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INTERSTATE CIGARETTE BOOTLEGGING: EXTENT, REVENUE LOSSES, AND EFFECTS OF FEDERAL INTERVENTION

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ABSTRACT

In this paper, we develop and estimate a model of commercial smuggling in which some, but not all, firms smuggle a portion of the cigarettes they sell. The model is used to examine the effects on interstate cigarette smuggling of the Contraband Cigarette Act and a change in the federal excise tax. We find that both policies have unintentional effects. While the Contraband Cigarette Act was imposed to reduce interstate smuggling, we find it had the opposite effect. In contrast, an increase in the federal tax is not intended to affect smuggling, but we find it increases the portion of cigarette sales that is commercially smuggled.

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I. Introduction

Within the last year, substantial increases in cigarette taxes have been either proposed or legislated at both the federal and state levels. The Clinton administration called for a 75 cent per pack increase in the federal tax, and a Congressional subcommittee recently proposed an increase of $1.01 per pack. Several states have already legislated increased cigarette taxes. Whether these increases are intended to reduce smoking or raise revenue, their success will depend on the extent to which firms and consumers respond by increasing their tax evasion efforts. It is not surprising, then, to find concerns in the popular press over increased cigarette smuggling.[1]

Not since the late 1970s has there been such concern over cigarette smuggling. In the early to mid seventies, interstate cigarette smuggling was serious enough that several states appealed to the federal government for assistance and the Advisory Commission on Intergovernmental Relations (ACIR, 1977) recommended federal legislation prohibiting the interstate transportation of contraband cigarettes. In response, Congress passed the Contraband Cigarette Act (CCA) of 1978 which prohibited single shipments, sale, or purchase of more than 60,000 cigarettes not bearing the tax indicia of the state in which they are found. It is commonly believed that smuggling declined significantly after this and that the decline was due to the federal intervention:

> The Commission concludes that the incidence of cigarette smuggling has declined significantly since 1977, due in large part, to the passage of the Federal Cigarette Contraband Act in 1978. (ACIR 1985, p. 4).

Thus, until the recent movement to increase taxes, cigarette smuggling had ceased to be a major policy issue.

With existing models, however, it is difficult to assess the impact on interstate smuggling of either the CCA or the proposed federal tax increase. In this paper, we develop and estimate a model of commercial smuggling which allows us to examine both policy issues. Estimation of commercial smuggling is important for the analysis of both policies, and it is a major difference between our study

[1]For example, see *The Wall Street Journal*, March 30 ("Tax cut spurs Canada cigarette sales") and April 5, 1994 ("Canada's Taxing Pols Outwitted by Underground Economy") and *The Chicago Tribune*, March 31, 1994 "Fewer smokers or more bootleggers?". Groups expressing concern range from health advocates and government officials to the Tobacco Institute, which has an incentive to discourage legislators from increasing taxes.

and others. The bulk of the literature on smuggling focuses on casual smuggling by consumers who cross state borders to take advantage of lower taxes in border states.[2] It is unlikely that the CCA could have affected this type of smuggling because it pertained to single loads in excess of 300 packs. This most likely omits even the most avid smoker among consumers who smuggle. It is also unlikely that a change in the federal tax would affect consumer smuggling across state lines. An increase in the federal tax might affect consumer smuggling across national borders, but that is not our primary interest. Our interest is interstate smuggling by firms, and any impact of the federal tax in our analysis occurs through its effect on firm costs (and, therefore, equilibrium industry behavior)

In Section II we develop a theoretical model in which firms smuggle in order to evade excise taxes in a high tax state. Firms choose the quantity of cigarettes to sell in a given state and the portion of sales on which to pay the state tax, taking as given the behavior of rival firms, the manufacturer's price, and enforcement parameters. The equilibrium we examine is one in which some firms pay tax on all sales while others smuggle a portion of their sales in order to evade the state tax. The portion of tax-paid sales in the state is a function of the state tax, the cost associated with acquiring and camouflaging smuggled cigarettes, expected penalties in the event of failure, as well as market parameters.

In Section III we derive an empirically estimable version of this function. In addition to the factors mentioned above, the estimation procedure involves estimating consumer demand. This allows us to account for the types of smuggling done by consumers, namely casual smuggling across state borders and smuggling from military bases and Indian reservations. The model is estimated using annual data from 1972-1990. This period contains both the enactment of the CCA in 1978 and an increase in the federal excise tax in 1983, enabling us to examine effects of both policies. Sections IV-VI report those results, as well as revenue losses associated with commercial smuggling.

Contrary to the ACIR conclusion, we find Federal entry into contraband cigarette enforcement had the *opposite* of the intended effect. According to our estimates, commercial smuggling increased slightly in 1979 and fell in the early eighties, but it would have decreased in all years and the decrease

[2]See, for example, Baltagi and Levin (1986), Baltagi and Goel (1987), Hamilton (1982), Warner (1982), and Manchester (1973) The ACIR (1985) study discusses commercial smuggling, but it does not distinguish between commercial and casual smuggling in its estimation.

would have been even greater if the act had not been passed. While this may seem surprising, we argue in Section IV that it can be explained in terms of a combination of factors related to the reaction of enforcement agencies to passage of the law.[3] Section V shows the results are robust to alternative non-constant elasticity variants of the model. Section VI reports the other somewhat surprising result, that an increase in the federal excise tax increases the portion of cigarettes smuggled. To understand the result, recall that our model includes firms who smuggle a fraction of their sales and firms whose sales are entirely legal. An increase in the federal tax increases costs for both types of firms, leading to a reduction in their equilibrium sales. As shown in Section VI, an increase in the federal tax will be associated with an increase in the portion of cigarettes smuggled for a sufficient reduction in sales by nonsmuggling firms. Section VII concludes.

As noted earlier, the literature on cigarette smuggling tends to focus on casual smuggling by consumers. In contrast, the literature on smuggling in international trade is primarily devoted to models of smuggling by firms. The model closest to ours is Thursby, Jensen, and Thursby's (TJT, 1991) model of camouflaging, in which some, but not all, firms in a market pay tariffs on a portion of their imports in order to camouflage smuggled imports. Although the focus of their theoretical work is imports, they present empirical evidence on the relevance of the model to interstate cigarette smuggling in the United States. We differ from TJT in two respects. In the theoretical analysis, we make assumptions on the tax structure and enforcement that are more appropriate to the cigarette case. In addition, we derive an empirically estimable smuggling function that allows for estimation of the extent of smuggling.

II. A Theoretical Model of Commercial Smuggling

In this section, we present a model of cigarette distribution in which some, but not all, firms smuggle in order to evade state excise taxes. We adopt TJT's assumptions on market structure and the form of smuggling, but we differ in the treatment of taxes and penalties for tax evasion. Firms who smuggle are able to evade taxes on only a portion of their sales because tax-paid sales are necessary to

[3]Warner (1982) notes that any decline in smuggling in the early eighties could have been due to the reduction in real tax differences that occurred with increasing rates of inflation. However, as with the ACIR (1985) study, Warner does not estimate the extent of commercial smuggling.

camouflage smuggled cigarettes. The market is quasi-competitive in that a finite number of firms compete as Cournot rivals, but as the number of firms increases, output and price approach the competitive outcome. Each firm makes its decisions taking as given its rivals' behavior, the manufacturer's price, tax structure, and government enforcement. It is in modeling the last two parameters that we deviate from TJT. Their theoretical analysis focuses on smuggling when firms face ad valorem taxes and the only penalty for smuggling is confiscation. These assumptions are inappropriate for our case since cigarette taxes are per unit and penalties include fines and/or imprisonment in addition to confiscation.[4]

Consider the decision problem of the ith cigarette distributor who purchases cigarettes either from the manufacturer or from an out-of-state wholesaler for sale in state s. The state government levies an excise tax of T_s per unit sold. If the firm pays the tax on all units sold, its profits are

$$(1) \qquad [P(Q) - w - c_i - T_f - T_s]q_i$$

where P(Q) is inverse demand facing firm i, Q is the quantity of cigarettes sold by all firms in s, w is the manufacturer's price, T_f is the federal tax, c_i is cost associated with transportation and /or retailing, and q_i is the quantity sold by firm i.

Alternatively, the firm may try to avoid paying the tax on $(1 - \gamma_i)q_i$ of its sales and report sales of $\gamma_i q_i$, where $\gamma_i < 1$ is the portion of sales on which it pays the state tax. In reality, this can occur in a variety of ways, but a common one is for a firm to purchase $(1 - \gamma_i)q_i$ cigarettes from a wholesaler in a low tax state, j, paying T_j per unit plus a premium to the wholesaler not to affix tax indicia to the cigarettes (ACIR, 1985).[5] The smuggling firm then affixes counterfeit indicia for tax payment in s.

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[4]Data from the ACIR (1985) suggest that state penalties are relatively low. Fines appear more prevalent than prison sentences, and state fines appear lower than those for a federal conviction. Our results for 1979-1984 show that the value of confiscations was less than one-tenth of one percent of estimated values for the amount smuggled.

[5]Athough some cigarettes are hijacked, we do not model hijacking. Tax administrators we interviewed indicated that they receive manufacturers' accounts of cigarettes sold to distributors, making it difficult to smuggle cigarettes purchased from the manufacturer. The mechanism we model is harder to detect, and enforcement evidence suggests it is a common method.

