Crime in Sweden:
Causality, Control Effects and Economic Efficiency

by

Harold L. Votey, Jr.*

INTRODUCTION

This paper reports on an econometric analysis of social and economic factors thought to influence crime and the effects of resources applied by the Swedish authorities to control it. An important aspect of the analysis is a test of whether law enforcement resources are allocated in accordance with rules that will yield economic efficiency across communities and crime categories. Crime is viewed both in the aggregate and broken down by broad offense categories: personal crimes, crimes against property, and motoring offenses. The data base for the analysis is a cross-section of 24 Swedish counties for the years 1975 through 1978. Modeling is similar to previous studies evaluating variation in deterrence or control effects that stem from variations in conviction probabilities and penalties. That approach has been criticized, most notably by Blumstein, et al. (1978), for a number of reasons. The empirical validity of some of their criticisms are subject to test. This study, in addition to providing a test of efficiency and an entirely new data base for comparison with earlier results for the U.S., thus provides an opportunity to evaluate those criticisms in the light of new data.

This study has the added advantage that it can test hypotheses about the effects of potential causal variables that typically haven't been included in U.S. studies, in part because

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beliefs that such variables are causally important may be held more strongly in Sweden than in the U.S. and in part because the Swedish penchant for recording such data in a systematic and easily accessible fashion is greater than that in the U.S. Social and economic factors that are investigated for crime-inducing effects are broken family relationships, alien population, and alcohol consumption levels, as well as lack of employment opportunities. Highway accidents, an outcome of motoring offenses, are perceived to stem from the level of driving, traffic density, and other factors reflecting the driving environment as well as from such illegal behavior as drunken driving.

Econometric results lend support to economic decision theory and neoclassical criminological theory predicting that criminal behavior will be deterred by the threat of sanctions. These results are consistent with an earlier aggregate time series study of Sweden by the author investigating similar effects at the national level. Acknowledging the criticisms of deterrence studies by Blumstein _et al_., (1978) one cannot claim that these results establish unambiguous evidence of a deterrence effect, however, they provide strong evidence of a control effect, a necessary condition for the establishment of the cost effective crime control efforts.

THE DATA

As noted, the data are comprised of annual information on 24 Swedish counties (län) for the years 1975 through 1978. All data have been provided by national collecting sources. Most are published or provided by the National Central Bureau of Statistics although some come directly from the responsible agency, as for example, alcohol consumption data have been provided, in part, by the Alcohol Bureau. Virtually all data that are compiled about individuals, even though aggregated, are based on national files where the unit of observation is the individual and where the data may be aggregated over county (län), municipality (kommun) or police district (polisdistrikt). Individual data of different categories, e.g., income, education, birth, marriage, accident, and health data are linked for an individual by a personnumber issued at birth. The aggregation is conducted with centralized computer facilities which, in theory, make it possible to have a complete file on all aspects of an individual's life from birth. In practice, the files are strictly segregated and extreme care is used to protect the privacy of information for individuals. The system can, however, yield highly accurate aggregate data on any desired level. Considerable care is taken to see that reporting is uniform across the country, since the collection and processing of any one class of data is done centrally by persons employed by the state rather than the local community. In general, local community preferences don't enter separately into decisions about how carefully or completely data shall be collected. In Sweden, careful data tabulation has been the rule for much annual economic data for more than a century and birth, death, and marriage records go back to the early 1700's. Thus, the data for this study are probably as accurate a representation of the nature of a particular community or county as could be produced in any country.

An alleged problem with much crime data has been that it may vary in quality across jurisdictions. This is less likely to be true in Sweden than in the U.S. because the police are organized, trained, and assigned at the national level. This does not mean that there are no local differences, but these tend to be minimized because transfers between communities are possible and standards and training are uniform across police districts. Some kinds of training are conducted at the national level. The criminal code does not vary across districts and judicial appointments are not a local decision. Corrections is largely a matter for the national authorities as well. Thus, the kinds of problems that worry researchers when using cross-section data in the U.S. particularly across states are not a matter of concern with Swedish data.

Swedish crime data and behavior are of particular interest because of a number of similarities with the U.S. Police procedures in Sweden follow a pattern very similar to that in the U.S. Sweden has tended to emulate U.S. criminal justice and law enforcement procedures to a considerable degree. For example, police are normally armed as they are in the U.S., they use virtually the same technology for patrol, communications, detection, and also corrections procedures are very similar. While Swedish law has evolved more from Roman law, with nothing like the English common law tradition that is the basis for U.S. law, this appears to have little impact in creating differences in the likelihood of conviction, or the nature of sentencing. Although the decision on what to record as a crime may vary somewhat between Sweden and the U.S., the uniformity of that decision across jurisdictions in Sweden is likely to be high.

Sweden is, of course, very similar to the U.S. in terms of average living standards, educational techniques and levels, health care, and attitudes toward work and leisure. Consequently, it provides an ideal for comparison with U.S. studies with the likely advantage of providing a more uniformly high quality of data for statistical evaluation that can be found elsewhere. This is not to say that Swedish crime data is without flaws. Sweden has a considerable amount of unreported crime just as in the U.S. and with less independent survey information on which to base estimates of the extent of underreporting. There is no reason to believe, however, that this problem is greater than in the U.S., nor that patterns of crime have changed over the time period or across jurisdictions of this study. Thus the Swedish data provide an ideal candidate for evaluation.

One characteristic of Sweden that differs from the U.S. is that of density of population. Sweden is a sparsely populated country, largely still involved in agriculture, forestry, or fisheries over much of the land area, with manufacturing concentrated in a few urban locations of modest size. There are only three cities greater than 240,000 population, Stockholm, Göteborg and Malmö. Crime in Sweden, as in the U.S., tends to be an urban phenomenon, but Sweden's urban areas are minimal and most of the country corresponds more in terms of population distribution to the rural U.S. This may have some bearing on why violent crime rates, on the average, tend to be lower in Sweden than in the U.S. The distribution of cities by size is shown in Table I. A comparison of typical Swedish and U.S. crime variables is

presented in Table II. In general, crime levels and their rates of growth are lower in Sweden than in the U.S. with the exception of reported property offenses. The fact that the latter are higher in Sweden could be a consequence of differences in the level of unreported crime or differences in police recording of offenses. There is no way to evaluate either possibilities.

TABLE I. Distribution of Municipalities by Size

Population	Number
≥= 500,00	1
250,000-499,999	1
150,000-249,999	1
100,000-149,999	8
50,000-99,999	23
25,000-49,999	61
0-24,999	178

Source: Statistisk Årsbok 1977

Another characteristic of Sweden recommends cross-section analysis using the county (län) as the unit of observation. Not only is income distributed quite uniformly across the Swedish population relative to that of most countries, the population is distributed geographically in such a manner as to minimize the likelihood of statistical problems associated with spillover effects. Examination of the dispersal of population with regard to urban clustering and county boundaries suggests that, since crime tends to be an urban phenomenon it will tend to focus inwards away from county boundaries rather than move across county boundaries. That is, if one would think of setting up a gravity model to explain crime based on the populations associated with denser, urban populations, one would expect to get the

TABLE II: Comparative Crime Statistics for Sweden and the U.S. - 1977

Country	Offenses	Crime Mix %	Rate per 100,000 pop.	Offenses 1968-77	Growth Reported Clearance Ratio %
Sweden					
	Violent	5.5	380.2	36.4	36
	(Homicide)	(0.6)	(4.8)	(73.8)	(56)
	Property	90.6	6320.8	55.8	15
	Drunken Driving	3.9	269.4	39.3	-
		100.0			
United States					
	Violent[1]	8.3	466.6	56.4	51.2
	(Homicide)	(.16)	(8.8)	(38.6)	(75.5)
	Property[2]	81.3	4588.4	62.1	18.9
	Drunken Driving	10.4	585.4	110.2	-
		100.0			

Sources: Sweden - Rättsstatistisk årsbok 1978
U.S. - FBI - Uniform Crime Reports 1977

[1]These include murder, forcible rape, robbery and aggravated assault.

