the tax to exactly mirror differences in support prices between Home and Abroad (as often is the case under the CAP MCA arrangements⁵); it may also be non-zero due to day-to-day fluctuations in market supply and demand which are not fully neutralised by market

⁵Such discrepancies are explained in Norton (1983a, p. 10).

regulation policy. It is assumed that $|\theta|$ is small relative to $p(1+t)$ and that traders, when deciding how to dispose of goods, know the current value of θ . (Note that θ plays no innovative role in the structure of the theory which follows; however it is important in understanding the empirical results in section 4 below. If the reader wishes, he may suppress it throughout the present section, but he should bring it back in interpreting the empirical findings).

q^S : Quantity allocated to smuggling activity by the trader.

q^L : Quantity legally exported by the trader.

$s(d)$, $L(d)$: The fractions of goods allocated to smuggling and legal trade, respectively, transported a distance d to the frontier, which evaporate in transit; $0 < s, L < 1$. It is assumed that the forms of these functions are the same for all traders, and that for a given d , s and L are constants; however, $s'(d)$ and $L'(d) > 0$. Thus we are adopting Samuelson's (1954) "iceberg" approach to transport costs. Note that, although partly the case, this is not merely a matter of convenience: live animals (which are among the goods traded under the CAP) do lose weight in transit.

μ : Probability of success, ie. non-detection, in smuggling. This is not independent of the number of units traded by a given operator. Nor are the probability distributions necessarily the same for all traders. Those located close to the frontier are likely to be more familiar with the surveillance operations of the authorities than those located more distantly. On the other hand, large firms which are historically well established in a given trade may suffer disadvantages in coming under closer scrutiny by the authorities in the event of suspected illegal trade: in general, they do not "fly by night", there today but gone tomorrow. In any

case it is assumed, for a potential trader located at distance d from the frontier, that $\mu = \mu(q^L, q^S)$; $0 < \mu < 1$, with partial derivatives $\mu_L > 0$, $\mu_S < 0$. If a trader is unsuccessful in attempted smuggling, the relevant goods are confiscated, thereby yielding the potential smuggler no return on his outlay. It is assumed that goods seized by the authorities are either destroyed or allocated to the intervention agency.

z : Loss to smuggler due to fines on detected contraband. (This is in addition to confiscations). It is assumed that this is proportional, by a factor α , to the at-frontier external value of contraband detected. On such merchandise, $z = \alpha p q^S (1 - s)$; $\alpha > 0$, and a smuggler's expected losses due to fines is $(1 - \mu)\alpha p q^S (1 - s)$.

If there were no risk costs attached to smuggling, the profits of any trader located at a particular distance d from the frontier, on moving goods into Home, would be

$$\pi(d) = (p + p_t + \theta)(1 - s)q^S + (p + \theta)(1 - L)q^L - p(q^S + q^L) \quad (1)$$

This is to be maximized subject to $q^S + q^L \leq \bar{q}$; $q^S, q^L \geq 0$; where \bar{q} denotes the amount of goods available to the trader at d (eg. on his own farm). Setting up the Lagrangian

$$V = \pi + \lambda(\bar{q} - q^S - q^L) \quad (2)$$

the Kuhn-Tucker conditions for a global maximum (which, in the problem at hand, are both necessary and sufficient) are that

$$\partial V / \partial q^S = p_t - p_s - p_{ts} + \theta - \theta_s - \lambda \leq 0 \quad (3a)$$

$$q^S \geq 0 \quad (3b)$$

$$q^S \cdot \partial V / \partial q^S = q^S (p_t - p_s - p_{ts} + \theta - \theta_s - \lambda) = 0 \quad (3c)$$

$$\partial V / \partial q^L = \theta - \theta_L - p_L - \lambda \leq 0 \quad (3d)$$

$$q^L \geq 0 \quad (3e)$$

$$q^L \cdot \partial V / \partial q^L = q^L (\theta - \theta_L - p_L - \lambda) = 0 \quad (3f)$$

$$\partial V / \partial \lambda = \bar{q} - q^S - q^L \geq 0 \quad (3g)$$

$$\lambda \geq 0 \quad (3h)$$

$$\lambda \cdot \partial V / \partial \lambda = \lambda (\bar{q} - q^S - q^L) = 0 \quad (3i)$$