Enforcement efforts make this a risky activity. We incorporate this aspect of smuggling by introducing a parameter, e, to denote the level of enforcement, and we express p, the probability firm i successfully smuggles a unit, as a function of e. It is also natural to assume this probability is a function of the portion of its sales the firm attempts to smuggle. We assume $p(\gamma_i, e)$ is increasing and concave in γ_i and decreasing, and concave in e. In addition, $p(\gamma_i, e) \in [0, 1]$ for all γ_i, $p(0, e) = 0$ for all e, and $p(1, e) = p(\gamma_i, 0) = 1$. As noted earlier, firms caught smuggling are subject to fines, imprisonment, and confiscation of cigarettes. We assume expectations are rational, so that $(1 - p(\bullet))$ is the true fraction of firm i's sales that are detected and confiscated. Thus, expected profit for a firm who tries to evade taxes in s are given by

(2) $$E\pi_i = [P(Q) - T_s]\gamma_i q_i + [p(\gamma_i, e)P(Q) - T_j - E_i](1 - \gamma_i)q_i - [w + c_i + T_f]q_i$$

where $E_i = ea_i + F[1 - p(\gamma_i, e)]$ represents per unit excess smuggling cost. The first term in E_i represents costs incurred by the firm whether or not it is successful in smuggling. The parameter a_i is included to differentiate firms by their ability and cost of smuggling. One could think of a_i representing the premium paid to a wholesaler in a low tax state. If the firm's management has established ties with the wholesaler,[6] it may pay a lower premium than others. Managers may also differ in their ability and /or experience in camouflaging. The second component of E_i represents fines (or an imputed cost associated with imprisonment) and is incurred only if the firm's smuggling efforts are unsuccessful. F is a constant per unit, so that the expected fine is decreasing and concave in γ_i.

Notice that (1) and (2) are equivalent when $\gamma_i = 1$. In addition, our specification of (1) and (2) implies that firms sell a homogeneous product. Even though cigarettes are differentiated, this specification can be justified since firms carry many of the same brands. We abstract from issues related to product differentiation primarily because our data are for all cigarettes, which precludes any such analysis. Aggregate data also preclude our distinguishing between wholesale and retail sales, hence our model will

[6] It is reported in ACIR (1985) that some smuggling firms have purchased wholesale firms in low tax states so as to lower their smuggling costs.

abstract from whether the firm operates at the wholesale and/or retail levels. It should also be noted that (2) implies any confiscated cigarettes are resold by the government.

Each firm is assumed to choose q_i and γ_i so as to maximize expected profit given by (2). Under the assumption of Cournot behavior, the first order conditions for an interior solution to the firm's problem are:

$$(3) \qquad \partial\mathcal{E}\pi_i/\partial q_i = [P(Q) + P'(Q)q_i][\gamma_i + (1-\gamma_i)p(\gamma_i, e)] - [w + c_i + T_f + \gamma_i T_s + (1-\gamma_i)(T_j + E_i)] = 0$$

$$(4) \qquad \partial\mathcal{E}\pi_i/\partial\gamma_i = P(Q)[1 + (1-\gamma_i)\partial p/\partial\gamma_i - p(\gamma_i, e)] + [T_j + E_i + (1-\gamma_i)F\partial p/\partial\gamma_i] - T_s = 0$$

Equation (3) implies the firm should expand sales in state s until expected marginal revenue equals marginal cost, and given any nonnegative q_i, equation (4) determines the optimal value of γ_i, which we denote by $\gamma_i = f_i(q; e, T_s, T_j, F, a_i)$ where $q = [q_1,...,q_N]$. Under our assumptions, $\partial f_i/\partial q_i = \partial f_i/\partial q_j < 0$, for all $i, j = 1, ..., n_s$, $\partial f_i/\partial e > 0$, $\partial f_i/\partial T_s < 0$, $\partial f_i/\partial T_j > 0$, $\partial f_i/\partial F > 0$, and $\partial f_i/\partial a_i > 0$ whenever $1 > \gamma_i > 0$. The equality of own and cross effects of sales follows from the fact that rival sales affect the fraction of legal sales only through the inverse demand term, P(Q), in (4). Under our assumption that the government resells confiscated goods at the market price, Q is simply the sum of all sales in state s (legal or not).[7]

Firm i will smuggle some, but not all, of its sales in state s ($1 > \gamma_i > 0$) whenever

$$(5) \qquad [P(Q) + F][1 + \partial p(0, e)/\partial\gamma_i] > T_s - T_j - ea_i > 0.$$

This is because $\partial\mathcal{E}\pi_i/\partial\gamma_i$ simplifies to $T_j + ea_i - T_s$ when $\gamma_i = 1$. $T_j + ea_i$ represents the expected marginal cost from switching a unit of sales from legal to illegal. When this is less than the marginal benefit from the switch, T_s, it is optimal for the firm to attempt to smuggle some of its sales. At the other extreme ($\gamma_i = 0$), $[P(Q) + F][1 + \partial p(0, e)/\partial\gamma_i] + T_j + ea_i$ represents the firm's excess cost and expected loss

[7]If confiscated cigarettes are resold, P(Q) represents inverse demand, but if they are destroyed, the firm's inverse demand is a function of its rival's smuggling behavior and the probability of success. See TJT, p. 794 for a discussion of how alternative assumptions on confiscation would affect the own and cross effects of sales.

from fines and confiscation. If this exceeds the marginal benefit, T_s, the firm will pay taxes in state s on some portion of its sales.

To define the market equilibrium, it is useful to restate the firm's problem as maximizing expected profit subject to $\gamma_i = f_i(q)$, where expected profit is given by

(6) $$\Pi_i = [P(Q) - T_s]f_i(q)q_i + [p(f_i(q), e)P(Q) - T_j - E_i](1 - f_i(q))q_i - [w + c_i + T_f]q_i.$$

The firm's sales are then determined by

(7) $$[P(Q) + P'(Q)q_i][f_i(q) + (1 - f_i(q))p(f_i(q), e)] = [w + c_i + T_f + f_i(q)T_s + (1 - f_i(q))(T_j + E_i)]$$

where $f_i(q)$ is defined by (4). For interior solutions to (4), the fact that $\partial f_i/\partial q_i < 0$ implies that expected marginal and average cost are declining in q_i. Thus, as in TJT, we assume Π_i is concave in q_i so that a unique maximum exists. The market equilibrium is a Nash equilibrium vector of sales, $(q_1^*, \ldots, q_N^*)$ such that $\Pi_i(q^*) \geq \Pi_i(q_i, q_{-i}^*)$ for all $q_i \in [0, K]$ where K is a real number such that $P(Q) = 0$ for $Q \geq K > 0$ and for all $i = 1, \ldots, N$.

Now suppose there are two types of firms, differentiated only by the excess smuggling cost parameter, a_i. Type 1 firms have a_1, which is low enough that (5) holds, and type 2 firms have a_2 which is high enough that (5) does not hold. The payoff function for type 1 firms is (6) evaluated at $\gamma_i = f_i(q) \in (0, 1)$ and the payoff function for type 2 firms is (6) evaluated at $f_i(q) \equiv 1$. Because firms are identical except for a_i, we can express the equilibrium level of sales in state s as $Q^* = N_1q_1^* + N_2q_2^*$, where N_1 and N_2 are the number or type 1 and 2 firms, respectively. Each type 1 firm will pay T_s on a fraction, $\gamma_1^* = f(Q^*)$, of its sales,[8] and q_1^*, q_2^*, γ_1^*, and Q^* are implicitly defined by

(8) $$[P(Q) + P'(Q)q_1][\gamma_1 + (1 - \gamma_1)p(\gamma_1), e)] = [w + c + T_f + \gamma_1T_s + (1 - \gamma_1)(T_j + E_1)], \text{ and}$$

[8]We can express γ_1 in this way because of the equality of the own and cross effect of sales and the fact that type two firms are identical.

(9) $[P(Q) + P'(Q)q_2] = w + c + T_f + T_s$.

In the next section, we develop an empirically estimable version of γ_1^*, but first it is useful to note comparative static properties of the theoretical model. Since $\gamma_1^* = f(Q^*; e, T_s, T_j, F, a_1)$ where $Q^* = N_1q_1^* + N_2q_2^*$, the comparative static results may differ in sign, as well as magnitude from those on γ_1 stated earlier. For example, a change in T_s affects γ_1^* directly (see equation 4), but it will also affect γ_1^* through its effects on q_1^* and q_2^*. The direct effect is negative, but the sales effects are ambiguous, so that we cannot sign the effect of a change in the T_s on the equilibrium fraction of state tax-paid sales. An increase in T_j or any of the excess smuggling cost parameters (e, a_1, or F) will increase sales of non-smuggling firms and the fraction of smugglers' legal sales, but will decrease the total sales of smugglers. Increases in the federal tax, manufacturer's price or transport cost act somewhat differently because they affect per unit cost of legal and illegal sales, while the tax in state j or the enforcement parameters only affect the cost of smuggled cigarettes. In general, we cannot sign the effect of an increase in the federal tax or manufacturer's price, but in the special case of linear demand, either has the intuitively expected effect of reducing both sales of non-smugglers and total sales of smuggling firms.