[2]These include burglary, larceny-theft, and motor vehicle theft.

same distribution of crime as if county boundaries defined the population borders. This, at least, would be the conclusion from analyzing population dispersal by county and major cities, noting the distance from population centers to county borders and to the next adjacent population center in contiguous counties. The data to do so are presented in Table III. Examination of the distribution of population county by county shows that on the average 47.3 percent of the population resides in an urban area central to the county, averaging 36.8 km. from the county border and 84.6 km. from the closest urban area of more than 15,000 population in the next adjacent county. No major cities lie close to county borders. Thus, while one would expect what is known in the trade literature as cross-hauling along borders, there is no reason to expect any systematic flow of criminals residing in one county and committing crimes in another. Casual inquiry suggests that the National Police believe spillovers are negligible, as would be expected based on U.S. studies in which spillover tend to be limited largely to traffic between closely proximate urban areas, certainly less than 40 or 50 km.

MODELING CRIMINAL BEHAVIOR

Criminal behavior has been examined extensively from a theoretical perspective in recent years, beginning with the landmark article by Gary Becker (1968) that was a revitalization and extension of the early work of the Utilitarians, including Beccaria and Bentham. A non-exhaustive list of notable studies include Ehrlich (1973), Block and Heineke (1975), and Heineke (1978). Empirical studies built on this framework include

TABLE III: Characteristics of Population Concentration Counties (lan).

Main City	Pop. Density	% of Total lan	Aver. Pop. Density of lan	Air Dist. Pop. Ctr. Dist.to Borders	Air Dis. Pop. Ctr. to Next Closest Pop. Ctr. in Adjacent lan
AB Greater Stockholm	3551	55	231	30 km.	55 km.
C Uppsala	56	60	33	18	55
D Nyköping Oxelsund	30	31	41	18	48
E Linköping-Norrköping	80	62	236	50, 20	50
F Jönköping	72	36	30	25	70
G Växjö	37	37	20	26	92
H Kalmar-Nybroborgholm	55	35	21	52	72
I Visby	17	100	17	105	105
K Karlskrona	57	39	53	23	70
L Kristionstad-Hassdholm	54	42	45	25	70
M Malmö-Lund	1562	43	150	32	58
N Halmstad	73	34	40	30	70
O Göteborg-Bohus	992	69	139	12	57
P Boras	88	25	36	29	57
R Mariastad	40	46	33	32	68
S Karlstad	62	42	16	50	98
T Örebro	63	53	32	36	72
U Sarahammar-Västeras	123	45	41	25	72
W Falan-Bolinge	78	42	10	25	82
X Gävle	54	55	16	44	82
Y Härnösand-Scandsrall	29	45	12	25	165
Z Ostersund	24	41	2	62	165
AC Umeå	32	63	4	60	98
BD Luleå	11	36	2	50	200
WHOLE COUNTRY		$\overline{x}$ =47.3 σ = 16.4	$\overline{x}$ = 20	$\overline{x}$ = 36.8 σ = 19.5	$\overline{x}$ = 84.6 σ = 38.3

Ehrlich (1973), Carr-Hill and Stern (1972), Sjoquist (1973), and Phillips and Votey (1975). In these models, the behavior that generates individual crime levels is thought to be a response to lack of economic opportunities and to other social and economic forces that contribute to antisocial behavior. It is moderated by the threat of imposition of real costs on the perpetrator through loss of freedom, fines, and other sanctions. Such models imply that crime levels or rates will be responsive to the individual's subjective probabilities of sanctions being imposed and, in the aggregate, are expected to be related to the objective probability of apprehension and conviction. Additionally, the expected costs of illegal behavior are influenced by the severity of the sentence imposed. Typically, studies have found that to a substantial degree these two forces alone explain the levels of crime that prevail.

Economists hardly believe that the process of crime generation can be completely described by the latter sparse specification, and most studies capture a part of the impact of other social factors by including unemployment and labor force participation rates or poverty indices to reflect legitimate earnings opportunities or their lack. Often ethnic variables are included to capture effects expected to fall more heavily on ethnic minorities. These are captured by a relation of the form

$$OF_i = g(CR_i,\ SV_i,\ \vec{SE},\ \ldots);\quad i = 1,\ldots n \tag{1}$$

in which OF_i represents aggregate crime rates for each of n crime categories, CR_i represents the probability of apprehension or conviction, SV_i represents the statutory penalty prescribed for

offenders, and $\vec{SE}$ represents a vector of social and economic factors that influence individual criminal behavior.

It is not appropriate to estimate this crime generation relationship in isolation because, as has been noted in numerous studies, arrest and conviction variables and perhaps sanction variables are jointly determined with the level of offenses.[1] Thus, to avoid simultaneity bias, one must account for the way apprehension probabilities are determined, i.e., take account of the process of crime control.

A criticism of this specification, noted by Blumstein, _et al._, (1978) is that the estimation of a formulation in which the independent variable is the denominator of a key explanatory variable will create a spurious negative relationship, thus confusing a test of causality.[2] The existence of that effect is tested by an appropriate reformulation of the estimation form as is reported with the estimation results.

CRIME CONTROL

Crime control is generally viewed as a production process in which law enforcement inputs interact with the offense load on the system to generate convictions and hence conviction probabilities. In the case of Sweden, the criminal justice system's control effort can be determined by the relation

$$CR_i = (OF_i, L_i, \ldots), \tag{2}$$

in which CR_i and OF_i have already been defined, and L_i are the amounts of law enforcement inputs allocated to the control of each crime classification. Some studies, e.g. Ehrlich (1973), include environmental variables in this relation to help differentiate among police districts for differences in the law enforcement environment or operating procedures that might affect output. In the Swedish case this was not felt to be necessary since the police are a national force, uniformly trained, and operating under common policy directives. Heineke (1978b) and Phillips (1978) test more sophisticated models of police productivity than that tested here, including tests of appropriate functional form, factor substitutionality, and returns to scale, using a cost function approach to estimation. For this study, in view of the lack of data on inputs other than police manpower, such sophistication is simply not feasible. As has been noted in other studies, however, police manpower generally represents as much as 85% of law enforcement inputs. The focus here has been on the role of law enforcement, in general, in controlling crime rather than on factor substitution.[3] Heineke (1978b) argues for the exclusion of OF as a load factor largely on the basis that the output elasticity with respect to load in other studies is insignificantly different from one, an assumption for his own data set that simplifies the analysis, but one he doesn't test. Here the role of OF in the simultaneous relationship makes its inclusion more important.

A potential weakness of this specification from an econometric perspective is that, since CR is a ratio of convictions to offenses, there will be a negative correlation between the dependent variable and OF, independent of any causal link in terms of load on the system. Thus, the parameter estimate may not measure what it purports to in the model and test statistics

may be biased in favor of the hypothesis with respect to load. Responding to that possibility it should be noted that in earlier studies, estimates using an alternative form in which OF didn't serve as the denominator of the dependent variable yielded identical coefficients to the case where it did and still highly significant parameter estimates.[4]

The need for conceiving of the problem as one of simultaneous estimation follows from the fact that the offense rate OF is the output of crime generation and at the same time an input (load variable) for the criminal justice production function. Similarly, the level of output of the criminal justice system CR is a deterrent force affecting crime generation. Taking account of the joint determination of OF and CR requires that a simultaneous estimation technique be used.

These is another potential simultaneity that should be considered. As noted by Blumstein, _et al_. (1978), it is possible that the level of law enforcement inputs is not exogenous to the system but is jointly determined in a demand-supply interaction along with the offense rate and the conviction ratio.[5] If this interaction is a simultaneous one, it can be captured by presuming a supply function for law enforcement inputs in which

$$L_s = s(w) \quad , \qquad (3)$$

i.e, the supply of law enforcement inputs is a function of their wage w.

With respect to demand, two possibilities might be considered. One is that society through its agents, the authorities in the criminal justice system, will act to minimize the social costs of crime. In this case they would want to minimize a social cost function of the form

$$SC = \sum_i r_i OF_i + w \sum_i L_i, \qquad (4)$$

in which r_i is the average loss rate per offense in each offense class. The process of social cost minimization incorporated into the simultaneous relationships of Eqs. (1), (2), and (3) will yield an equilibrium level of law enforcements inputs L of the form

$$L = h(OF_i, r_i, w_i, Y), \qquad (5)$$

i.e., a function of offense levels, the loss rate per offense (r_i,) input prices (w_i), and community income levels (Y). The express derivation of the estimating form will follow Phillips and Votey (1975), (1976) and Votey (1982). Details for this model are in the Appendix.