A smuggled good evaporates by a factor $(1 - s)$ and earns $(p + p_t + \theta)$, while its cost in terms of alternatives in Abroad is p . Hence "book" profit per unit smuggled is $(p + p_t + \theta)(1 - s) - p$, and for smuggling to dominate internal trade, $\theta > ps / (1 - s) - p_t$. Since s is increasing in d , smuggling is less likely to yield "book" profits the higher is d . Similarly, a unit legally exported from Abroad evaporates by a factor $(1 - L)$ and earns $(p + \theta)$, while its cost in terms of alternatives in Abroad is also p . Hence "book" profit per unit legally exported is $(p + \theta)(1 - L) - p$, and for such export to dominate internal trade in Abroad, $\theta > pL / (1 - L)$. Since L is increasing in d , legal exports are also less likely to yield "book" profits the higher is d . Of course, the availability of "book" profits in an activity does not mean that the rational trader would necessarily engage in that activity.

Let q^d denote internal trade by the firm under consideration. Depending on the parameters of the problem, the Kuhn-Tucker conditions are consistent with seven possible kinds of optimal allocations by the trader:

$$q^S = 0, q^L > 0, q^d > 0 \quad (i)$$

$$q^S = 0, q^L > 0, q^d = 0 \quad (ii)$$

$$q^S = 0, q^L = 0, q^d > 0 \quad (iii)$$

$$q^L = 0, q^S > 0, q^d > 0 \quad (iv)$$

$$q^L = 0, q^S > 0, q^d = 0 \quad (v)$$

$$q^d = 0, q^S > 0, q^L > 0 \quad (vi)$$

$$q^S > 0, q^L > 0, q^d > 0 \quad (vii)$$

Because of the linear structure of the problem, and because zero profits are obtainable by trading on the domestic market, zero profits would surely be obtainable in cases (i), (iii), (iv) and (vii). Also because of the linear structure, the trader would certainly be indifferent between any volume of legal exports and domestic trade in case (i), of smuggling and domestic trade in case (iv) and between any allocation of the three forms of trade in case (vii); thus an optimal allocation is not unique in those three cases. Hence, in cases (i), (iii), (iv) and (vii), engaging in domestic trade only is (also) optimal. In case (vi), again because of linearity, the trader is indifferent between any amount of smuggling and legal exports; thus smuggling his entire endowment is optimal (as also is legally exporting the entire endowment). In case (ii), only legal exports prevail, though there is no guarantee that this solution is unique. Finally, in case (v) the entire endowment is allocated to smuggling, but again (for a given set of parameters) we cannot be certain that this solution is unique. For any set of parameters in the problem at hand, the trader can optimize by setting some one choice variable at a positive level (equal to \bar{q}) and the remaining two at zero levels; this merely reflects the basic theorem of linear programming. If a solution is unique (a determinate equilibrium) the trader does one thing only; he mixes his activities only in the event of a non-unique solution.

The four cases among the above set of possibilities in which $q^s > 0$ are of interest. Consider, for example, case (iv). From the Kuhn-Tucker conditions

$$p_t - p_s - p_{ts} + \theta - \theta_s = \lambda$$

$$= 0 \text{ since } q^d > 0 \quad (3c')$$

$$\theta - \theta_L - p_L \leq 0 \quad (3d')$$

Condition (3d') must be negative if the trader is not also indifferent between smuggling and legal exports; suppose for the moment that he is not indifferent. At the initial equilibrium in this case the trader earns zero economic profits (rents) from smuggling, and would incur losses if he exported legally. Suppose now that the distance to the frontier decreased: we can

think of ourselves as comparing the initial trader with another closer to the frontier, but identical in all other respects. Conditions (3c') and (3d') imply that initially