III. An Empirical Model of Commercial Smuggling

In this Section we develop an empirically estimable function for tax paid sales in a state as a fraction of total sales (legal and illegal) in the state. Although this function is similar to γ_1^*, it takes into account issues of estimation and data availability not considered in our theoretical analysis. In Section A we derive an estimating equation that allows us to account for the fact that market data reflect smuggling by consumers as well as the commercial smuggling of interest to us. We also explain the variables used to reflect taxes and enforcement parameters. Section B is devoted to a discussion of data and the estimation procedure.

A. Estimating Equation

We address three types of cigarette smuggling.[9] First, "casual" smuggling is done by consumers in high tax states who cross state lines to purchase cigarettes in low tax states. The second type is the sale of tax free cigarettes on American Indian reservations and military installations to non-Indians and non-military personnel. This smuggling, like the first, is thought to be primarily smuggling by consumers.

Organized or commercial smuggling by firms is the third type, and the one targeted by the CCA. This type of smuggling often involves firms purchasing tax-paid cigarettes in low tax states and is the type modeled in Section II. Note that with this type of smuggling, cigarettes are legal in the state where they are purchased because the low tax state's excise tax is paid. However, the wholesaler in the low tax state is paid not to affix the local tax indica. The primary sources for such cigarettes are the tobacco producing (and lowest tax) states North Carolina and, to a lesser extent, Kentucky and Virginia. Table 1 presents the per capita tax paid cigarette sales is these three out-smuggling states as well as the U.S. average for selected years. Smuggling is not thought to have been a problem in 1965 when the largest difference in taxes (excluding local taxes) with other states was $.46 (in 1990 prices) and few states had differences larger than $.30. Per capita sales in KY and VA[10] for 1965 are similar to the U.S. average. By 1970 many states had tax differences close to $.40 and per capita tax paid cigarette sales in the three out-smuggling states had risen well above the U.S. average. The primary reason for this rise is thought to be the increasing tax differentials.

We start with a standard cigarette demand function which treats cigarettes in neighboring states as a substitute for "local" cigarettes, and which accounts for the presence of non-tax paid sales on military bases and Indian reservations. Our initial demand equation is

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[9] Mail-order sales of cigarettes are an additional source. Such smuggling is thought to be of minor importance (ACIR 1977; Maltz, Edelhurtz, and Chamberlain (1976) report mail-order smuggling to be on the decline) since mail fraud statutes apply to the activity and because of the difficulty in smuggling large quantities of cigarettes while, at the same time, avoiding detection by postal authorities.

[10] Data on NC are unavailable as only data on tax paid sales are gathered and NC did not tax cigarettes in 1965.

$$(10) \quad \ln Q_{st} = \delta_s + \beta_1 \ln RP_{st} + \beta_2 \ln INC_{st} + \beta_3 t + \beta_4 \ln(AVRP_{st}/RP_{st}) + \beta_5 \ln CAN_{st}$$
$$+ \beta_6 MILITARY_{st} \times \ln TAX_{st} + \beta_7 INDIAN_{st} \times \ln TAX_{st} + \beta_8 \ln Q_{st-1} + \varepsilon_{st}\,.$$
$$\equiv \delta_s + X_{st}\beta + \beta_8 \ln Q_{st-1} + \varepsilon_{st}$$

The subscripts $t = 1, \ldots, T$ and $s = 1, \ldots, N$ refer to the year and state, respectively, of the observation. Variables are defined as follows:

Q = per capita cigarette demand.

RP = retail price.

INC = state per capita income.

t = time trend

CAN = ratio of average tax in adjacent Canadian provinces to tax in state s if state s is adjacent to any Canadian provinces, otherwise CAN=1.

MILITARY = percent military in state s.

INDIAN = percent American Indian in state s.

TAX = state cigarette excise tax.

AVRP = the average retail price of cigarettes in adjacent states.

ε = random error assumed to be distributed $N(0, \sigma_s^2)$.

The parameters δ_s allow for a different constant term for each state. A fixed effects model is estimated in order to adjust for any demographic differences across states that might lead to different cigarette demand; we assume that demographic changes over our sample period were unimportant with respect to cigarette demand. We allow for heteroscedasticity by assuming a different disturbance variance for each state. Below we relax the constant elasticity assumption with respect to price and income.

A time trend is included to account for (apparent) declines in cigarette smoking due to advertised adverse health effects; the sign of its coefficient, β_3, is expected to be negative. $AVRP_{st}$ and CAN_{st} are measures of the incentive for consumer to cross borders to purchase cigarettes. States with cigarette prices generally lower than that of their neighbors will observe higher demand (*ceteris paribus*) for cigarettes due to out-smuggling of cigarettes by consumers from neighboring states; the opposite occurs in states with prices generally higher than their neighbors.[11] We do not have available information on average retail prices in Canada hence we use tax rates. AVRP (CAN) are introduced in ratio with RP (local state tax rate) simply for ease of presentation: by doing so we can interpret β_1 as the price elasticity of demand *net* of any cross-bordering smuggling by consumers.[12] Canada and neighboring states enter separately because of the added difficulty in crossing the US/Canadian border. Data on Mexico are unavailable, and, in addition, we can find no mention of smuggling across the US/Mexican border as a problem.

$MILITARY_{st} \times lnTAX_{st}$ and $INDIAN_{st} \times lnTAX_{st}$ are included since sales of cigarettes on Indian reservations and military bases are free of state taxes, and military bases and Indian reservations have often been mentioned as a source for smuggled cigarettes. Tight control of sales on military bases (e.g., sales only to military personnel or dependents and limits on the number of cartons sold to a consumer) would suggest that any smuggling off military bases would be casual. It is not clear whether smuggling off Indian reservations is done solely or primarily by consumers. We assume that casual smuggling is the primary form of this smuggling.[13] Large Indian and/or military populations should lead to decreased demand for cigarettes sold through tax paid outlets, but total demand will be higher since cigarette prices are lower on bases and reservations and this may spill over into tax paid cigarette sales (our observed quantity). In addition, it is well known that cigarette smoking is more prevalent among the military than among civilians. For these reasons we are unable to hypothesize signs on β_6 and β_7.

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[11] We also considered the ratio of taxes in neighboring states as well as retail prices in neighboring states because smuggling by consumers is confined primarily to what might be loosely termed "economic" regions where factor costs are similar. In the area where a casual smuggler operates one could argue that price differentials are due primarily to tax differences. That is, a price difference that leads to casual smuggling is a difference due primarily to tax differences rather than to price differences stemming from, say, differing labor costs. Results using the two measures are very similar so we only report the results based on prices (which is the measure typically used by other researchers).

[12] Only the standard error of the estimate of β_1 is affected by using ratios.

[13] This assumption should have little, if any, effect on our estimates of the extent of organized smuggling since our measure of the incentive for organized smuggling is the difference in a state's excise tax with the excise tax in North Carolina which remained at two cents throughout our sample period. If we were to introduce separately the incentive for firms to smuggle off Indian reservations we would use the local state tax rate which is almost perfectly collinear with the tax difference with North Carolina.

Data available on cigarette sales are on "tax-paid" or "legal" sales: we only observe the portion of the ith state's cigarette demand for which the ith state's taxes are paid. In the absence of commercial smuggling we would observe Q_{st} (which, of course, reflects the demand or supply of cigarettes from neighboring states). In the presence of commercial smuggling we observe the portion of sales that are legal. Define γ_{st}, $0 < \gamma_{st} \leq 1$, to be the fraction of demand in the sth state in year t which is not supplied or "bootlegged" into the state by commercial smugglers. In equilibrium γ_{st} equals tax-paid sales as a fraction of total sales in the state.[14] That is, we observe $L_{st} = \gamma_{st}Q_{st}$ rather than Q_{st} (or γ_{st}), where L_{st} is the per capita quantity of legal sales in state s in year t. Substituting the accounting identity $Q_{st} \equiv L_{st} + S_{st}$ into the above, where S_{st} is the level of commercial smuggling in state s at time t, we solve for the level of organized smuggling activity as

$$(11) \qquad S_{st} = L_{st}(1 - \gamma_{st})/\gamma_{st}.$$

γ_{st} is unobserved, but it is estimable. Its theoretical analog is a function of the level of enforcement as well as the tax differential with the low-tax states. The functional form chosen is

$$\gamma_{st} = \exp[\ \delta_1 TAXDIF_{st} + \delta_2 TAXDIF_{st}^2 + \delta_3 ENFORCE_{st} + \delta_4 RP_{st} \times TAXDIF_{st} + w_{st} \times TAXDIF_{st}\ ]$$

where

TAXDIF = the difference in the tax rate in state s and the tax in the low tax state where purchases are made by organized smugglers,

ENFORCE = the level of enforcement (representing E_i in the theoretical model),

and w_{st} is a random error assumed to be distributed $N(0, \sigma_w^2)$.

Enforcement level is unobserved, but it is a function of a set of observable variables. We consider this below, though we note for now the reasonable assumption that ENFORCE is equal to zero if

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[14] In the event that all firms smuggle a portion of their sales, $\gamma_{st} = \gamma_1^*$. Otherwise, $\gamma_{st} = [\gamma_1^* N_1 q_1^* + N_2 q_2^*]/[N_1 q_1^* + N_2 q_2^*]$.