A simpler hypothesis is that while society may allocate funds to crime control, rather than to other potential recipients of national funds, on the basis of some vague notion of rising crime costs, law enforcement authorities do not allocate across jurisdiction on the basis of variation in offense levels. In this event, the overall magnitude of L may depend upon the loss rate in the sense that political pressure for public safety efforts will depend upon overall costs of crime, but allocation across communities will be responsive to income levels simply because they represent ability to tax, and tax revenues in turn reflect power to demand services from the criminal justice

establishment. In this event, variations in offense levels across communities would not be good predictors of community law enforcement allocations.

It also seems plausible that law enforcement input demand is recursive rather than simultaneous, if one considers how criminal justice budgets are determined. Since law enforcement is a public enterprise with budgets established annually for the coming year, a plausible alternative would be to assume that in estimating with annual data, all the variables on the right hand side of Eq. (5) should be lagged by one year to account for the budgetary process. Then there would be no need to take into account Eq. (5) when estimating (1) and (2). With these possibilities in mind, we can proceed to the specifications of relationships for estimation, taking into account data availability.

IMPLEMENTATION OF THE MODEL

Offense Generation

The offense generation relationship Eq. (1) is estimated in two forms: as an aggregate, and disaggregated to consider separately personal (violent) crimes, property offenses, and motoring offenses within the systems framework. One of the reasons for doing so is that there are sound reasons to expect that different types of crimes are motivated by different causal factors. For example, one would be likely to expect the motive for property offenses to be economic gain, whereas personal crimes are more likely to be generated by frustrations and deteriorating interpersonal relationships, some of which might, of course, be aggravated by economic hardship. It is often alleged, in

Scandinavia in particular, that alcohol use may be a contributing factor to crime by reducing inhibitions to illegal behavior and by inciting individuals to be less rational, perhaps more violent. The presence of a greater number of aliens in the population is thought by some to be associated with higher crime levels. This may be a consequence of a higher incidence of social instability related to lack of economic opportunity, in which case we might expect crime to be predicted better by economic indicators than the level of alien population. On the other hand, the higher crime levels may be a consequence of more complex problems associated with the assimilation of people into an alien culture. A specification that investigates crime generation by distinguishing, even to a limited extent, among crime classes should help to generate insights into underlying causal relationships.

In the case of motoring offenses, the analysis becomes additionally complex, since the crime loss in the case of motoring offenses stems from the social cost of accidents. To deal with this a complete specification requires the inclusion of an accident relationship.[6] The consideration of motoring offenses adds a further complication to the analysis because of the way such crimes are recorded. Unlike personal and property crimes, motoring offenses are not generally reported to the police by victims or persons observing the offense. Rather, they are almost invariably the result of traffic or preventive patrol and show up on the record first as arrests, rather than as offenses

reported to the police. To see how this problem must be dealt with, it is useful to specify the disaggregated model in greater detail.

The Disaggregated Model

The model to be used for estimation is composed of 8 equations as follows:

$$OFV = V \cdot CRV^{\gamma_v} ATSV^{\sigma_v} ALIEN^{\eta_v} DIV^{\delta_v} UP^{\mu_v} ALC^{\phi_v} \epsilon_V \quad (6)$$

$$OFP = P \cdot CRP^{\gamma_p} ATSP^{\sigma_p} ALIEN^{\eta_p} DIV^{\delta_p} UP^{\mu_p} ALC^{\phi_p} \epsilon_P \quad (7)$$

$$OFM = M\ CRM^{\gamma_m} ATSM^{\sigma_m} ALC^{\phi_m} KD^{k_m} VM^{v_m} \epsilon_M \quad (8)$$

$$CRV = v\ OFV^{\omega_v} L_v\ \beta_v\ \epsilon_v \quad (9)$$

$$CRP = p\ OFP^{\omega_p} L_p\ \beta_p\ \epsilon_p \quad (10)$$

$$CRM = m\ OFM^{\omega_m} L_m\ \beta_m\ \epsilon_m \quad (11)$$

$$AC = a\ OFM^{\theta} KD^{k_A} VM^{\gamma_A} \epsilon_A \quad (12)$$

$$L = n\ OF^{\rho} AC^{\tau} Y^{\lambda} \epsilon_L \quad (13)$$

Variables are defined in Table IV.

TABLE IV. The Variables Defined

OF	Offenses reported to the police (per capita)
OFV	Personal offenses reported (per capita)
OFP	Property offenses reported (per capita)
OFM	Motoring offenses based on arrests (per capita)
CR	Total Convictions/Total Offenses
CRV	Personal Crime Convictions/Personal Offenses
CRP	Property Crime Convictions/Property Offenses
CRM	Motoring Offense Convictions/Motoring Offenses
AC	Fatal and Serious Injury Accidents (per capita)
L	Law enforcement manpower per capita; when associated with specific crimes inputed values assigned to those crimes
ATS	Average Time Served per conviction; when associated with specific crime classes time served is for that class of crime
ALIEN	Non-Swedish Population/Population
DIV	Divorces and Legal Separations/Population
UPM	Unemployed Males/Male working age population
ALC	Consumption of Pure Alcohol/Population 15 yrs. and older
KD	Index of kilometers driven
VM	Two-wheeled vehicles/Total vehicles
Y	Median real income (per capita)
r	Loss rate per offense
w	Factor price: average wage to law enforcement
ϵ_i	Stochastic error terms

Additional relationships needed to complete the system are the identities

$$L \equiv L_V + L_P + L_M + k\ L \qquad (14)$$

and

$$OF \equiv OFV + OFP + OFM\ , \qquad (15)$$

where k is the proportion of law enforcement manpower that is devoted to activities other than dealing with crime control, presumed to be proportional to the total resources available.

There are still a number of problems that need to be resolved before the model can be estimated. In particular, it was previously noted that motoring offenses are not recorded in a comparable way to other offenses. It would be possible to

estimate Eq. (8) using the reported figures for arrests, but this would mean that Eqs. (6), (7) and (8) would not be receiving parallel treatment since personal and property crimes are measured by offenses reported to the police. An alternative would be to consider the real target of social intervention into a criminal behavior of reducing the social cost of that behavior. If we regard accidents as the target, it need not be a matter of concern that we can't properly measure OFM or CRM.[7] By substitution, the accident relationship of Eq.(12) can be written

$$AC \equiv a^*\ L_M^{\beta_A}\ ATSM^{\alpha_A}\ KD^{k_A}\ VM^{\gamma_A}\ \epsilon_A\ . \qquad (16)$$

Since L, and hence L_M, are perceived as potentially endogenous to the system, Eq.(16) should still be estimated in a simultaneous framework. However, if law enforcement labor is determined recursively based on the previous period's magnitudes for the explanatory variables, Eq. (16) can be thought of as a reduced form relationship in which L_M is exogenous.

The concern that a spurious result insofar as causation is concerned will be the consequence of regressing offenses on a probability in which the denominator is the offense level can be dealt with in the formulation of Eqs. (6) and (7) by estimating the form

$$OF_i = C_i^{\frac{1}{1+\gamma}} CON_i^{\frac{\gamma}{1+\gamma}} ATS_i^{\frac{\alpha}{1+\gamma}} ALIEN^{\frac{\eta}{1+\gamma}} DIV^{\frac{\delta}{1+\gamma}} UP^{\frac{\mu}{1+\gamma}} ALC^{\frac{\phi}{1+\gamma}} \epsilon_i^{\frac{1}{1+\gamma}} \qquad (17)$$

The results of this estimation are reported for comparison with the model estimated directly with the equations as specified by

(6) and (7). This test was not applied to Eq. (8) since that equation was not estimated with comparable data to (6) and (7) and the results of estimating Eq. (16) were considered more meaningful. The formulation of Eq. (16) avoids the potential criticism, in any event.

Another potential problem stemming from lack of observable data relates to the breakdown of law enforcement labor among the various activities included in Eq. (14). One alternative is to assume that this allocation is determined by the police maximizing their preference function with respect to convictions or crimes-cleared-by-arrest, permitting, under appropriate assumptions, the substitution of L for the L_i in the production relations Eqs. (9), (10) and (11).[8] A second alternative is to assume that police minimize a social cost function of the form of Eq. (4).

