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Articles

LEARNING BY CRIMING AND LEARNING BY POLICING: WHO LEARNS MORE?

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This paper theoretically analyzes and empirically tests the learning by doing of both criminals and police. Both are hypothesized to learn from their accumulated experience. The more crimes committed by criminals, the more knowledgeable and skillful they become, and more crime is executed. Thus, over time the level of crime is expected to rise. Police also learn from their accumulated experience. Past police performance affects productivity and reduces apprehension costs. The monetary gains of the community from police learning are far in excess of the monetary gains to criminals from their learning. Formal well organized learning channels which are an integral part of police activities are more effective than the informal and sporadic learning channels of criminals.

I. INTRODUCTION

In a recent study Deutsch et al., [1990] introduced and empirically tested the effect on their current performance of the accumulated learning experience of criminals. They concluded that accumulated past criminal experience produces a positive effect on current criminal activity. Ceteris paribus, the level of crime increases over time. The paper raises the possibility of learning by police. However, no attempt was made to present such learning.

The purpose of this work is to introduce the possible existence of learning by police vis-à-vis the criminals' learning process. The police are hypothesized to learn from their accumulated experience over time. Criminals are also expected to learn from their own and others' accumulated experience. The alternate hypothesis is that criminals and/or police do not exhibit any learning by doing.

The empirical analysis tests whether the learning of both the criminals and the police is significant. It is expected to reveal the hypothesized existence of "learning by doing" for both the criminals and the police. Section II presents the theoretical model of Learning by Criming (LBC) and Learning by Policing (LBP). Section III discusses the empirical model. Section IV presents the statistical results, and Section V summarizes the major findings and offers public policy implications.

II. LEARNING BY CRIMINALS AND LEARNING BY POLICE

The model of learning by doing was first introduced by Arrow [1962] and elaborated upon by Spence [1981]. It refers to the phenomenon whereby the per unit production cost diminishes with the accumulated output of the firm. The experience inherited from a longer production run yields a decline in per unit costs, ceteris paribus.

The model is adapted to explain the learning processes of both criminals and the police. Our hypothesis is that police demonstrate learning by doing if apprehension costs diminish with time. Similarly, criminals are learning by doing if their productivity in illegal activity increases with experience and the passage of time.

In their work Deutsch et al. [1990] argue that criminals improve their performance with their own and other criminals' accumulated experience. While at large, the interaction among criminals generates further experience for all of them ("positive externalities"). For example, sons of criminals are exposed to the criminal experience of their parents and their associates and are likely to capitalize on that past accumulated knowledge. The criminal's education is also acquired in prison where the opportunities for extended interactions with other inmates exist. On the other hand, not all the accumulated crime indicates more experience and leads to higher levels of crime. With the passage of time, some individuals withdraw from criminal activities, and new inexperienced individuals enter the crime labor market (Barnett et al. [1987]). Thus, some of the criminals' accumulated experience is being lost.

Learning by the police is more formal and institutionalized. Today policemen are almost universally graduates of high school, and a large and increasing proportion of them have two or more years of college. Furthermore, in most cases they are graduates of police academies where they learn specific forensic skills and acquire the accumulated knowledge of the law enforcement community.

Once on the job as rookies they are often paired with more experienced officers. The pairing is intended to provide the rookies with an opportunity to learn from their more

experienced brethren. Finally, policemen have opportunities for career development which depend on demonstrated learning. Indeed, lifetime careers are more frequent among law enforcement personnel than among criminals.

The diffusion of police knowledge is further enhanced by research conducted by criminologists and police experts. Findings are widely disseminated by national organizations like the National Institute of Justice, the Academy of Criminal Justice Sciences, the International Association of Chiefs of Police, and the Police Foundation. Many professional and academic journals are used to transmit information to others, and police personnel often attend professional meetings. No such channels are available for criminals. Since police learning is more formal and their job attachment is greater than that for criminals it is expected that the extent of police learning is greater.

But the application of formal forensic skills must await the day when a crime is committed. Hence, those forensic skills usually lag the innovations implemented by criminals to elude capture. The drug trade provides the most ready example. When smugglers began bringing drugs into the country in luggage, the police began using dogs to sniff out the contraband. The smugglers resorted to using other products to mask the odor of the drug. When the police found a solution to the masking, the smugglers began flying their own planes. When the police began relying on radar to detect the planes, the smugglers began flying at lower altitudes to pass under the radar, and so on. While the examples are extreme, similar circumstances can be found in the more pedestrian sorts of crime, e.g., radar detectors on the highway.