TAXDIF = 0. A quadratic in TAXDIF is used to account for possible nonlinearity in the effects of tax differences.

We choose an exponential form for γ_{st} as well as interact the random error and RP with TAXDIF because this implies, as it should, $\gamma_{st} = 1$ (that is, no commercial smuggling) if the tax difference with the low tax state, and hence the incentive to smuggle (and to enforce against smuggling), is zero. Recall that in the theoretical model γ_1^* is a function of the equilibrium aggregate sales in the state (Q_{st}). Note, however, in equation (4) the effect is shown to be through the inverse demand equation. Hence we use RP_{st} in place of Q_{st}. Our analysis does not imply a sign on the coefficient of RP. Also recall that the direct effect of an increase in TAXDIF on γ_1^* is negative, but that an increase in TAXDIF also changes total sales of smugglers and non-smugglers. These latter effects can outweigh the direct effect so that the net effect is positive. It is nonetheless our expectation that increases in TAXDIF reduce γ_{st} ($\delta_1 < 0$).

Our measure of the tax differential, $TAXDIF_{st}$, is the difference between the tax rate in the sth state at time t and the tax in North Carolina at time t. As noted above, many of the cigarettes smuggled by firms are "legal" at the point of origin: that is, smuggling firms pay the state excise tax in North Carolina, Kentucky, or Virginia. The nominal taxes in these three states were unchanged during the period of our observations at 2, 3, and 2.5 cents, respectively. Since North Carolina is considered to be the primary source of smuggled cigarettes we measure the incentive for firms to smuggle using the difference in the local state excise taxes and the excise tax in North Carolina. Results change very little if we use the state excise tax rate rather than the tax differential given a constant nominal North Carolina tax rate.

In the theoretical model the effect of enforcement is unambiguous, so that we expect $\delta_3 > 0$. As the level of enforcement rises the proportion of legal sales to quantity demanded, γ_{st}, should increase. However, enforcement is itself a function of the tax differential: an increase in the tax differential increases the incentive for states to engage in enforcement activities since the returns to enforcement activity are potentially greater. There is little direct evidence available on the level of anti-smuggling enforcement. Other than the tax differential, our evidence includes the date of passage of the Contraband Cigarette Act, the fact that some states were members of joint enforcement operations, some qualitative information on the severity of penalties for smuggling, and the rebate offered to wholesalers for each legal sale.[15] The joint enforcement groups were the Interstate Revenue Research Center (IRRC), with member states MI, MN, IN, IL, OH, FL, and MS, and the Eastern Seaboard Interstate Cigarette Tax Enforcement Group (ESICTEG), with member states CN, DE, MD, MA, NJ, NY, and PA. The information on the severity of smuggling penalties is from ACIR (1977) where states are categorized as having light, moderate, or severe criminal penalties for smuggling. The states in the latter two categories are CA, CN, MI, NE, NY, OH, and TN. Benjamin (1992) aregues that the payment of a discount or rebate to wholesalers for each legal sale is a form of enforcement. Ostensibly, the discount is to cover the cost of affixing the tax indica, but it is widely agreed that the rate is substantially in excess of the cost of stamping the cigarettes and is therefore a disincentive for smuggling.

We account for the level of enforcement using the function

$$(12) \qquad ENFORCE_{st} = \alpha_1 TAXDIF_{st} + \alpha_2 TAXDIF_{st}^2 + \alpha_3 MEMB_s \times TAXDIF_{st} + \alpha_4 FELONY_s \times TAXDIF_{st} + \alpha_5 DISC_{st} \times TAXDIF_{st} + CCA_t + v_{st} \times TAXDIF_{st}$$

where

MEMB = 1 if the state is a member of IRRC or ESICTEG, 0 otherwise.[16]

FELONY = 1 if the state imposes a moderate or severe penalty for cigarette smuggling, 0 otherwise.

DISC = the discount rate paid to cigarette wholesalers.

v is a random error assumed to be distributed $N(0, \sigma_v^2)$.

and CCA_t captures the effects of the Contraband Cigarette Act in one of two ways:

$CCA_t = \alpha_6 D79\_90_t \times TAXDIF_{st} + \alpha_7 D79\_90_t \times TAXDIF_{st}^2$ where D79_90 = 1 if the year is a year after 1978 (i.e., a year in which the Contraband Cigarette Act was in effect), 0 otherwise, or

[15] Part of the reason it is hard to measure accurately enforcement activities by state is that enforcement is undertaken by both state law enforcement and tax agencies. The relative importance of these agencies in enforcement activities varies from state to state (ACIR, 1977). See also the discussion in Maltz, Edelhurtz, and Chamberlain (1976, especially pages 23-24).

[16] We experimented with separate dummies for membership in IRRC and ESICTEG but results were poor.

$CCA_t = \Sigma_{j=1}^{12}\alpha_{j+5}D_{jt}\times TAXDIF_{st}$ where $D_{jt} = 1$ if the year is the jth year in which the Contraband Cigarette Act was in effect, 0 otherwise. That is, $D_{1t} = 1$ if the year is 1979, 0 otherwise, $D_{2t} = 1$ if the year is 1980, 0 otherwise, etc.

The first specification of the period in which the Contraband Cigarette Act was in effect imposes a quadratic structure on the time effects of the Act, while the second specification allows the effect to "freely" vary over the twelve year period. We shall refer to the first (second) model as the CCA-1 (CCA-2) model. If correct, the first specification is more efficient than the second; however, evidence presented in ACIR (1985) and given in private discussion to the authors suggests that enforcement activity varied substantially during the 80's. We shall return to this below.

In (12) interaction with TAXDIF is used so that the level of enforcement is zero if there is no incentive for firms to smuggle (TAXDIF = 0). It is expected that membership in IRRC or ESICTEG will increase the level of enforcement ($\alpha_3 > 0$) and that more severe penalties for smuggling will also have a positive effect on enforcement ($\alpha_4 > 0$). The effect of the passage of the Contraband Cigarette Act is generally considered to be an increase in the level of enforcement.

The above implies

(13)
$$\begin{aligned}\gamma_{st} = \exp\{ & (\delta_1+\delta_3\alpha_1)TAXDIF_{st} + (\delta_2+\delta_3\alpha_2)TAXDIF_{st}^2 \\ & + \delta_3\alpha_3 MEMB_i\times TAXDIF_{st} + \delta_3\alpha_4 FELONY_s\times TAXDIF_{st} \\ & + \delta_3\alpha_5 DISC_{st}\times TAXDIF_{st} + \delta_3 CCA_t + \delta_4 RP_{st}\times TAXDIF_{st} \\ & + w_{st}\times TAXDIF_{st} + \delta_3 v_{st}\times TAXDIF_{st}\} \\ \equiv & \exp(Z_{st}\phi + u_{st}\times TAXDIF_{st})\end{aligned}$$

where $u_{st} = w_{st} + \delta_3 v_{st}$ is distributed $N(0, \sigma_u^2)$ and $\sigma_u^2 = \sigma_w^2 + \delta_3^2\sigma_v^2$. Substituting $Q_{st} = L_{st}/\gamma_{it}$ and $Q_{st-1} = L_{st-1}/\gamma_{st-1}$ into (10) and taking logs gives

(14)
$$\begin{aligned}\ln L_{st} &= \delta_s + X_{st}\beta + \beta_8 \ln L_{st-1} + Z_{st}\phi - \beta_8 Z_{st-1}\phi + v_{st} \\ &= \delta_s + X_{st}\beta + \beta_8 \ln L_{st-1} + (Z_{st} - \beta_8 Z_{st-1})\phi + v_{st}\end{aligned}$$

where $$v_{st} = \varepsilon_{st} + u_{st} \times TAXDIF_{st} - \beta_8 u_{st-1} \times TAXDIF_{st-1} .$$

Note the non-linear restrictions among the coefficients of (14). An estimate of ϕ from estimation of (14), used in (13) and (11), provides estimates of the extent of commercial smuggling in each state.

Before proceeding to estimation, several points need to be made. First, the coefficients of (12), the enforcement equation, are not identified since they are each multiplied by δ_3, the coefficient of enforcement in the equation for γ, which is presumed positive. Second, the coefficient of $TAXDIF_{st}$ is the sum of a (presumed) positive, unidentified coefficient (δ_1), and the product of two positive, unidentified coefficients (δ_3 and α_1), hence $TAXDIF_{st}$'s coefficient cannot be signed *a priori*. Likewise, the coefficient of $TAXDIF_{st}^2$ is a combination of unidentified coefficients and cannot be signed. Finally, the variances σ_w^2 and σ_v^2 are not identified.

B. Data and Method of Estimation

We estimate (14) using annual data from 1972 - 1990 for 39 states plus the District of Columbia. Our data exclude observations on states with local government excise taxes (AL, IL, MO, NJ, NY, and TN) since the information needed to calculate an effective tax rate is unavailable (see also TJT). HI and AK are excluded since smuggling of cigarettes for these states may be of a distinctly different characteristic given the necessity of ocean travel or travel through Canada when hauling contraband cigarettes. Observations on NC, KY, and VA are excluded since they reportedly sources of commercially smuggled cigarettes. The data are a total of 760 observations (T=19 and N=40). In Table 2 are the mean values of per capita tax paid cigarette sales, price, and state tax levels (both in 1990 prices) for the 40 states in our sample for each of the 19 years.