To test the hypothesis of cost minimization with respect to allocating police manpower across offense classes, i.e., to minimize the sum of perceived losses to crime and law enforcement resources requires taking account of the first order conditions with regard to manpower allocation derived from the minimization calculation. This is a procedure that has been used effectively in Phillips and Votey (1975), (1976), and in Votey (1982). For such a test there are no data on the loss rates (r_i). Consequently, in the estimation these variables are captured by the constant term or are assumed to be a function of income levels. Given the short time period over which the study is conducted, this should not be a serious concern, since what is relevant is whether the ratio of r_i/r_j changes over the estimation period

rather than the absolute levels of r_i. Changes in law enforcement wages are presumed to be linked to income, since in Sweden, as elsewhere, salaries of civil service workers tend to move with national income levels. Thus, the test comes down to whether the crime generation relationships are improved by specifying manpower per crime class in the general form

$$L_i = M_i \frac{OF_i}{\Sigma a_i OF_i} L \quad i=1,3 \qquad (18)$$

(The details of this result are supplied in the Appendix.)

The only point in the estimation in which the inclusion of this variable makes a difference is in relations (9), (10), and (11). Taking account of relation (18) implies that a term $L/\Sigma a_i OF_i$ will replace L as an explanatory variable in those equations. The interpretation of the coefficient will be modified in the process of excluding the OF_i and $\Sigma a_i OF_i$ from the right hand side of the equations since these are endogenous to the system.

The first test that has been applied to the data has been to estimate the so-called covariance model in which it is assumed that each cross-sectional unit and each time period has its own intercept. This was done estimating the model using two-stage least squares. For a typical offense generation equation this required the estimation of 32 coefficients, including the constant term. Not surprisingly, no significant coefficients were produced by these estimates, but a number of the variables specified in Eqs. (6) - (13) tended to show greater significance than the regional and time dummies. One exception was that a dummy for region 13 tended to show some significance, suggesting it be included in a reduced set of parameter estimates in which other regional and time dummies were excluded.

A number of statistical concerns have been taken into account in establishing the subsequent procedure for estimation. An obvious concern when dealing with cross-section data is the presence of heteroscedasticity. To consider that possibility in any practical sense requires one to have some notion of what the source of heteroscedasticity might be. One possibility is that crime varies over counties for reasons not fully accounted for by the variables included in the explanatory set. This could be a consequence of size alone since it is an observed fact that urban crime rates in the U.S. vary positively with city size. All non-ratio variables have been standardized by population and all variables are expressed in their natural logarithms to minimize this effect, but, of course, if crime varies other than log-linearly with population this will not be a sufficient correction, unless the set of explanatory variables contains sufficient information to explain why crime rates vary with community size. Crime may vary with population density but, with population already included in expressing offenses in terms of crime rates, adding population density would be including a variable likely to be negatively collinear with the others since it would represent the county's population divided by a constant.

Income variations by county could have an influence on crime rates. In estimating the cost minimization model, incomes enters in the reduced form equations and should thus reduce the likelihood of heteroscedasticity if the relationship varies approximately log-linearly with income. Tests of the regression results

will allow conclusions to be drawn in this regard.

The possibility of crime spillovers is a potential concern in estimating the offense generation equations with cross-section data. It is conceivable that offenses recorded in one jurisdiction could be a consequence of differentials in expected returns to crime because of differences among jurisdictions in opportunities for gain or in expected costs to the criminal because of differences in apprehension rates and penalities among jurisdictions. Studies of spillovers for the U.S. have tended to focus on two classes of causal forces in association with arrest or conviction probabilities (Fabrikant [1979], Hakim <u>et al.</u> [1979]). These are income or wealth differentials among jurisdictions, and distance. The most complete effort in terms of specification is Fabrikant who takes into account distance, wealth differentials, the degree of competition among criminals in the location of residence, and differentials in arrest probabilities. He finds both wealth and distance to be significant, but by far the most important factor is distance. The implication of his study of data for the Los Angeles area is that the proportion of crimes committed outside a criminal's own census tract falls to less than one percent in approximately 16 miles. Furthermore, geographical barriers such as freeways form an almost impenetrable barrier insofar as spillovers are concerned. That such an effect could be important for Sweden is further reinforced by Hägerstrand (1967) who in communication across space makes explicit reference to the severely limiting effects of water barriers to both migration and communication. These results, combined with the previous discussion of the distribution of population among Swedish counties would suggest that spillovers should not be a major concern in estimating crime relationships with county data. Nonetheless, to the extent that this possibility can be tested as a hypothesis, it should be. The effect would be spatial autocorrelation and the potential biasing of parameter estimates as a consequence of violating the assumption that error terms are uncorrelated, in this case, across the cross-sections.

A further problem worth considering is the possibility of time series autocorrelation for the time series observations of each of the counties in the data set. While the data set is a short one in terms of time , so that serial correlation would intuitively not seem to be a problem, nonetheless, it is a possibility that should not be ruled out in establishing an estimation procedure.

An appropriate procedure for estimation would be to specify a cross-sectionally correlated and time-wise autoregressive model. Such a procedure, discussed in Kementa (1971), would test in a single estimating procedure for heteroscedasticity, mutual correlation of cross-sectional error terms and auto regression over time. With appropriate data sets, this procedure can be applied using SAS-TSCSREG for single equation estimation. That procedure was undertaken here for reduced forms of the offense generation equations with the unfortunate outcome that results apparently were thwarted by the degree of multicollinearity among the set of explanatory variables comprising the instruments.[9] As

a consequence, other estimating techniques have been undertaken to conduct a piecemeal test of heteroscedasticity and serial correlations over space and time.

The literature discussing the problem of spatial interaction suggests a number of alternatives for dealing with it.[10] A typical procedure would involve the calculation of a weighting function based on the factors that are the most important in generating the interactions, in this case crime spillovers. For Sweden, where wealth and income vary very little across jurisdictions as broad as counties, the most likely candidate would be distance. The possibility for variations in crime commission costs clearly exists if there is sufficient variance in conviction probabilities for them to be a significant determinant of variations in offense levels.

A likelihood of crime spillovers where the unit of observation is the county will be quite small, however, if the distance effects are similar to those in the Fabrikant study. In that study, analysis of the raw data indicated that spillovers across unpopulated areas were virtually nill. In Sweden, urban areas across county lines are separated by extensive agricultural and/or forest areas and in a number of cases by large bodies of water. Population centers in the northern counties are separated by very large distances [see Table III], but even in the more populous south, virtually every separation would exceed the 16 miles noted above for communities greater than 3,000 or 4,000 persons. In Sweden, where there is considerably greater use of public transportation and less reliance on private automobiles, one would expect spillovers to become negligible at even smaller distances. Nonetheless, the hypothesis should be tested that spatial autocorrelation could exist, i.e., that error terms are correlated for contiguous counties across whose borders spill-overs could take place.

The geographical distribution of Swedish counties lends itself to a simplified estimation procedure for testing the hypothesis of spatial interaction using the autoregressive model for the error terms as discussed in Ord (1975). The approach involves taking note of the natural barriers to criminal transactions between counties when criminals are accustomed to operation within a limited radius of their residential location. If one focuses upon the main transportation links and the physical layout of Swedish counties, it is possible to construct an organization of the counties that places contiguous counties in a linear continuum in which the major communication links would be along that continuum and any links of the linear continuum would entail physical barriers such as lakes, forest and/or agricultural areas where distances would exceed the limit beyond which interactions would become minimal.