$$ps + pts + \theta s < pL + \theta L + pt \quad (4)$$

If the distance to the frontier now falls, we can be sure that internal trade will disappear. However the allocation between the two forms of export depends on the manner in which the reduction in d affects s and L , both of which decrease. If we assume, for example, that for all d , $s = L$, then inequality (4) will hold for all d , and the reduction in d will cause the trader to allocate his entire endowment to smuggling, in which he would now earn an economic rent $\lambda > 0$ per unit in equilibrium. Hence marginal smugglers earn zero economic rents and intramarginal smugglers earn positive economic rents in equilibrium. For a given t , the lower d (and hence the lower $s = L$), the higher the per unit economic rents of intramarginal smugglers.

Similar conclusions hold if, in the spirit of earlier models, for all d , $s > 0$ and $L = 0$. Initial equilibrium conditions in case (iv) are then (3c') and (3d') with an equality holding in (3d') -- $\theta \leq 0$ -- only if the trader is indifferent between legal and illegal modes of export. A reduction in d will not affect the left hand side of (3d'), but it will make that of (3c') positive. With the lower d , then, only smuggling is optimal, and $\lambda > 0$ denotes the per unit economic rents obtainable in equilibrium by smuggling from the reduced d .

Suppose that case (iv) applies initially, as before, but that t increases. Price in Home will then have moved in favour of smuggling from Abroad rather than internal trade in Abroad or legal exports from Abroad. Internal trade by the firm will go to zero, the left hand side of (3c') will become positive and that of (3d') will stay zero if the trader was initially indifferent between the two forms of export. However, the left hand side of (3c') will then exceed that of (3d'), so that legal exports by the trader would now surely be suboptimal -- they

would incur relative losses. Thus, assuming some initial smuggling from a given d , an effect of an increased t is to raise the economic rents obtainable by smugglers from d . But this means that some firms with a higher s than those at d , which initially traded in their domestic market only, will now engage in smuggling. Thus (on the plausible assumption that a finite number of traders are located at a given d) smuggling is an increasing cost industry because given the other parameters of the system, in order surely to induce more smuggling, t must rise, and since $s'(d) > 0$, the marginal suppliers have higher transport costs than those inside the margin.

The analysis when cases (v), (vi) and (vii) initially apply is along the general lines of that for (iv), just outlined.

Although it is a movement in the direction of reality in showing that smugglers in favourable locations earn economic rents, and although yielding determinate outputs for smuggling firms and the smuggling industry (except in the case of those firms which, by virtue of transport costs, are indifferent between smuggling and non-smuggling), the model as developed has the unsatisfactory feature that each firm's optimal decision can be categorised as of an all-or-nothing variety: if a firm is not indifferent between activities (in which case its allocation is indeterminate) it will engage in only one of the three possible activities. Also, the question of confiscations and fines has been ignored. However, it is easy to extend the model, as hereto developed, to rectify those deficiencies.

With risk of confiscation and fines in the model, the problem of a particular trader, with endowment \bar{q} , located at a specific distance d from the frontier, is to maximize

$$\begin{aligned} \pi(d) = & \mu(q^L, q^S)(p + pt + \theta)(1 - s)q^S \\ & - (1 - \mu)\alpha(1 - s)pq^S - pq^S \\ & + (p + \theta)(1 - L)q^L - pq^L \end{aligned} \quad (5)$$

subject to $q^S + q^L \leq \bar{q}$, and $q^S, q^L \geq 0$.

In regard to $\mu(q^L, q^S)q^S$, it is assumed that $q^S \mu_{SS} + 2\mu_S < 0$ and that $(q^S \mu_{SS} + 2\mu_S)(q^S \mu_{LL}) > (q^S \mu_{SL} + \mu_L)^2$, where the subscripts denote partial derivatives. These assumptions are sufficient (though not necessary) to ensure that $\mu(q^L, q^S)q^S$ is strictly concave. The objective function itself is then surely strictly concave in q^L and q^S . The single structural constraint function is convex. It follows that, for any set of permissible values of the parameters, the Kuhn-Tucker maximum conditions will necessarily characterise a global maximum, and for any given trader, the solution will be unique.