It is well known that the usual fixed effects (within) estimator (that is, ordinary least squares, instrumental variables, generalized least squares, etc., estimators of (14) after differencing the data from its "time" means to remove individual effects δ_s) is inconsistent for fixed T (number of time periods) when the regressors are not all strictly exogenous. Strict exogeneity fails here because of the presence of the lagged dependent variable on the right hand side of (14). Hence the preferred approach is to estimate

(14) after quasi-differencing the data to remove individual effects (see Holtz-Eakin, Newey, and Rosen (1988) and Wooldridge (1991)). This view presumes large N and small (and fixed) T. In the present context, N is fixed (and fairly small) while T is not (at least conceptually) fixed though it is small. Hence any appeal to consistency *for either estimator* must reside on the notion that T can potentially increase without limit; thus neither the usual estimator or estimation after quasi-differencing would appear to dominate. We stick with the usual fixed effects estimator.

RP_{st} and Q_{st} (and hence L_{st}) are simultaneously determined so we use instrumental variables. In addition, we allow the possibility that γ_{st} and $ENFORCE_{st}$ are stochastic by including the disturbances w_{st} and v_{st}. If γ_{st} and/or $ENFORCE_{st}$ are indeed stochastic this implies that the disturbances in (14) are the sum of a heteroscedastic disturbance, ε_{st}, and a heteroscedastic MA(1) process, $u_{st} \times TAXDIF_{st} - \beta_8 u_{st-1} \times TAXDIF_{st-1}$. The implied disturbance variance and first order autocovariance in (14) are

(15) $$E(v_{st}^2) = \sigma_s^2 + (TAXDIF_{st}^2 + \beta_8^2 TAXDIF_{st-1}^2)\sigma_u^2$$

and

(16) $$E(v_{st}\, v_{st-1}) = -\beta_8 \sigma_u^2 TAXDIF_{st-1}^2.$$

All other elements of the covariance matrix are zero. Since the errors are correlated through time L_{st-1} and RP_{st-1} are not independent of the disturbance. To obtain consistent estimates of the parameters of (14) requires, in addition to an instrument for RP_{st}, instruments for L_{st-1} and RP_{st-1}. However, if $\sigma_u^2 = 0$ the problem with the endogeneity of L_{st-1} and RP_{st-1} disappears.

We begin estimation by testing for the presence of heteroscedasticity in (i) the u_{st} due to heteroscedasticity in the fraction of legal sales equation (13), and in (ii) the demand equation (10). We use a likelihood ratio test comparing the alternative model

(17) $$\hat{v}_{st}^2 = \sigma_s^2 + W_{it}\sigma_u^2 + e_{st}$$

against the null model

(18) $$\hat{v}_{st}^2 = \sigma^2 + e_{st}$$

where $W_{st} = (TAXDIF_{st}^2 + \hat{\beta}_8^2 TAXDIF_{st-1}^2)$.[17] and the $\hat{v}_{st}$ are the residuals and $\hat{\beta}_8$ is the estimate of β_8 from instrumental variables estimation of (14) using instruments for RP_{st}, RP_{st-1}, and L_{st-1}.

We test for heteroscedasticity using both definitions of CCA_t (models CCA-1 and CCA-2), and we estimate (14) both imposing and not imposing the non-linear restrictions among the coefficients. This gives a total of four tests. As instruments for both retail price and lagged legal sales we use their predicted value from regressions on the other right hand side variables in (14) as well as lagged income and two period lags of income and TAXDIF; the current, one-period lagged, and two-period lagged state cigarette tax rate; the current, one-period lagged, and two-period lagged manufacturer's price to wholesalers plus the federal excise tax rate; a dummy variable equal to one for the years when the federal excise tax was \$.16 and 0 for those years when it was \$.08; and an index of the wage rates of grocery store workers as well as the one and two-period lags of the index. The results of the four tests is a rejection of the null model (18) at any reasonable significance level: the largest p-value is 0.0001.

We then tested model (17) versus a model without fixed effects (that is, model (17) versus the null model $\hat{v}_{st}^2 = \sigma^2 + W_{st}\sigma_u^2 + e_{st}$), again using a likelihood ratio test. The null model is again rejected (the largest p-value is .00007) implying heteroscedasticity in the demand equation (10). Finally, we tested (17) versus the null model $\hat{v}_{st}^2 = \sigma_s^2 + e_{st}$ (that is, fixed effects only). We use Lagrange multiplier (LM) tests which are simply the tests for significance of the coefficient of W_{it} in (17).[18] The results are mixed. The p-values for Model CCA-1 are both larger than 0.32 while the p-values for CCA-2 are 0.062 and 0.161. Since results are mixed, we estimate the model without the restriction $\sigma_u^2=0$.[19]

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[17] This test is similar to the Lagrange multiplier tests suggested by Breusch and Pagan (1979) and White (1980). See also the discussion in Godfrey (1988, pp. 188-190) and references therein regarding application of heteroscedasticity tests in models with endogenous regressors.

[18] Note that the null value ($\sigma_u^2 = 0$) lies on the boundary of the parameter space; however, in this case, the LM statistic is still valid in large samples (Breusch and Pagan 1979).

[19] We also obtained estimates after imposing the restriction that the variance of u_{st} is zero. Not surprisingly, it makes almost no difference in the results for Model CCA-1.

The estimation method is generalized non-linear 2SLS (see, e.g., Amemiya, 1985, pp. 240-241).

IV. The Level of Smuggling and Enforcement Results

A. *Parameter Estimates*

Estimates of model (14), after imposing the non-linear restrictions among the coefficients, are found in Table 3. The naming of variables is done in an obvious shorthand. Only CAN is insignificant in both models. Of the remaining coefficients, only INDIAN has a sign that is counter to our intuition. Price and income elasticity magnitudes are appealing given the addictive nature of smoking. They tend to be lower than estimates reported elsewhere. Lewitt and Coate (1982) and Wasserman, *et. al.* (1990) review a number of prior studies and report that estimated price elasticities are in the range -.23 to -1.30.

Turning to the variables associated with γ_{st}, we first consider the null hypothesis that all coefficients of the variables in γ_{st} are jointly zero; that is, we test whether $\gamma_{st} = 1 \ \forall$ s and t. The p-values for each of the tests are very close to zero, hence we reject the hypothesis that all are jointly equal to zero. The coefficients of TAXDIF and TAXSQ are jointly significantly different from zero at standard significance levels for CCA-1 and are jointly significantly different from zero at the 17% level for CCA-2. Recall, however, that their coefficients are combinations of unidentifiable parameters and their signs are indeterminant, hence, significance or a lack of significance is a moot point. MEMB, FELONY, DISC and RP are significant only in Model CCA-2. In that model, the coefficient on membership in anti-smuggling organizations has, as expected, a positive effect on the proportion of legal sales, but the coefficients of FELONY and DISC have signs counter to our expectations.

Recall the quote given earlier attributing reductions in smuggling in the early 80's to passage of the Contraband Cigarette Act. Our estimates imply the contrary. Holding other factors constant, passage of the act is associated with a fall in the proportion of legal sales. Smuggling activity did appear to fall during the early 80's (see below), but not in response to passage of the Act. In Model CCA-1, the coefficient of the linear term (CCAxTAX) associated with the years 1979-92 is different from zero at standard significance levels, and the coefficient associated with the quadratic term is close to being significant at the 10% level (they are also jointly different from zero with a p-value very close to zero). The linear coefficient is negative and the quadratic coefficient is positive. The overall effect on the proportion of legal sales is negative; evaluated at mean regressor values for the period 1979-1990 (the non-zero values for the CCA term) the quadratic form is negative. Using a different dummy variable (interacted with TAXDIF) for each year the Act is in effect (CCA-2) shows a negative effect on γ_{st} for all years except for 1985 (for which the effect is positive but insignificant). For all other years except 1986-87, the estimated coefficients are significant at the 10% level. A joint test of whether all the coefficients of these variables are zero has a p-value close to zero.

What could account for this apparent, and counter-intuitive, effect of the passage of the Contraband Cigarette Act? If we accept the reasonable position that an increase in enforcement increases the proportion of legal sales, then we are left with the result that passage of the Act lowered enforcement. Several hypotheses are possible, but consider the following points. First, broadly speaking, enforcement activities are undertaken by two groups: law enforcement agencies and tax administrators. Testimony before the ACIR clearly indicated the importance of both groups for effective enforcement. The federal agency responsible for implementation of the Act, the Bureau of Alcohol, Tobacco, and Firearms (ATF), cannot supply the second type of enforcement since it is a law enforcement agency. Its personnel are not tax auditors, and they are allowed to examine records of suspected smugglers only by court order. Second, the ACIR (1985) expressed concerns ".. that some states are using federal actions to justify reducing their role in enforcing cigarette tax laws." The ACIR concluded that state enforcement efforts were reduced after the CCA because both the presence of the federal government in enforcement and the perception that smuggling was lower reduced the returns to state enforcement efforts. Third, beginning in 1980, the federal government began attempts to reduce or eliminate funds appropriated for enforcement of the Contraband Cigarette Act (see ACIR, 1985). We were told by state tax administrators that the ATF currently does not allocate any efforts toward enforcement. The smuggling problem is believed to have disappeared and the states have been told that the ATF will reinstate enforcement efforts if the states feel smuggling has again become a problem. Finally, these administrators claim that, by and large, cigarette smuggling is not detectable unless an agency is actively looking for smuggling .