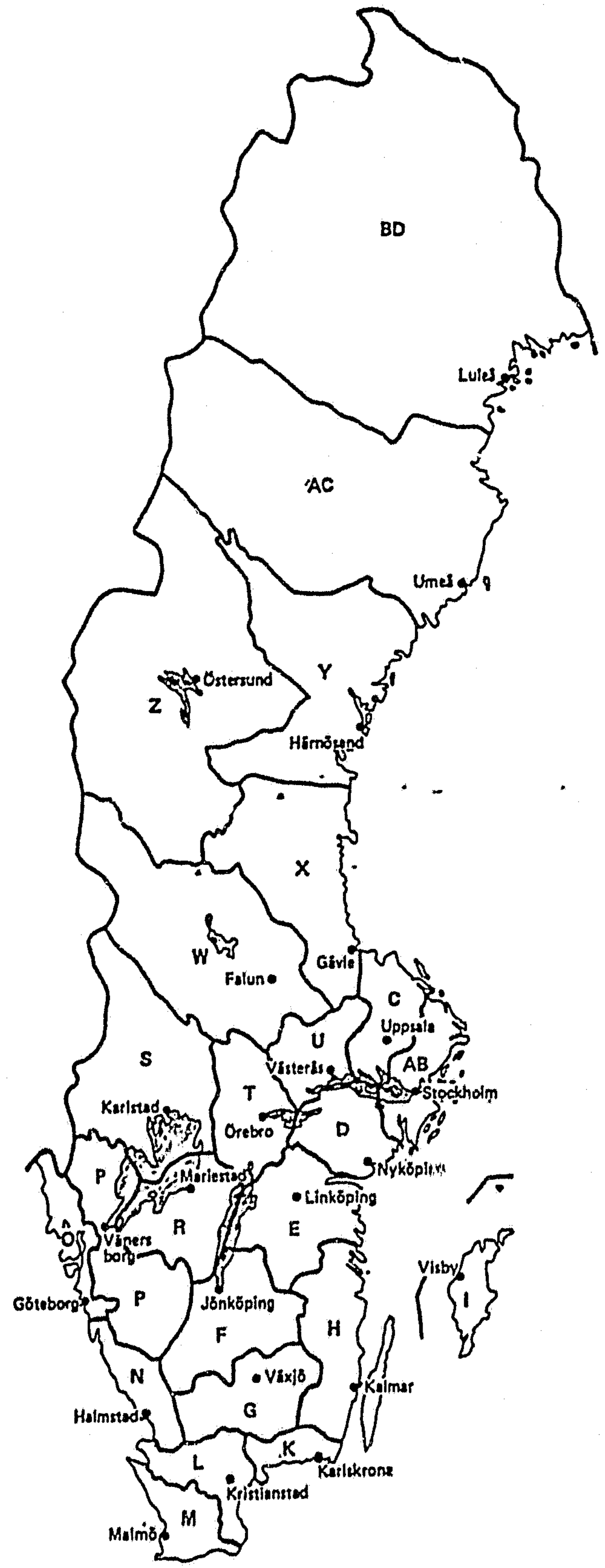
An ordering of counties with these factors taken into account is presented in Table V. The geographical location of counties is shown in Fig. 1. The counties are ordered in such a way as to place adjacently in the continuum the counties that are most closely connected by highways between municipalities of greater than 5,000 persons. Minimum distances between such communities are indicated in column 2 along with the name of the next closest community in the adjacent county to one in the county under consideration. Contiguous counties are noted which

TABLE V: Ordering of Counties to Test for Spatial Autocorrelation

COUNTY	Closest Municipality by Highway	Bordering Coastal Counties	Farm, Forest Open Country Separation	Water Barrier Separation
C Uppsala	Gävle, X (20)			
AB Stockholms	Sigtuna, AB (30) Uppsala, C (30)	AB	U	D,X
D Södernanlands	Nyköping, D (70) Sodertälje, AB (70)	C,D		
E Östergötlands	Norrköping, E (58) Nyköping, D (58)	AB,E		C,U,T
I Gotlands	Tranås, F (30) (Island in Baltic)	D,H	F,T	I,R
H Kalmar	Kisa,E (40)			E,H
K Blekinge	Karlskrona, K (58) Emmmaboda, H (58)	E,K	F,G	
L Kristianstads	Kristianstad, L (30) Sölvesborg, K (30)	H,L	G	
M Malmöhus	Ystad, M (40) Kristianstad, L (25)	K,M,N	G	
N Hallands	Ängelholm, L (35) Ängelholm, L (35)	L		
G Kronoborgs	Kungsbacka, O (22) Varnamo, F (42)	L,O	F,G,P	
F Jönköpings	Karlskrona, K (42) Ljungby, G (42)		H,K,L,N,F	
P Älvsborgs	Tranemo, P, (26) Göteborg, O (45)		N,G,H,E,P	R
O Göteborg och Bohus	Gislaved, F (26)		N,F,O,R,S	
R Skaraborgs	Trollkättan, P (28) Jönkoping, F (20)	N	P	
S Värmlands	Vårgårda, P (28) Karlskoga, T (22)		T	E,F,S
T Örebro	Arboga, U (35)		P,T,W	R
U Västmanlands	Vingåker, D (48) Enkoping, C (44)		R,S,U,W	E,D
W Kopparbergs	Hofors, X (38)		T,E,C,W,X	D
X Gävleborgs	Sundsvall, Y (72)		S,T,U,X,Z	
Z Jämtlands	Sundsvall, Y (110)		U,W,Z,Y	C
Y Västernorr-lands	Ostersund, Z (110)		W,X,Y,AC	
AC Västerbottens	Umeå, AC (79) Piteå, BD (70)	X,AC	Z	
BD Norrbottens	Ornskolderik, Y (99) Skellefteå, AC (70)	Y,BD AC	Z	

Figure 1. *Counties and provincial capitals of Sweden*

AB	Stockholms
C	Uppsala
D	Södermanlands
E	Östergötlands
F	Jönköpings
G	Kronobergs
H	Kalmar
I	Gotlands
K	Blekinge
L	Kristianstads
M	Malmöhus
N	Hallands
O	Göteborgs och Bohus
P	Älvsborgs
R	Skaraborgs
S	Värmlands
T	Örebro
U	Västmanlands
W	Kopparbergs
X	Gävleborgs
Y	Västernorrlands
Z	Jämtlands
AC	Västerbottens
BD	Norrbottens



Source: Statistisk årsbok för Sverige 1978

are joined along the coast where population is more concentrated than in the interior agricultural/forest areas.

In the case of crime spillovers, it would be appropriate to assume the weights between non-contiguous counties to be zero, since spillovers are virtually ruled out in any meaningful statistical sense. Similarly, also between counties not in direct contiguity along the continuum, in view of the natural barriers, it would be appropriate to assume weights of zero. This leaves weights to be chosen for contiguous counties along the continuum. If one makes the simplifying assumption that spillovers all along the continuum are equally likely, then the appropriate weights would all be one. This yields the standard model for the analysis of time series autocorrelation in which the autoregressive parameter, ρ , is estimated by an iterative regression procedure. Such an approach is particularly fortunate in the case of the problem at hand in which simultaneity among structural equations is expected to be of the utmost importance, because the model can be estimated by a two-stage Cochrane-Orcutt estimation technique. That procedure has been adopted here to test the hypothesis of spatial interaction along the continuum representing the primary intercounty economic activity and hence also the most likely path of crime spillovers.

EMPIRICAL RESULTS

To deal with simultaneity the model is initially estimated by Two-Stage Least Squares with the data ordered as supplied by Swedish sources, i.e., not in a manner to explicitly check for the possibility of serial correlation across counties. This is the ordering of Table III. The results of the estimation are shown in Table VI for the aggregate model and in Table VII for the disaggregated approach.

One point that stands out from these results is the lack of sensitivity of the control variables to the degree of aggregation or model specification. The coefficient on the conviction ratio is of the same order of magnitude (-0.789 to -1.29) and always highly significant (at the .0001 level or better), whereas time served in jail is uniformly insignificant. In contrast to this result, it makes a difference whether the model is aggregate or disaggregated with regard to the implied effect of some of the causal variables. While divorces and separations are uniformly and positively related to offense rates irrespective of model specification or degree of aggregation, the proportion of alien population tends to be significantly negatively related to offense rates in the aggregate models but highly significantly positively related to property offense rates and somewhat less to personal offense rates when these crimes are estimated separately. Similarly, alcohol consumption is shown to be negatively related to aggregate offense rates and weakly positively related to property offenses when offense classes are estimated separately. The unemployment variable, which is defined here as the proportion of unemployed males to their component of the population, is weakly positively associated with offense rates. The level of significance, although still low, rises with disaggregation. Surprisingly, divorces and separations seem to have a bigger impact on property crimes than personal crimes both in terms of magnitude of the coefficients

Table VI. Estimates for the Aggregate Model

Test	Dependent Variable	Constant	Coefficient on: CR	ATS	OF	L	DIV	ALIEN	UPM	ALC	MEDY	D-W	F (DF)
						(Exogenous Law Enforcement Resources)							
I	OF	.050 (0.06)	-.789 (10.94)*	-0.000 (0.06)			.771 (6.15)*	-0.089 (2.13)*	0.027 (0.71)	-0.119 (2.99)*		2.01	87.94 (6,88)
	CR	3.03 (3.68)*			-1.08 (11.35)*	1.08 (11.10)*						2.38	334.86 (2,93)
						(Endogenous Law Enforcement Resources)							
	OF	0.14 (0.10)	-.812 (9.60)*	.002 (0.23)			1.778 (5.98)*	-.082 (1.93)*	.033 (0.87)	-.119 (2.99)*		2.02	88.81 (6,88)
	CR	5.11 (5.22)*			-1.17 (10.48)*	1.44 (10.36)*						2.39	253.09 (2,92)
	L	13.05 (11.75)*			-.030 (0.33)						1.44 (6.30)*	2.05	23.05 (2,92)

Student's t-statistics (abs. value) are in parentheses.
*Significant at the .05 level (1-tailed test).