Setting up the relevant Lagrangian, and along the lines of (2) and (3a) to (3i), the Kuhn-Tucker (necessary and sufficient) conditions for a maximum yield

$$(p + pt + p\alpha + \theta)(1 - s)(\mu + q^S \mu_S) - (p + p\alpha - \alpha ps) \leq \lambda \quad (6a)$$

$$(p + pt + \alpha p + \theta)(1 - s)q^S \mu_L + \theta - pL - \theta L \leq \lambda \quad (6d)$$

$$\bar{q} - q^L - q^S \geq 0 \quad (6g)$$

where μ_L and μ_S denote partial derivatives.

The objective function is to maximize the surplus over and above the domestic value of goods (pq) by smuggling and/or legal exports. A trader can get a net return of zero by selling on his domestic market (or by maintaining the goods on his farm); thus he foregoes that return by engaging in international trade. Hence, the imputed cost (λ) of engaging in any form of international trade is at least zero, and the trader will not engage in either form of such activity unless he covers that imputed cost. If $\lambda > 0$, the trader gains economic rents from some form of international trade. However, he would then engage only in that activity (those activities) -- legal exports and/or smuggling -- for which the marginal net return -- the left hand side of conditions (6a) and (6d) -- exactly equals (equal) the marginal imputed cost.

For different values of the trader's parameters, the model with uncertainty present, as developed, is now consistent with only four of the seven possible kinds of optimal solution listed earlier for the certainty case. An allocation of type (i) could not optimally prevail because the firm gets zero profit on domestic trade, and (if case (i) did apply) it would also get zero profit on the marginal unit exported legally. But since $q^S = 0$, that would imply zero profit on all units legally exported. As the solution is unique, that could not arise. Nor could an allocation of type (iv) optimally apply. If a firm's domestic trade and smuggling were both optimally positive, the profit on the marginal unit smuggled would be zero. But profit in the last unit would be the same as that on all intramarginal units, and domestic trade would be as good as smuggling. Again by virtue of uniqueness of the solution, that could not optimally arise. Finally, an allocation of type (vii) could not apply, for reasons similar to those under case (iv). These observations (assuming strict convexity of the objective function) leave only cases (ii), (iii), (v) and (vi) to consider.

In case (ii), $q^L > 0$ and $q^S = q^d = 0$. As the solution is unique, and because profit per unit on legal exports is here constant, $\lambda > 0$. Condition (6a) then holds as a strict inequality while (6d) is an equality, which means that the trader obtains positive economic rents per unit in legal exports but none in smuggling. In case (iii), $q^d > 0$ and $q^S = q^L = 0$, and because the solution is unique, the trader is not indifferent between internal trade and any alternative. Thus (6a) and (6d) hold as strict inequalities and $\lambda = 0$: the firm engages in neither form of export because the marginal gross profit (the left hand side of (6a) and (6d)) on such activities would be negative. As in case (ii), λ must be positive in case (v), where $q^S > 0$ and $q^L = q^d = 0$. However the roles of legal and illegal exports are here reversed; condition (6a) holds as an equality and (6d) as a strict inequality. Smuggling, which obtains per unit economic rents equal to λ , is the only activity which, at the margin, covers its implicit costs. In case (vi), where $q^d = 0$ and q^S and q^L

are both positive, λ must again be positive; otherwise the firm would be indifferent between all three kinds of activity. Also conditions (6a) and (6d) here hold as exact equalities. The marginal economic rent on each of the two export activities here equals λ .