Based on the above we hypothesize the following as an explanation of the adverse effect of passage of the Contraband Cigarette Act. Many states reduced enforcement activity because of the presence of federal enforcement activities. The ATF, being only a law enforcement agency, and not an agency of tax auditors, is less effective per dollar spent on enforcement than are the states which have both law enforcement and tax auditing capabilities. Beginning before passage of the Act, smuggling activity had been declining and continued to decline after a jump in 1979 (we turn to this below) leaving the impression that the ATF was indeed quite effective. With the impression that smuggling was disappearing, the states did not search for smugglers, and hence were not in a position to determine the adverse effects of the Act.

B. Level of Smuggling and Revenue Effects

Estimates of the parameters of the γ_{st} function permit estimation of the level of commercial smuggling. Estimates are presented in Table 4 under two scenarios. In the first we estimate commercial smuggling implied by Models CCA-1 and CCA-2 (the "With CCA" columns of Table 4). We then re-estimate smuggling assuming that the Contraband Cigarette Act was never passed. In the latter experiment we set to zero all variables associated with the Act for all years rather than just the years prior to 1979 (the "Without CCA" columns of Table 4); that is, $CCA_t = 0 \; \forall \; t$. The columns titled "%Smug" in Table 4 give the average values of the percent of total sales ($100 \times (1 - \gamma_{st})$) commercially smuggled into the 40 states in our sample for each of the 19 years. Presented also are the estimated standard errors for these averages (columns "SE"). The standard errors are based upon the standard errors for the estimated γ parameters. Asymptotic statistical theory suggests normality of the estimated γs. Also presented are the average per capita packs of cigarettes smuggled in the 40 states (columns Smug). For some states and time periods the value of γ is greater than one implying no smuggling. The columns "%Smug" are based on the estimated value of γ regardless of whether or not it is above or below one; this allows for a correct estimated variance. However, the columns "Smug" are calculated by setting to one any value of γ in excess of one. This change is relevant for Model CCA-2 for which about 20% of the estimated γs are greater than one.

Smuggling activity was generally declining from 1972 until 1979 when it takes a jump before continuing its downward trend before turning up in the late 80's. In the absence of the Contraband Cigarette Act there would not have been a jump in 1979. Model CCA-1 (Model CCA-2) implies that smuggling was higher in 1979 by about two (one) packs of cigarettes per capita due to changes following passage of the Act. Note in Model CCA-2 that estimates of the percent smuggled are not significantly different from zero in years 1985 and 1986.

In Table 5 are presented revenues as well as revenue losses for the 19 years in our sample. Here again we set to one any value of γ in excess of one. "Revenue Received" is the total revenue received by the states in our sample. "Revenue Lost" is the amount that would have been received in the absence of organized smuggling. "Ratio" is the ratio of Revenue Lost to the sum of Revenue Lost and Revenue Received. We also compute the values in the absence of the Contraband Cigarette Act. The implied aggregate revenue losses for the period 1979 - 1990 due to reduced enforcement after passage of the Act is $828 million and $1,103 million for Models CCA-1 and CCA-2.

Are the smuggling numbers reported in Tables 4 and 5 reasonable? In the 1985 ACIR report it is claimed that cigarette tax evasion had declined 45% between 1975 and 1985. Our estimates of the decline in smuggling based on Models CCA-1 and CCA-2 (using columns Smug) are 28% and 49%, respectively. The number reported by the ACIR includes all forms of smuggling for all states while ours is an estimate of the decline in organized smuggling for the 40 states in our sample. On the revenue side, the 1977 ACIR report claims a loss in 1976 of $900 million (using in 1990 dollars) in tax revenues from all forms of cigarette smuggling. Their figure includes gains to those states that attract consumers from neighboring states. Our estimate of the loss from organized smuggling is $635 million and $278 million for Models CCA-1 and CCA-2, respectively. If all contiguous states except KY, NC, and VA are included, our estimates of the losses are $865 million and $313 million for Models CCA-1 and CCA-2, respectively. These last figures, of course, do not include losses on local cigarette taxes.

V. Nonconstant Elasticity Models

Wasserman, *et. al.*, report evidence suggesting non-constant price and income elasticities of demand for cigarettes. Their regressions use not only income and the log of price, but also those variables interacted with a time trend.[20] We alter our empirical models by introducing the interaction of the time trend with the logs of price and income. We refer to these new models as CCA-1t and CCA-2t. The regression results are in Table 6. Wasserman, *et. al.*, found that the estimated income elasticity of demand went from positive and significantly different from zero in 1970 to negative and insignificant in 1988. They further report that consumers became more sensitive to price as time passed. Both Models CCA-1t and CCA-2t imply a falling income elasticity of demand. However, the evidence in the two models concerning the price elasticity of demand is contradictory. Table 7 gives the elasticity by year and model along with the standard error for the elasticity (columns "SE"). In every case the price and income elasticities of demand are significantly different for zero at commonly used significance levels.

Note that the coefficients of TREND in both CCA-1t and CCA-2t are positive (though only marginally significant in CCA-1t). This implies that, holding constant other factors that influence cigarette consumption and allowing for nonconstant price and income elasticities, cigarette consumption has been increasing over time. This effect is counter to commonly held beliefs about changing cigarette habits.

Tables 8 and 9 report the smuggling and revenue effects of smuggling for the models with trending elasticities. The evidence on smuggling and its revenue effects are very similar to that observed with the earlier models. In particular, there is a jump in smuggling associated with the passage of the Contraband Cigarette Act.

VI. Federal Excise Taxes and Smuggling

It has been proposed by the Clinton administration (and others) that the federal excise tax on cigarettes be raised from the current 24 cents per pack to anywhere from 50 cents to $2. The purpose is not only to raise federal revenues but also to discourage cigarette smoking.

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[20] Note, however, that Laughunn and Lyon (1971) report no such interaction effects.

What effect might these proposed increases have on commercial smuggling? In the development of the theoretical model we showed that the federal tax affects smuggling only indirectly through its effects on equilibrium sales. With the exception of linear demand, an increase in the federal tax has an ambiguous effect on the level of organized smuggling. In our empirical model this tax is embedded (enters) in the retail price term which appears both in the demand equation (10) and the legal sales equation (12). An increase in the excise tax, all else equal, will increase price, hence an analysis of changes in smuggling pre and post 1983, the only year in our sample in which the federal excise tax was changed, might shed light on the effects of federal taxes on organized smuggling. Unfortunately, we are unable, with the model as expressed above, to separate changes in retail price due to, say, shifts in labor costs, from changes due to excise tax changes. To remedy this we re-estimate (14) after introducing the federal excise tax directly into the γ function (12). This allows us to measure the effect on the level of legal sales of a change in excise tax, holding constant retail price. The fact that we now introduce the excise tax as well as retail price does not imply misspecification in the models estimated earlier. This follows from the fact that the excise taxes were included in our earlier models, *albeit* indirectly. Note that we cannot simply enter the excise tax as one regressor and the difference between the retail price and the excise tax since, in general, only a portion of the tax will appear in the price term.

Models CCA-1, CCA-2, CCA-1t, and CCA-2t were reestimated after introducing the level of the federal excise tax into the γ function. In every case the coefficient of the federal excise tax was negative and significant implying decreases in the proportion of legal sales with increases in the federal excise tax. While federal tax collections might well rise, state collections will fall. The implied elasticities of γ with respect to the federal excise tax ranged from -.031 to -.076. We continue to find that passage of the Contraband Cigarette Act is associated with an increase in smuggling.

Although our estimate of γ_{st} differs somewhat from its theoretical analog, the theory is useful for understanding why γ_{st} might decrease with an increase in the federal tax. Recall that $\gamma_{st} = [\gamma_1{}^*N_1q_1{}^* + N_2q_2{}^*]/[N_1q_1{}^* + N_2q_2{}^*]$. Since the sign of $\partial q_i{}^*/\partial T_f$ is ambiguous, any empirical result is consistent with the theory. However, if demand is linear or not too convex, $\partial q_i{}^*/\partial T_f < 0$ for i = 1,2. This is the intuitively expected result since an increase in the federal tax increases per unit cost of both smuggled and legal units sold. In this case, γ_{st} will decrease for N_i fixed, if the response of a legal trader is greater than that of a smuggler. Although it is not included in our theoretical model, an increase in the federal tax may induce firms to exit, in which case γ_{st} is more likely to decrease if N_2 decreases more than N_1.

VII. Concluding Remarks

In this paper we develop a theoretical and empirical model that permits estimation of the level of organized smuggling of cigarettes out of the low-tax and cigarette producing states NC, KY, and VA. The level of smuggling, as well as the generally decreasing trend in that level, accords well with evidence presented in the 1977 and 1985 ACIR reports. We find two important policy results. First, passage of the federal Contraband Cigarette Act did not deter smuggling, as has been claimed. Those who have claimed success for the Act interpreted the general decline in cigarette smuggling from levels in the 70's to much lower levels in the 80's as evidence of its success. We find, however, that the decline was not due to passage of the Act. Rather, it followed from generally decreasing real levels of state tax differentials. In every model we estimate we find an increase in smuggling following passage of the Act; this increase is then followed by a continuation of the downward trend in cigarette smuggling.