Table VII. Estimates for the Disaggregated Model

Test	Dependent Variable	Constant	Coefficient on: CR	ATS	OF	L	DIV	ALIEN	UPM	ALC	MEDY	KD	VM	D-W	F (DF)
							(Exogenous Law Enforcement Resources)								
II	OFV	-4.54 (4.58)*	-1.04 (7.62)*	.005 (0.06)			.240 (1.97)*	.097 (1.60)*	.060 (1.29)	.046 (0.80)				1.91	40.08 (6,89)
	OFP	1.03 (1.11)	-.819 (8.58)*	-.161 (1.26)			.616 (5.27)*	.153 (3.04)*	.047 (1.08)	.123 (2.55)*				1.60	45.26 (6,89)
	AC	-4.66 (3.26)*		-.049 (0.22)		-.267 (2.17)*				.089 (2.25)*		.507 (3.58)*	.210 (3.67)*	2.38	17.10 (5,90)
	CRV	-2.05 (2.54)*			-.709 (8.16)*	.534 (5.04)*								1.96	147.16 (2,93)
	CRP	2.01 (2.91)*			-.732 (8.60)*	1.03 (9.91)*								2.12	174.81 (2,93)
	CRM	-.841 (1.12)			-.906 (8.93)*	.721 (8.04)*								1.69	173.66 (2,93)
							(Endogenous Law Enforcement Resources)								
III	OFV	-5.07 (4.22)*	-1.29 (7.45)*	.036 (0.41)			.306 (2.07)*	.060 (0.81)	.065 (1.14)	.006 (0.08)				2.03	22.76 (6,89)
	OFP	1.16 (1.01)	-1.19 (8.11)*	-.158 (0.99)			.797 (5.25)*	.149 (2.36)*	.094 (1.69)*	.089 (1.46)				2.10	23.71 (6,89)
	AC	-6.97 (3.95)*		-.085 (0.36)		-.515 (3.13)				.053 (1.23)		.438 (2.96)*	.192 (3.27)*	2.36	15.57 (5,90)
	CRV	-2.91 (3.36)*			-.730 (8.67)*	.418 (3.43)*								2.02	148.48 (2,93)
	CRP	1.74 (2.28)*			-.740 (8.94)*	.992 (8.18)*								2.12	177.59 (2,93)
	CRM	-.874 (1.14)			-.979 (9.96)*	.773 (7.36)*								1.75	171.71 (2,93)
	L	-12.61 (12.05)*			.035 (0.49)						1.38 (6.37)*			1.75	23.43 (2,93)

Student's t-statistics (abs. value) are in parentheses.
*Significant at the .05 level (1-tailed test).

and statistical significance. The same is shown to be true for the variable representing alien population. The overall results, in conjunction with the information on the proportion of variance explained by the estimated relationships, based on F-statistics, lends support to the notion that property crimes are more likely to be rational, less impulsive acts than personal crimes.

The accident relationship in the disaggregated model yields similar results with respect to enforcement resources, the latter having a significant and negative impact on accidents and presumably drunken driving. Once more, time served in jail is not shown to be significant and both these results are consistent irrespective of model specification. As might be expected, alcohol consumption levels are positively related to accidents as is the index of distance driven, and the proportion of two-wheel to four-wheel vehicles, consistent with other studies.[11] The outcome of specifying a relationship that takes account of the demand for law enforcement has been the finding that law enforcement manpower is not significantly related to offense levels contemporaneously, but strongly related to median family income levels across communities. This conclusion holds whether offenses are included by category (incl. accident levels) or as an aggregate. This suggests that, at least for the Swedish data, the concern expressed by Blumstein <u>et al</u>. (1978) in regard to an unspecified positive link between offense levels and manpower inputs biasing the estimated results for control effects is unfounded in this instance. Further, the reason was not found to be a recursive relationship, i.e., a consequence of a lag between budget setting and crime control operations, since estimating the

relation with one year lags on the explanatory variable does not improve the fit.[12]

The criticisms that regressing offense rates on the probability of conviction (which necessarily incorporates offense levels in the denominator) will yield spurious results with regard to the effect of law enforcement on offenses can be laid to rest insofar as these data are concerned. The results of running the offense rate relations for the case in which law enforcement resources are endogenous (Test III) yields highly significant results for the coefficient on convictions ($t = 3.44$ and 3.02 for personal and property crime convictions respectively) and implied values for γ, the control effect, of -1.83 and -2.17 for personal and property offenses. These values compare favorably with the results of estimation of Eqs. (6) and (7) of -1.29 and -1.19, respectively, making it clear that the sign and magnitude of the effect do not depend upon a mechanical link of including the dependent variable in the denominator of the conviction probability.

The test of the social cost minimization hypothesis would seem to indicate that the police are not allocating manpower among tasks in a way consistent with cost minimization. That is, the statistical results on the labor input variable of the form of relation (18) yield coefficients hardly significant and of opposite sign of that to be expected, indicating that the balance of enforcement activity among activities implied by the cost minimization hypothesis is not being maintained.[13] This is hardly surprising when it seems clear that allocations across communities are similarly not related to implied crime costs, the other part of the social cost minimization hypothesis tested here. Based on this result, one would have to conclude that the more complex modeling of cost minimization is not a superior approach for modeling crime control across Swedish counties.

The limited tests for spatial autorcorrelation along the continuum outlined in Table V indicate that when estimators are derived from an instrumental variables approach to two-stage estimation, the hypothesis of serial correlation over the cross-section cannot be rejected out of hand with Durbin Watson statistics either falling in the inconclusive range or that for accepting they hypothesis of serial correlation. When the Cochrane-Orcutt technique for two-stage least squares is applied, the effects of aliens and weak effects of alcohol on personal and property offenses become weaker, but all other relationships that were previously significant at substantial levels remain so.

The cross-sections have been estimated singly, year by year, to asses the effect of time-series auto-correlations. While, not surprisingly, significance falls for all variables, still the conviction variables remain highly significant as do divorces and separations for personal and property crimes. For accidents, there is no qualitative difference aside from moderately lower t-values.[14]

As to heteroscedasticity, it is clear by plotting the residuals for the offense generations equations against the log of population that expressing variables in per capita terms and in natural logs effectively eliminates any heteroscedasticity associated with population size.[15] Since, the income distribution in Sweden is such that the more populous counties are also those with the higher median incomes, it is similarly unlikely that heteroscedasticity exists associated with income variation.

Three aspects of these results deserve additional comment which, while in some sense speculative, may shed light on why they have been found. One is the result with respect to time served in jail. While some theoretical arguments suggest that severity of sentence should be less important than probability of apprehension in deterring crime, that theory doesn't predict a complete lack of significance.[16] One difficulty with using the Swedish data base over a short time period for such analysis is that, as has been noted previously, there is relatively little variance across jurisdictions with respect to sentencing. The weak result is precisely what was predicted by statisticians of the Swedish Central Bureau of Statistics even though they had not conducted their own analyses of the data. It was not that they weren't convinced that sentence length makes a difference. The conventional wisdom there is that Swedish sentencing, like the Swedish income distribution, is highly egalitarian. Thus, in the short run, there was not sufficient variance across counties to facilitate estimation of the effect. As will be discussed in comparisons with time series results, it was found that for the aggregate model over a longer time series, sentence length was negatively related to offense levels, a fact that lends support to their position, since there have been changes in sentencing policy over time. Such speculation is hardly science, however. At best, it suggests that other means should be developed to test hypotheses about impacts of sentencing.

A second point of concern is the result with respect to lack of employment opportunities. In Sweden, those people who are officially listed as unemployed are supported far better by their government than citizens of almost every other nation. While the variable used to measure the extent of lack of employment was essentially the product of the unemployment and labor force participation rates so that it would tend to capture the effect of the discouraged worker hypothesis, that effect is likely to be weaker in Sweden than elsewhere. If lack of economic opportunities is the key, the population most likely to turn criminal in Sweden as a consequence of lack of employment are those youth who do not yet qualify for support payments because they don't have a work history. Employment experience for those persons will be captured imperfectly by a statistic that represents the proportion of officially unemployed males to the total male working age population. Thus, these results are an imperfect test of the hypothesis that lack of economic opportunities will be causally related to crimes and particularly property crimes.