When legal and illegal exports are combined, as in case (vi), legal exports appear to incur a relative loss; this is similar to Pitt's (1981) finding that legal exports appear to incur an absolute loss. The terms $\theta - pL - \theta L$ in the (as now) equality (6d) denote the direct, or apparent, profit per unit on legal trade. As $q^S > 0$, the remaining part of the left hand side of (6d) is positive; thus $\theta - pL - \theta L < \lambda$. Hence, taking only direct effects into account, the marginal unit of legal export yields an apparent (or "book") profit less than its implicit cost, λ . However, the entire left hand side of (6d) -- the direct plus indirect profit on the marginal unit legally exported -- exactly covers its implicit cost because of its "external" effect on the probability of success in smuggling. Thus, at the margin, apparently suboptimal legal export is worthwhile because of its camouflage effect on smuggling.

The multiplier λ denotes the expected economic profit or rent on a marginal unit optimally allocated. If it is positive, the trader gets positive economic profits or rents by either smuggling or exporting legally, or by doing both (as in case (vi)). Suppose, for the trader under consideration, that smuggling is worthwhile, given the alternatives. That would be true if either cases (v) or (vi) applied. Suppose that case (v) -- $q^L = 0$, $q^S > 0$, $q^d = 0$ -- applies initially, and that transport cost per unit smuggled falls, given all the other parameters of the problem. Because no more can be smuggled from the point in question, we need only consider the derivative of the left hand side of (6a) with respect to $(1 - s)$. It is easily confirmed that this is positive⁶. Thus a reduction in s increases the economic rents obtainable by

⁶Divide the LHS of (6a) by $(1 - s)$ and compare the resulting (positive) expression with the derivative of the LHS of (6a).

smuggling from a given distance across the frontier. Turning to case (vi), where $q^d = 0$, $q^s > 0$, $q^L > 0$, note that a decrease in s cannot increase the volume traded internationally by a given firm located at a distance d from the frontier. However it will increase λ . Thus (assuming that both forms of export remain positive -- the new allocation depends on μ_L and μ_s) it will increase the economic rents on the marginal units exported, both legally and illegally. In the remaining two possible kinds of allocation, cases (ii) and (iii), where smuggling by the trader is initially zero, a reduction in s will tend to make the smuggling option less unattractive and, depending on the parameter values, it may generate positive economic rents in smuggling activity.

The assumption that $\mu(q^L, q^s)q^s$ is strictly concave meant that for given values of the parameters faced by the trader, the solution was unique. If the trader's objective function is concave, but not strictly so, the Kuhn-Tucker conditions are necessary and sufficient for a global maximum, but a solution-point might not be unique. But (with a linear structural constraint as in the problem at hand) if the objective function is not concave, the Kuhn-Tucker conditions, although still necessary for a global maximum, may be satisfied at a local maximum which is not global.

So far the discussion has focused mainly on a given producer/trader located at a particular distance from the frontier, given initial endowments of goods and given other parameters faced by him. It was concluded that if the trader were not engaged in any smuggling to begin with, then a reduction in smuggling transport costs would reduce the unattractiveness of the smuggling option; if, however, he were initially engaged in some smuggling, a reduction in such transport costs would increase the marginal (which equal average) economic rents obtainable from that activity.

Moving from the context of a single potential smuggler to one of many traders, it is noted that these differ in terms of the

parameters under which they optimize; their initial endowments may differ; fines on detection of smuggling may differ (first time caught versus the multiple offender); their distributions for the probability of success in smuggling will tend to vary from one trader to another⁷. However, the lower the transport costs attached to smuggling, the greater the incentive to smuggle. Assuming that some smuggling exists to begin with, as the rate of tax at the frontier increases, so too will the volume of smuggling: some existing smugglers (those whose endowments permit them) will tend to smuggle more, and traders for whom smuggling was previously non-viable will also smuggle. Thus, given the other parameters of the system, the aggregate volume of smuggling will be an increasing function of the tax rate at the frontier. As the tax rate increases, intra-marginal smugglers will increase their economic rents from smuggling and the distance-margin for worthwhile smuggling will be extended. Under our assumptions, the activities of each firm are fully determinate. Also, smuggling is indeed an increasing cost industry. But that is not because expansion of the smuggling industry causes upward shifts in the cost structures of existing intra-marginal smugglers; rather, it is because, given the other parameters of the system, in order to induce existing smugglers to increase their contraband at the expense of legal exports (which are opportunity costs of smuggling) the tax rate must rise, and, given that $s'(d) > 0$, the distance-margin for contraband by new smugglers can be extended only at higher costs for firms which did not previously engage in smuggling. In the model as specified, marginal smugglers earn almost-zero economic rents, but those located close to the frontier may earn large positive rents consistent with competitive equilibrium. (We say almost-zero rather than zero rents in the former case, because if their rents were zero the traders in question would be indifferent between legal trade and smuggling, in which event the traders in question would not have a unique solution).