Second, we find that increases in the federal excise tax are associated with a greater proportion of smuggled cigarettes. Proposed increases in the excise tax may well operate, as hoped, to raise federal tax revenues and lower the level of cigarette smoking, but it will also serve to increase the proportion of smuggled cigarettes and thereby reduce state revenues. This result has not been anticipated by government officials or previous studies of smuggling. Officials are clearly aware that changes in the federal tax could affect consumers smuggling across the Canadian and Mexican borders, but our results come from examining commerical smuggling. Since previous studies have tended to focus on smuggling by consumers, the effects we find have been unnoticed.

Table 1: Per Capita Tax Paid Sales in the U.S. and Out-Smuggling States*

Year	Ky	NC	VA	Mean U.S.
1965	129	NA	123	127
1970	156	172	124	118
1975	223	226	153	131
1978	225	206	156	134
1980	215	188	149	133
1985	182	156	135	122
1990	183	134	119	104

* Data are from The Tobacco Institute (1990).

Table 2: Per Capita Tax Paid Sales, Average Price, and Average Tax

Year	Per Capita Tax Paid Sales	Price	Tax
1972	128.4	1.261	0.313
1973	129.8	1.225	0.301
1974	132.0	1.179	0.275
1975	133.1	1.166	0.261
1976	135.8	1.132	0.251
1977	135.2	1.185	0.243
1978	134.8	1.146	0.226
1979	132.8	1.084	0.207
1980	133.0	1.005	0.184
1981	133.4	1.011	0.172
1982	131.2	1.108	0.175
1983	126.0	1.226	0.186
1984	120.4	1.241	0.181
1985	118.7	1.274	0.189
1986	116.0	1.336	0.196
1987	113.2	1.395	0.212
1988	109.1	1.464	0.208
1989	104.8	1.532	0.219
1990	99.9	1.535	0.218

Table 3: Models CCA-1 and CCA-2

	CCA-1		CCA-2	
	Coef	t-Ratio	Coef	t-Ratio
Demand Parameters				
lnRP	-0.0700	-4.3806	-0.2581	-7.6610
lnINC	0.0687	3.9518	0.1089	5.1118
TREND	-0.0048	-13.2096	-0.0051	-7.2775
ln(AVRP/RP)	0.0296	1.0286	0.1492	3.6590
lnLAGSALES	0.8434	36.2553	0.4597	12.5385
CAN	0.0044	0.6313	-0.0101	-1.1596
INDIAN	0.0069	4.3364	0.0149	7.4890
MILTARY	-0.0068	-1.6361	-0.0104	-2.1939
Fraction Legal Sales Parameters				
TAXDIF	-0.4625	-3.1696	-0.2730	-1.5156
TAXSQ	-0.3510	-1.5649	-0.4030	-1.5064
MEMB	-0.0104	-0.1375	0.3717	9.4536
FELONY	-0.0608	-0.8762	-0.2894	-7.3663
DISC	0.0097	1.0566	-0.0294	-5.2880
RP	0.1502	1.3450	0.2962	1.6768
CCAxTAX	-0.1470	-2.5795		
CCAxTAXSQ	0.3189	1.6162		
D79			-0.0533	-2.6597
D80			-0.0951	-1.7242
D81			-0.2051	-3.0574
D82			-0.1843	-3.1820
D83			-0.1379	-2.4843
D84			-0.1572	-2.5983
D85			0.0266	0.4478
D86			-0.0268	-0.4069
D87			-0.0511	-0.6886
D88			-0.1617	-1.9621
D89			-0.2890	-3.0039
D90			-0.4272	-4.0809
R-Square	0.9240		0.8880	

Table 4: Smuggling Estimates

	With CCA			Without CCA		
Year	%Smug	SE	Smug	%Smug	Se	Smug
Model CCA-1						
1972	9.18	0.337	14.50	9.18	0.337	14.50
1973	9.36	0.326	14.89	9.36	0.326	14.89
1974	8.70	0.316	13.91	8.70	0.316	13.91
1975	8.04	0.303	12.59	8.04	0.303	12.59
1976	7.81	0.300	12.26	7.81	0.300	12.26
1977	7.60	0.284	11.90	7.60	0.284	11.90
1978	7.23	0.273	11.44	7.23	0.273	11.44
1979	8.03	0.257	12.37	6.62	0.256	10.25
1980	7.49	0.242	11.47	6.09	0.239	9.34
1981	7.02	0.230	10.64	5.64	0.225	8.56
1982	6.85	0.225	10.16	5.47	0.220	8.12
1983	6.85	0.228	9.82	5.48	0.220	7.85
1984	6.91	0.236	9.13	5.52	0.226	7.26
1985	6.81	0.236	8.90	5.41	0.226	7.05
1986	7.05	0.247	8.81	5.65	0.238	6.99
1987	7.03	0.251	8.50	5.64	0.243	6.73
1988	7.34	0.265	8.50	5.94	0.258	6.81
1989	7.23	0.274	8.68	5.82	0.266	6.97
1990	7.26	0.284	8.50	5.89	0.279	6.93
Model CCA-2						
1972	4.02	0.427	6.73	4.02	0.427	6.73
1973	4.08	0.403	6.72	4.08	0.403	6.72
1974	4.20	0.371	6.65	4.20	0.371	6.65
1975	3.90	0.354	6.12	3.90	0.354	6.12
1976	3.49	0.356	5.76	3.49	0.356	5.76
1977	3.07	0.342	5.21	3.07	0.342	5.21
1978	2.19	0.343	4.27	2.19	0.343	4.27
1979	3.11	0.297	4.86	2.06	0.311	3.84
1980	3.68	0.288	5.29	2.00	0.285	3.60
1981	5.04	0.269	6.72	1.74	0.267	3.18
1982	4.48	0.244	5.81	1.53	0.267	2.81
1983	3.10	0.243	4.12	0.80	0.291	2.01
1984	2.91	0.253	3.66	0.17	0.323	1.44
1985	-0.38	0.267	1.05	0.09	0.327	1.36
1986	0.46	0.261	1.59	-0.04	0.355	1.27
1987	0.69	0.274	1.65	-0.28	0.372	1.07
1988	2.56	0.273	2.98	-0.66	0.410	0.84
1989	4.71	0.280	5.38	-0.99	0.438	1.11
1990	7.29	0.279	8.15	-1.23	0.477	1.11

Table 5: Revenue Effects

Year	Revenue Received	With CCA Revenue Lost	With CCA Ratio	Without CCA Revenue Lost	Without CCA Ratio
Model CCA-1					
1972	7081630	966922	0.120	966922	0.120
1973	7005291	963137	0.121	963137	0.121
1974	6547196	808564	0.110	808564	0.110
1975	6053877	670962	0.100	670962	0.100
1976	5980019	635098	0.096	635098	0.096
1977	5677877	580740	0.093	580740	0.093
1978	5583805	542258	0.089	542258	0.089
1979	5019042	525778	0.095	442171	0.081
1980	4560397	439758	0.088	362689	0.074
1981	4216295	376256	0.082	305711	0.068
1982	4094050	352614	0.079	284306	0.065
1983	4113346	360596	0.081	291654	0.066
1984	3960401	338867	0.079	272930	0.064
1985	3889966	327394	0.078	262954	0.063
1986	3954004	336542	0.078	270732	0.064
1987	3882539	328943	0.078	264513	0.064
1988	3943635	352056	0.082	287163	0.068
1989	4034206	369842	0.084	301186	0.069
1990	4030457	396845	0.090	331052	0.076
Model CCA-2					
1972	7081630	426830	0.057	426830	0.057
1973	7005291	411377	0.055	411377	0.055
1974	6547196	366940	0.053	366940	0.053
1975	6053877	310686	0.049	310686	0.049
1976	5980019	278362	0.044	278362	0.044
1977	5677877	236602	0.040	236602	0.040
1978	5583805	183821	0.032	183821	0.032
1979	5019042	190060	0.036	149788	0.029
1980	4560397	187928	0.040	127674	0.027
1981	4216295	220937	0.050	103201	0.024
1982	4094050	189336	0.044	90015	0.022
1983	4113346	141909	0.033	66514	0.016
1984	3960401	124663	0.031	46388	0.012
1985	3889966	33976	0.009	44377	0.011
1986	3954004	56479	0.014	44826	0.011
1987	3882539	58689	0.015	37321	0.010
1988	3943635	117038	0.029	30947	0.008
1989	4034206	229693	0.054	46906	0.011
1990	4030457	403837	0.091	63805	0.016