Finally, comment is indicated in regard to the finding that police manpower deployment across counties is unrelated to offense rates, but is related to income. Swedish authorities were not surprised with the former result, but highly skeptical of the latter one. They in fact asserted that manpower deployment in Sweden is based on a formula that considers primarily urban population density and nothing else. They weren't willing to accept the notion that ability to pay taxes, the relative valuation placed on losses that might vary with income, or

political influence that might relate to income or the productivity of a given community could have anything to do with the allocation of police protection. Still, it is certainly true that offense levels consistently show up as insignificant in the police manpower relation across all model variants tested whereas income continues to show up strongly positively related to manpower deployment. Further investigation would appear to be warranted on all three of these issues.

COMPARISON WITH TIME SERIES RESULTS

An interesting comparison can be made between the results of estimation based on the recent (1975-1978) cross-section-time-series-data and the longer time series (1954-1977) for the county as a whole. These (latter) results are summarized in Table VIII.[17] The most striking similarity is with respect to the control effect of increasing conviction probabilities and the weaker or in some cases lack of significance of time-served-in-jail. One should note, however, as was mentioned previously, in aggregate versions of the time series model, time-served-in-jail was statistically significant at the .01 level or better (1-tailed test). While there are some similarities with respect to the impacts of the causal variables for personal crimes and property crimes, there is a considerable difference in significance levels, no doubt due in part to the better quality of data for more recent years and the larger sample size for the pooled study. No meaningful comparison can be made for accident results since accidents were separated between serious and fatal accidents and estimation procedures were not fully comparable.

Table VIII: Estimates from Time Series Analysis: National Data 1954-1977
(Endogeneous Law Enforcement Resources)

Dependent Variable	Constant	Coefficient on: CR	ATS	OF	L	DIV	ALIEN	UP	ALC	MEDY
OFV	-.284 (1.90)	-.898 (5.37)*	-.053 (0.54)			.190 (1.97)*	.264 (2.68)*		.199 (.095)	
OFP	-.052 (0.06)	-.655 (4.00)*	0.28 (0.34)				.175 (1.19)	.068 (1.11)		
AC				No Comparable Estimates						
CRV	-2.69 (6.21)*			-.386 (3.55)*	-.688 (2.37)*					
CRP	-1.92 (5.00)*			-1.09 (3.90)*	-.586 (0.68)					
CRD				No Comparable Estimates						

Student's t-statistics (abs. value) are in parentheses.
*Significant at the .05 level or greater.

The results for police effectiveness show similarities with respect to the impact of load variables but not with respect to the effect of manpower resources. The results that accord with theoretical expectations in the cross-section study are probably attributable to the improved quality of data on police manpower. The series that was available for the annual aggregate study suffered from definitional changes that left serious doubt as to its being a reliable continuous series.

COMPARISONS BETWEEN RESULTS FOR SWEDEN AND COMPARABLE U.S. STUDIES

In view of the similarities between Sweden and the U.S. in terms of income levels. life styles, criminal behavior, and enforcement, it is interesting to compare these results with those of similar studies for the U.S. Results of such a comparison for the impact of law enforcement effectiveness on reported offenses is shown in Table IX for studies that view the determination of crime levels and law enforcement effectiveness as a simultaneous process. One would hardly expect identical results in view of the differences in levels of aggregation and in model specifications and the fact that, even if the relationships in the two countries were identical, estimates might differ for Sweden since, except for property crimes, she is operating in a range of lower offense rates. Consequently, it is interesting to note that the elasticities for Sweden fall in the middle of the range of estimates for the U.S.

It is also possible to compare estimates of the productivity of law enforcement manpower in determining control effectiveness.

Table IX: Offense Elasticities With Respect to Measures of Law Enforcement Effectiveness: Comparison of Results for Sweden and the U.S.

	Class of Offenses	Law Enforcement Effectiveness Measure: Arrest Ratio	Clearance Ratio	Conviction Ratio	Imprisonment Ratio	Source
Sweden	Felonies			-.789 to -.812		Table V
	Property			-1.04 to -1.19		Table IV
	Personal			-.819 to -1.29		Table IV
U.S.	Felonies				-.99	Ehrlich (1973)
	Homicide	-1.5				(1975)
	Robbery	-2.99				Mathieson & Passell (1976)
	Felonies		-1.95			Jackson (1980)
	Felonies			-.61		Phillips & Votey (1981)

These comparisons are shown in Table X. For these estimates, model specification differs to an even greater degree than is the case for offense generating functions, but, again, it is interesting to note that the results for Sweden do not differ qualitatively from similar estimates for the U.S. and tend to fall in the middle of the range of U.S. estimates.

It did not appear fruitful to attempt to compare results for other parameter estimates.[18] A number of similar studies show significant positive results for deteriorating economic opportunities and crime rates in the U.S., but as noted previously, the Swedish data available do not permit a direct comparison.[19] U.S. studies do not take account of effects of a high proportion of alien population since, for most areas, this has not been thought to be a problem in the past. On the other hand, when race variables are included in U.S. studies, they are typically significant depending on model specifications with respect to other causal variables.[20] The latter effect may be related to the suspected effect of aliens in Sweden, but, since the latter variable is not significant for most of the Swedish results, little remains to be said.

IMPLICATIONS FOR POLICY

The implications of these results for policy are that we still don't know enough about penalties to advocate a change one way or the other. However, with respect to law enforcement inputs, the impact of an increase is shown to be substantial. To illustrate this, one can calculate the output elasticities with respect to the personal crime rate, the property crime rate, and

TABLE X: Police Effectiveness Elasticities with Respect to Offense Levels and Law Enforcement Manpower: Comparison of Results for Sweden and the U.S.

	Class of Offenses	Measurement of Police Effectiveness	Elasticity with Respect to Offense Levels	Elasticity with Respect to Police Manpower	Source
Sweden	Felonies	Conv. Ratio	-1.08 to -1.17	1.08 to 1.44	Table V
	Property	Conv. Ratio		.992 to .103	Table IV
	Personal	Conv. Ratio		.418 to .534	Table IV
U.S.	Felonies	Conv. Ratio	-1.45 to -1.60	2.24 to 2.32	Phillips & Votey (1981)
	Felonies	Imprsnmnt. Ratio		.30	Ehrlich (1973)[1,2]
	Property	Arrest Ratio		.60	Chapman (1976)
	Robbery	Arrest Ratio		.22	Mathieson & Passell (1976)[3]
	Burglary	Clearance Ratio	-.814	.722	Votey & Phillips (1981)[1]
	Larceny	Clearance Ratio	-.372	.405	Votey & Phillips (1981)[1]

[1]These are OLS estimates.
[2]Ehrlich's estimate was insignificant.
[3]Manpower is measured relative to the number of offenses rather than per capita.

serious and fatal accidents by working through the structural equations using the estimates of Table VI. The results obtained from a one percent increase in law enforcement inputs, assuming a middle range estimate of 1.0 for the two offense rates, for the elasticity of offense rates with respect to changes in the conviction ratio, and using the estimated values from Eq. (12), will be a 1.55% decrease in the personal crime rate, 3.91% decrease for the property crime rate and .515% decrease for fatal and serious accidents. The cost effectiveness of such an expenditure will depend upon the resultant change in the number of offenses and the accidents, the appropriate loss rates per offense, and the marginal cost of the added resources, easily made calculations given expenditure data for law enforcement and reasonable estimates for the social cost of the offenses prevented.

Such an outcome presumes that the allocation of resources among offenses remains as it has been over the period of the study. It may appear, however, that based on the loss rates perceived per type of offense, a different enforcement emphasis is indicated. Unfortunately, study at this level of aggregation doesn't provide insights into the relative effectiveness of internal reallocations in cases in which substantial changes are made in enforcement emphasis. The efficacy of such an internal reallocation depends upon the nature of the transformation curve among outputs in relation to loss rates for the offense categories.

These results should not be surprising for anyone familiar with econometric research on crime in the U.S., if one is willing to believe that the Swedish population and their institutions do not differ in substantial degree from those of the U.S. They tend to support the results of a number of U.S. studies and to allay some of the reasonable concerns of their critics.