⁷ Also, although for simplicity we have assumed to the contrary for a given d , the forms of the $s(d)$ and $L(d)$ functions are likely to vary from one trader to another -- some might have to travel across mountains, others across plains.

The analysis is not greatly modified if not all traders have strictly concave objective functions; indeed the assumption of strict concavity for all is unlikely to hold, due to differing probability distributions of the random variable μ attached to different traders. Thus $\mu(q^L, q^S)q^S$ may be strictly concave for some traders but not for others. Under such circumstances, zero rents could accrue to marginal smugglers; also, an optimal solution for a given trader could fall into any one of the seven categories outlined earlier for the situation under certainty. However the conclusions that smuggling is an increasing cost industry and that intra-marginal smugglers earn rents would be unaffected; likewise, the prediction that an increase in t would extend the distance-margin for smuggling would be unaffected.

If the model is altered to permit a trader to have endowments at, say, N different locations beyond the frontier, the analysis is not modified in substance: to determine his optimal decision at each d we can regard him as akin to N individual traders. The analysis would be more complex, but not modified in spirit, if it were assumed that some traders were dealers rather than producers, provided that they could procure goods for legal activity and/or smuggling in a neighbourhood of the prevailing market (support) price in Abroad. In all these cases marginal smugglers would earn zero, or almost-zero, economic rents, while intra-marginal smugglers would earn surpluses. In each case the model would predict that other things being equal, if the tax rate is increased, then the volume of smuggling will increase, largely because the economically viable distance-margin for smuggling will have been extended.

4. Empirical Support

Earlier empirical work on trade in CAP products between the Republic of Ireland (RI) and Northern Ireland (NI), January 1974 to December 1982, is consistent with, and gives support to, the theoretical framework outlined above. In almost every

week between October 1974 and December 1982 there were MCA taxes and subsidies on trade in CAP products between the two national jurisdictions. These EEC-implemented measures were meant (approximately but not always exactly) to mirror differences (using local currencies and market exchange rates) in guaranteed (support) prices of CAP products in the two States. The purpose of such taxes and subsidies was to prevent the differing support prices from causing deflections of (legal) trade from one market to another. The percentage gap between the two sets of support prices varied from week to week; therefore the rates of MCA tax/subsidy applicable on cross-border trade varied from one week to the next.

Between October 1974 and early 1980 official CAP product prices were lower in NI (and in the UK generally) than in RI. Thus, to bridge the gap in such support prices, MCA subsidies applied on RI exports to NI, while MCA taxes (equal in absolute values to the subsidies) applied on trade in the reverse direction. Since early in 1980, CAP support prices have been higher in NI than in RI; therefore MCA taxes have been applied on CAP goods moving northwards, whilst subsidies have been available on those going from NI to RI.

Given the levels of production in RI and NI, changes in MCA rates would not in themselves systematically induce large changes in recorded trade between RI and NI if all trade were through legal channels. That is because the MCA border taxes and subsidies simply (as an approximation) bridged the gap, in terms of local currencies and using market exchange rates, between EEC support prices in the two States. But given the smuggling option, a priori one would expect that when MCA subsidies were obtainable on RI exports to NI, RI exports would go through legal channels and would therefore be recorded. At the same time there would be a symmetric tax on RI imports from NI; thus one would expect that RI imports would be under-recorded, due to smuggling into RI. Similarly one would expect that when MCA taxes were applicable on RI exports to NI,

RI exports to NI would be smuggled and would therefore be underrecorded; symmetrically, an MCA subsidy would then be available on RI imports from NI, which would be recorded. If these a priori expectations were correct, recorded RI/NI trade would systematically vary with the rate of MCA and, given the levels of production/inventories in the two States, the extent to which recorded trade was "explained" by the MCA variable in a plausible econometric specification would yield an estimate of induced illegal activity in CAP products across the frontier.