Table 6: Models CCA-1t and CCA-2t

	Coef	t-ratio	Coef	t-ratio
Demand Parameters				
lnRP	-0.0523	-1.7300	-0.3442	-6.4845
t*lnRP	-0.0043	-2.0064	0.0126	3.1521
lnINC	0.1665	5.1201	0.2882	8.3356
t*lnINC	-0.0040	-2.7050	-0.0128	-8.1539
TREND	0.0057	1.5856	0.0246	6.3777
ln(AVRP/RP)	0.0837	2.5287	0.1862	5.0073
lnLAGSALES	0.7788	25.5725	0.5416	15.1428
CAN	0.0005	0.0718	-0.0214	-2.5170
INDIAN	0.0092	5.2346	0.0169	7.8514
MILITARY	-0.0057	-1.3215	-0.0050	-1.1377
Fraction Legal Sales Parameters				
TAXDIF	-0.5523	-3.5632	-0.6003	-3.2178
TAXSQ	-0.5838	-2.6004	0.1012	0.3576
MEMB	-0.0242	-0.3341	0.1461	3.2422
FELONY	-0.1054	-1.5920	-0.3062	-7.5554
DSCNT	0.0094	1.0731	-0.0012	-0.2129
RP	0.3069	2.5495	0.3195	1.8057
CCA*TAX	-0.1595	-2.7625		
CCA*TAXSQ	0.3736	1.8635		
D79			-0.0613	-3.0713
D80			-0.0388	-0.5885
D81			-0.0952	-1.2559
D82			-0.0816	-1.2809
D83			-0.0630	-1.0268
D84			-0.0983	-1.4510
D85			0.1399	2.1081
D86			0.0249	0.3332
D87			0.0136	0.1514
D88			-0.0977	-0.9525
D89			-0.2551	-1.9680
D90			-0.4490	-3.0127
R-Square	0.9235		0.9122	

Table 7: Price and Income Elasticity Estimates: Models CCA-1t and CCA-2t

Year	Price Elas.	(SE)	Income Elas.	(SE)
Model CCA-1t				
1972	-0.0566	(0.0287)	0.1625	(0.0313)
1973	-0.0609	(0.0272)	0.1585	(0.0301)
1974	-0.0652	(0.0257)	0.1545	(0.0289)
1975	-0.0695	(0.0244)	0.1505	(0.0277)
1976	-0.0738	(0.0232)	0.1465	(0.0266)
1977	-0.0781	(0.0222)	0.1425	(0.0255)
1978	-0.0824	(0.0213)	0.1385	(0.0244)
1979	-0.0867	(0.0206)	0.1345	(0.0234)
1980	-0.0910	(0.0200)	0.1305	(0.0224)
1981	-0.0953	(0.0197)	0.1265	(0.0215)
1982	-0.0996	(0.0197)	0.1225	(0.0207)
1983	-0.1039	(0.0198)	0.1185	(0.0199)
1984	-0.1082	(0.0202)	0.1145	(0.0192)
1985	-0.1125	(0.0208)	0.1105	(0.0187)
1986	-0.1168	(0.0215)	0.1065	(0.0182)
1987	-0.1211	(0.0225)	0.1025	(0.0178)
1988	-0.1254	(0.0236)	0.0985	(0.0175)
1989	-0.1297	(0.0248)	0.0945	(0.0174)
1990	-0.1340	(0.0262)	0.0905	(0.0174)
Model CCA-2t				
1972	-0.3316	(0.0499)	0.2754	(0.0333)
1973	-0.3190	(0.0469)	0.2626	(0.0320)
1974	-0.3064	(0.0440)	0.2498	(0.0307)
1975	-0.2938	(0.0412)	0.2370	(0.0295)
1976	-0.2812	(0.0388)	0.2242	(0.0283)
1977	-0.2686	(0.0366)	0.2114	(0.0271)
1978	-0.2560	(0.0347)	0.1986	(0.0260)
1979	-0.2434	(0.0332)	0.1858	(0.0250)
1980	-0.2308	(0.0322)	0.1730	(0.0239)
1981	-0.2182	(0.0316)	0.1602	(0.0230)
1982	-0.2056	(0.0315)	0.1474	(0.0221)
1983	-0.1930	(0.0319)	0.1346	(0.0213)
1984	-0.1804	(0.0328)	0.1218	(0.0206)
1985	-0.1678	(0.0341)	0.1090	(0.0200)
1986	-0.1552	(0.0359)	0.0962	(0.0195)
1987	-0.1426	(0.0380)	0.0834	(0.0191)
1988	-0.1300	(0.0403)	0.0706	(0.0188)
1989	-0.1174	(0.0430)	0.0578	(0.0187)
1990	-0.1048	(0.0458)	0.0450	(0.0187)

Table 8: Smuggling Estimates

	With CCA			Without CCA		
Year	%Smug	SE	Smug	%Smug	Se	Smug
Model CCA-1t						
1972	8.41	0.357	13.72	8.41	0.357	13.72
1973	8.82	0.342	14.48	8.82	0.342	14.48
1974	8.39	0.327	13.80	8.39	0.327	13.80
1975	7.72	0.312	12.40	7.72	0.312	12.40
1976	7.39	0.309	11.89	7.39	0.309	11.89
1977	7.28	0.293	11.71	7.28	0.293	11.71
1978	6.74	0.282	10.91	6.74	0.282	10.91
1979	7.72	0.262	12.06	6.29	0.262	9.96
1980	7.34	0.246	11.44	5.91	0.244	9.30
1981	6.94	0.234	10.70	5.52	0.230	8.58
1982	6.66	0.230	10.04	5.24	0.225	7.95
1983	6.37	0.234	9.24	4.95	0.227	7.24
1984	6.15	0.244	8.24	4.71	0.235	6.35
1985	5.98	0.245	7.94	4.54	0.235	6.07
1986	6.06	0.257	7.66	4.63	0.250	5.83
1987	5.92	0.263	7.26	4.49	0.255	5.49
1988	6.04	0.278	7.11	4.62	0.273	5.43
1989	5.75	0.289	7.14	4.32	0.283	5.45
1990	5.58	0.302	6.73	4.19	0.298	5.21
Model CCA-1t						
1972	4.01	0.430	6.69	4.01	0.430	6.69
1973	4.61	0.400	7.24	4.61	0.400	7.24
1974	5.13	0.362	7.74	5.13	0.362	7.74
1975	5.04	0.343	7.52	5.04	0.343	7.52
1976	4.75	0.344	7.20	4.75	0.344	7.20
1977	4.87	0.327	7.38	4.87	0.327	7.38
1978	4.41	0.325	6.66	4.41	0.325	6.66
1979	5.66	0.282	8.42	4.48	0.295	6.61
1980	5.20	0.290	7.76	4.53	0.270	6.73
1981	5.89	0.268	8.77	4.39	0.253	6.47
1982	5.42	0.237	7.88	4.15	0.253	5.98
1983	4.67	0.240	6.48	3.65	0.272	5.03
1984	4.87	0.256	6.28	3.20	0.301	4.12
1985	0.65	0.280	1.66	3.06	0.305	3.91
1986	2.42	0.276	3.16	2.88	0.332	3.60
1987	2.41	0.313	3.03	2.66	0.348	3.26
1988	4.31	0.334	4.87	2.41	0.384	3.01
1989	7.03	0.382	8.77	2.15	0.410	3.31
1990	10.51	0.415	13.17	1.87	0.447	3.05

Table 9: Revenue Effects

		With CCA		Without CCA	
Year	Revenue Received	Revenue Lost	Ratio	Revenue Lost	Ratio
Model CCA-1t					
1972	7081630	917964	0.115	917964	0.115
1973	7005291	941067	0.118	941067	0.118
1974	6547196	805636	0.110	805636	0.110
1975	6053877	663137	0.099	663137	0.099
1976	5980019	617870	0.094	617870	0.094
1977	5677877	573191	0.092	573191	0.092
1978	5583805	519409	0.085	519409	0.085
1979	5019042	512187	0.093	431218	0.079
1980	4560397	438493	0.088	361714	0.073
1981	4216295	377832	0.082	306428	0.068
1982	4094050	347499	0.078	278201	0.064
1983	4113346	339216	0.076	269970	0.062
1984	3960401	305554	0.072	239610	0.057
1985	3889966	291054	0.070	226665	0.055
1986	3954004	291740	0.069	226428	0.054
1987	3882539	279180	0.067	215462	0.053
1988	3943635	291589	0.069	228448	0.055
1989	4034206	302374	0.070	235502	0.055
1990	4030457	314988	0.072	252761	0.059
Model CCA-2t					
1972	7081630	368813	0.050	368813	0.050
1973	7005291	399407	0.054	399407	0.054
1974	6547196	393214	0.057	393214	0.057
1975	6053877	355623	0.055	355623	0.055
1976	5980019	325091	0.052	325091	0.052
1977	5677877	318540	0.053	318540	0.053
1978	5583805	273812	0.047	273812	0.047
1979	5019042	328730	0.061	251334	0.048
1980	4560397	275287	0.057	235632	0.049
1981	4216295	292309	0.065	210173	0.047
1982	4094050	257812	0.059	191381	0.045
1983	4113346	225672	0.052	172141	0.040
1984	3960401	219571	0.053	139236	0.034
1985	3889966	50634	0.013	130674	0.033
1986	3954004	108155	0.027	124554	0.031
1987	3882539	102754	0.026	111247	0.028
1988	3943635	183526	0.044	109087	0.027
1989	4034206	366099	0.083	135674	0.033
1990	4030457	626096	0.134	153005	0.037

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