Results in this study say more for the effects of law enforcement in the control of offenses and accidents than they do for other causal factors. This is true simply because, not only are the results statistically significant at substantial levels, but they are largely consistent with previous time series analyses. The results with respect to police effectiveness in using resources are also impressive in terms of the extremely high levels of significance. The findings in regard to allocative efficiency across communities and among crime classes are not what economists would hope to find and must indicate that law enforcement authorities have not been under pressure to concern themselves with crime mix or the efficiency of manpower allocations across communities. The results for the variables representing social and economic factors contributing to crime provide insights with respect to a number of factors thought to be contributing or influencing factors in crime.

With respect to policy implications, while it is not so clear how the information on causal variables can lead to policy improvement, it is quite clear that law enforcement activities have a substantial impact on accidents and offenses whose social value could be readily established with reasonable extensions of this research.

Footnotes

* The author acknowledges the financial support of the Swedish National Council for Crime Prevention and the University of California-Santa Barbara's Committee on Research.

[1] There is, by now, an extensive literature on the deterrence issue and crime generation. Surveys of this literature are in Blumstein, et al. (1978), Cook (1977), and Palmer (1977).

[2]Blumstein, et al. (1978), p. 24.

[3]Phillips and Votey (1975), p. 467.

[4]Votey and Phillips (1972), p. 438.

[5]See Blumstein, et al. (1978), pp. 30-33.

[6]A more detailed theoretical and empirical analysis that focuses on the accident relationship and its control and the derivation of estimating relationships is in Votey, (1982).

[7]For results of analyzing other data sets where this approach has been followed, see Votey (1982).

[8]This is the technique followed in Votey and Phillips (1972).

[9]This SAS program was "not supported by the author or SAS" so that the conclusion that collinearity among the instruments was the cause for the program's failure could only be deduced by general statements that collinearity would cause the program to

fail and the knowledge that collinearity among the instruments was substantial.

[10]An excellent introduction to the subject of spatial autocorrelation is Cliff and Ord (1973).

[11]A number of such studies are cited in Votey (1982), p. 95.

[12]While the unlagged version is superior to that in the model specifying one year lags, difference between the two estimates for this equation are slight and only in significance level.

[13]Efforts to model law enforcement productivity as joint production using only a single input measure are reported in Votey (1981). In general, the simple formulation used here, not assuming cost minimizing behavior by the authorities, proved to fit the data best.

[14]For accidents, in all years estimated, time served in jail had the expected negative coefficient and, in fact, in two years it was statistically significant.

[15]Not only was there no relationship between county population and the magnitude of residuals, but the counties with the largest urban population showed no special similar characteristics in terms of their residuals that were seemingly different from, say, the least populated county.

[16]See Becker (1968), p. 171.

[17]The time series results have been presented in Votey (1980).

[18]It is notable that for the effect of law enforcement resources on accidents, Norway has similar results to those here, based on estimates presented in Votey (1982).

[19]A number of such studies are reported in Phillips and Votey (1981). Efforts to link lack of economic opportunities to crime with individual data have shown mixed effects. See, for example, Witte (1980) and Myers (forthcoming). The Witte results show negative or insignificant effects on recidivism for the time in months to the first job for released prisoners and Myers finds that the number of months a released prisoner has a job is negatively related to recidivism. The difficulty with attempting to compare such results with those reported here is that, in an aggregate study such as this, there is no distinction made between general and specific deterrence, and, for that matter, effects of incapacitation, whereas in individual studies only specific deterrence is measured. Behavior among persons without criminal experience is likely to differ extensively from persons who have already been apprehended and sanctioned at least once.

[20]In Phillip and Votey (1975) an extensive list of potential causal forces was evaluated with county data for California. In those results ethnic variables became insignificant when economic opportunity variables were included in the set.

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APPENDIX

Derivation of relationships for estimating law enforcement manpower levels and allocation among activities based on social cost minimization:

It is presumed that the objective is to minimize Eq.(4), subject to crime generation relations (6) and (7), law enforcement productivity relations (9), (10), and (11), the relation for accidents (12), and the identity of (14). The results also depend upon the condition that the wage level for law enforcement personnel is a function of the general level of income in the community and that loss rates for crime tend to vary with income levels.

The Lagrangian function

(A1) $$\Psi = r_1AC + r_2OF2 + r_3OF3 + wL + \psi_1(L(1-k) - L1 - L2 - L3) + \psi_2(OF2 - gCR2^{\gamma_2}) + \psi_3(CR2 - hOF2^{\omega_2}L2^{\beta_2}) + \psi_4(OF3 - mCR3^{\gamma_3}) + \psi_5(CR3 - nOF3^{\omega_3}L3^{\beta_3}) + \psi_6(AC - dL1^{\beta_1}) + \psi_7(w - sL^{\sigma}),*$$

yields the following first order conditions:

(A2) $$\frac{\partial\Psi}{\partial AC} = r_1 + \psi_6 = 0$$

(A3) $$\frac{\partial\Psi}{\partial OF2} = r_2 + \psi_2 - \psi_3\omega_2 \frac{CR2}{OF2} = 0$$

(A4) $$\frac{\partial\Psi}{\partial OF3} = r_3 + \psi_4 - \psi_5\omega_3 \frac{CR3}{OF3} = 0$$

(A5) $$\frac{\partial\Psi}{\partial CR2} = - \psi_4\gamma_3 \frac{OF3}{CR3} + \psi_5 = 0$$

(A6) $$\frac{\partial\Psi}{\partial L} = w + \psi_1(1-k) - \psi_7\sigma \frac{w}{L} = 0$$

(A7) $$\frac{\partial\Psi}{\partial L1} = - \psi_1 - \psi_6\beta_1 \frac{AC}{L1} = 0$$

(A8) $$\frac{\partial\Psi}{\partial L2} = - \psi_1 - \psi_3\beta_2 \frac{CR2}{L2} = 0$$

(A9) $$\frac{\partial\Psi}{\partial L3} = - \psi_1 - \psi_5\beta_3 \frac{CR3}{L3} = 0$$

(A10) $$\frac{\partial\Psi}{\partial w} = L + \psi_7 = 0$$

* Note that the causal variables are ignored for the purpose of this derivation since they have no bearing on the cost minimization process.

From the first order conditions the result can be obtained that

(A11) $$L = \frac{1}{w(1+\sigma)} (a_1 AC + a_2 OF2 + a_3 OF3),$$

where $a_1 = r_1\beta_1$, $a_2 = \frac{r_2\gamma_2\beta_2}{\gamma_2\omega_2 - 1}$, and $a_3 = \frac{r_3\gamma_3\beta_3}{\gamma_3\omega_3 - 1}$.

If it is postulated that wages are related to community income levels

(A12) $$w = c(Y) ,$$

and perceived loss rates vary with income levels

(A13) $$r_i = b_i(Y) ,$$

then one can write

(A14) $$L = f(AC, OF2, OF3, Y) ,$$

where one would expect

$$\frac{\partial L}{\partial AC} , \frac{\partial L}{\partial OF2} , \frac{\partial L}{\partial OF3} , \text{ and } \frac{\partial L}{\partial r_i}\frac{\partial r_i}{\partial Y} > 0 ,$$

and

$$\frac{\partial L}{\partial w}\frac{\partial w}{\partial Y} < 0 .$$

In order to facilitate estimation in the simultaneous framework, it is assumed this relationship can be approximated by the estimating form

(A15) $$L = n\, OFV^{\rho_V} OFP^{\rho_P} AC^{\tau} Y^{\lambda} \epsilon_L .$$

To calculate relations for the L_i, note that (14) can be written in the typical form

(A16) $$L2 = \frac{L2(1-k)}{L1 + L2 + L3} L .$$

Note also that from the first order conditions, results for the L_i can be derived which, substituted into (A16) yield a set of results typified by

$$L1 = \frac{a_1(1-k)\, AC}{a_1 AC + a_2 OF2 + a_3 OF3} L .$$

For estimation purposes this yields relations

(A18) $$L_i = M_i \frac{OF_i}{\Sigma a_i OF_i} L .$$

In estimating the model with (A18) in the production function, the effect of OF_i will be included in the coefficient on the load variable and the labor input will be represented by $L/\Sigma a_i OF_i$. Estimation of the a_i will have to be an iterative process. The initial estimation will presume the a_i=1, i.e., that accidents (AC) will be counted equally with offenses as elements of the load.

END