For the volume of RI/NI recorded trade in live cattle, live pigs and unmilled barley, Norton (1984) estimated three sets of linear regressions of the following forms:

$$X = f(\text{MCA}, \text{OTHER}), \text{ and}$$
$$M = h(\text{MCA}, \text{OTHER}'), \text{ where}$$

- X: Amount of one of the three commodities recorded as being exported from RI to NI, monthly.
- M: Amount of the same commodity recorded as being imported into RI from NI, monthly.
- MCA: Net percentage rate of subsidy applicable to the commodity on RI exports to NI and the symmetric tax on RI imports of the commodity from NI. This variable had a negative value at times when RI exports were taxed (since a tax is a negative subsidy). Mid-month observation points were used.

OTHER,

OTHER': Vectors of other variables.

Sample data for the 108 months from January 1974 to December 1982 were employed for the estimation in the case of cattle and pigs; for barley (because of data limitations) observations of recorded trade over the 60 months January 1978 to December 1982 were utilised. The key variable explaining variation in recorded trade in the six regressions was the MCA rate -- which, of course, should not have any explanatory power if all trade were through legal channels. The coefficient of the MCA

variable was used to estimate illegal trade induced by each percentage rate of MCA tax. It was estimated that at moderately high rates of MCA tax (between 7% and 14%), very high proportions of RI/NI trade went through the smuggling route. For example, it was estimated that in 1981, when the average rate of MCA tax on RI exports to NI was about 10.5%, the following percentages of total (officially unrecorded and recorded) RI exports to NI were smuggled: live cattle, 21%; live pigs, 43%; unmilled barley, 46%. The corresponding estimates for 1982, when the average rate of MCA tax on RI exports to NI was 8.7%, are: cattle, 17%; pigs, 42%; barley, 64%.

Herlihy and Cowan (1983) also studied NI/RI pig smuggling, using a methodology (disposals analysis) different from that of Norton. Consider their estimates for the 14 quarters 1976, 3, to 1979, 4, when MCA subsidies (at rates which went as high as 31%) on RI exports to NI, and symmetric taxes on movements from NI to RI, applied. According to the official (ie. recorded) RI trade statistics, RI was a net exporter of 379,000 live pigs to NI over the period. But Herlihy and Cowan estimate that in fact (taking unrecorded movements into account) RI was a net importer of 852,000 live pigs from NI over the period. They estimate that over the period true (one-way⁸) recorded plus unrecorded RI imports of pigs from NI

⁸The term "one-way" is used to distinguish simple smuggling from the so-called "carousel" trade, ie. smuggling goods where a tax is due and bringing them back through legal channels to collect the symmetric subsidy. This kind of sham "trade", which at times has been on a substantial scale between contiguous EEC countries (Agra Europe, 1982; Herlihy and Cowan, 1983; Norton, 1983a) was anticipated in Smith's (1776, pp. 832,3) remarks that "our merchant importers smuggle as much, and make entry of as little as they can. Our merchant exporters ... make entry of more than they export ... sometimes to gain a bounty. In order to obtain the bounty ... the goods ... are ... sent to sea; but soon afterwards clandestinely relanded in some other part of the country." The carousel trade can be readily explained by extending the theoretic model of section 3.

came to 942,000 head; their estimate for (one-way) smuggling of live pigs into RI from NI was 918,000 head. According to these estimates practically all imports of live pigs into RI from NI, 1976, 3, to 1979, 4, (close to a million in total) came through the smuggling route.

Movement of agricultural produce, especially live animals which lose weight in transit, is expensive. Furthermore, in the absence of extra transport costs, the stocks of such commodities at any distance from the frontier cannot significantly be increased in a short period of time (such as a month): once inventories close to the frontier are exhausted, further (one-way) smugglings can take place only by drawing on inventories located at points further from the frontier. Such increased smugglings can be induced only at higher transport costs, and are therefore likely to be economically viable (in an EEC context) only if the rate of MCA tax (reflecting higher support prices beyond the frontier of a given country) is increased; hence the higher volumes smuggled at increased rates of MCA.

At very low rates of MCA, a significant amount of smuggling will take place only from points quite close to the frontier -- perhaps simply by permitting animals to walk from one field to the next, and the like. As the rate of MCA is increased, so too is the hinterland from which smugglers draw. It is difficult enough (as in Herlihy and Cowan, 1983, and in Norton, 1983a, b, 1984) to estimate the aggregate volume of smuggling of a commodity; it is harder still to detect the exact source-locations from which smugglers draw. However, apart from a priori reasoning, there are a few tangential pieces of information in that context. It would seem from reports from time to time in the press and elsewhere (see Norton, 1983a, chap. VII) that the bulk of NI/RI cross-border smuggling of CAP products has been by persons and families (specialised in the art) resident quite close to the frontier. For these, distance to the frontier, detailed knowledge of relevant

transportation networks ("unapproved" roads, farms located on both sides of the frontier, etc.) and familiarity with the customs officials and their modus operandi, are clear advantages. But if the MCA tax is sufficiently high, others are induced into the activity. Early in 1980 there was a zero MCA on cross-border trade. In the autumn of 1981, when the MCA tax on legal movements ex RI into NI was about 6%, it was reported that "meat plants along border areas [in RI] had been hardest hit by the smuggling [because they encountered difficulties in obtaining their raw materials locally] . The main problem was north of a line from Dublin to Galway [in RI, within 70 miles from the frontier with NI]. Northern buyers were evident at all the marts openly buying for smuggling". (Quoted in Norton 1983a, p. 107). A few months earlier, in the summer of 1981, when the MCA tax on legal movements into NI was around 11%, another popular source (quoted in Norton, 1983a, p. 105) reported that a smuggler resident close to the frontier "said that even the Munstermen were trying to cut in and recently in the middle of the day a Cork driver arrived in Castleblayney with a load of cattle and enquired of locals where the border was." (Castleblayney is in RI, almost on the frontier with NI. Cork is in the province of Munster, in the very south of RI, about 200 miles from the frontier with NI.)

A priori reasoning aside, there is also a small amount of evidence to the effect that legal trade has been used to camouflage smuggling (as specified in Pitt, 1981, and in section 3 above). In 1975/6, when MCA taxes applied on NI exports to RI, smuggling of live animals southwards was so severe that it threatened the future of NI meat plants. To maintain supplies for finishing there, the UK introduced slaughter subsidies in NI. Smuggling of pigmeat southwards then switched away from live pigs to bacon sides: in November 1976 it was estimated that almost 6,000 sides, or the equivalent of 3,000 pigs, were being smuggled southwards each week. The situation was complicated by the fact that there were also small-scale legal imports of bacon to RI from NI. In consequence, wholesalers were able to produce documentation to show that quantities of NI bacon

were in fact legally imported, but these, it was claimed, were supplemented by illegally imported bacon (Norton, 1984, pp. 24, 25).

In closing, it is remarked that in section 3 it was stated that intramarginal smugglers would earn economic rents in competitive equilibrium. It may be argued that such rents would accrue to landlords close to the frontier. To some extent, that may have been the case -- though it should be noted that smugglers and landowning farmers have largely been one and the same. However, because MCA's varied from week to week, so too did the incentive to smuggle. Indeed, the incentive to smuggle from a given location could (and did) switch, in a fairly unpredictable manner and in a short period of time, from positive to zero to negative. As the contracted rent of a given piece of land does not vary from week to week, it seems reasonable to speak of economic rents or quasi-rents from smuggling as accruing to smugglers at favourable locations rather than to landlords.

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