It is probably more accurate to say that the private sector security industry is in the business of devising procedures and hardware to thwart criminal behavior. Criminals learn in response to innovations in security. Police, the public sector security industry, are in the business of locating perpetrators of crime. The fact that a crime has been committed indicates that learning by the criminal has occurred. The police then demonstrate their own learning by trying to solve the crime. In any event the police find themselves in the position of demonstrating the extent of their learning by their success in solving crimes that have already been committed. The possibility then exists that measured learning by police is less than that of criminals.

To formalize, assuming the same theoretical model of criminal behavior as in Deutsch et al. [1990] we derive the criminal's production function:

$$q_t = q(Q_t, P_t, Y_t, U_t, D_t, M) \tag{2-1}$$

where q_t is the level of current property crimes, Q_t is past accumulated criminal activities, and P_t is the current level of police effectiveness measured by the clearance rate.

To restate the results of the theoretical model, as the criminal accumulates more criminal experience his performance improves and he increases his supply of crime.

Thus, it is expected that $\partial q_t/\partial Q_t > 0$. The hypothesized deterrent effect of police is $\partial q_t/\partial P_t < 0$.

As the empirical analysis is based on annual data for 64 New Jersey communities in the Atlantic City area for the period 1979 to 1984, we include in the production function additional socio-economic variables which characterize each community and affect criminal behavior. The crime "generating" variables in (2-1) are the following:

State equalized real estate valuation (Y_t) represents the opportunities available to the criminal in a particular community. Higher real estate values indicate greater portable and fungible wealth, i.e., loot. A wealthier community attracts more criminals since the expected monetary value of the loot increases. This interpretation may be termed the crime attraction model. However, the effect of income on crime may be of the opposite direction; wealth correlates highly with income, which is the legal opportunity cost of an agent's time (Willis [1983], Buck et al. [1983], Sampson and Castellano [1982]). As income rises, the higher opportunity cost serves to reduce the criminal activity of the indigenous population. This may be termed the crime generation model.

The crime generating model suggests that $\partial q_t/\partial Y_t < 0$. On the other hand, the attraction model suggests that $\partial q_t/\partial Y_t > 0$. Thus, the empirically observed coefficient of Y expresses the net effect, and its sign is a priori ambiguous (Hakim [1980]).

The rate of unemployment (U_t) is another economic variable that expresses the low monetary opportunity cost of the pool of potential criminals (Willis [1983], Conyers [1979]). Bloom [1966] argues in his seminal ecological school study that economic disruptions cause socially deviant behavior. We expect therefore $\partial q_t/\partial U_t > 0$.

D_t is population per square mile. High density areas are known to experience more crime than low density areas. Wirth [1938], in his classic work, argues that interpersonal ties, social cohesion, and the population consensus is weakened with density. Social control mechanisms are weakened by urbanism and lead to more crime.

Also, as density increases, the composition of the population changes, becoming more heterogeneous in race, age, and economic status, which in turn weakens social ties and leads again to higher crime (Sampson [1984], Shaw and McKay [1969], Brantingham [1984, p. 154]). From another point of view, higher density may reflect less wealth, leading to fewer crimes (Hakim [1980]).

The final independent variable is the distance of the community from Atlantic City (M). Using a tradional Von Thunen model, it can be argued that the crime rate diminishes with distance from Atlantic City. The argument is based on travel costs and familiarity (Buck and Hakim [1989], and Buck, Hakim, and Spiegel [1989]). We expect therefore that $\partial q_t/\partial M > 0$.

Summarizing, the criminal's improved work practices, resulting from his accumulated experience, yield a current increase in his criminal activities for given levels of police effectiveness and other crime generating variables.

Criminals maximize their net benefit from committing property crimes in the community. The police objective, which follows subsequent to the criminal's initiation of the crime, is to maximize the number of crimes cleared by arrest (a) constrained by its budget. The accumulated number of crimes cleared by arrest, (A), expresses the learning and experience gained by police over time. This problem can be formulated as:

$$\max a = a(L_1, ..., L_m, A) \tag{2-2}$$

subject to:

$$\sum_{i=1}^{m} P_i L_i = T \tag{2-3}$$

where $a()$ is the police production function, L_i are inputs used to produce the arrest rate a, such as police manpower, patrol vehicles, and special equipment. A is the accumulated number of crimes cleared by arrest, P_i is price of input i, and T is total police expenditure.

For a given level of T, the optimal allocation of the police budget is reached at the production level which satisfies the condition that the marginal productivity of the last dollar of expenditure is equal across all inputs. From the usual duality theorems, an optimal long-run cost function can be derived, which relates the level of police expenditure T to the level of cleared crimes a. In addition, the accumulated experience of the police has a positive effect on the marginal productivity of all inputs used by the police, which lowers the cost of apprehension. In other words, the police cost function T is:

$$T = T(a, A) \tag{2-4}$$

satisfying $\partial T_t/\partial a_t > 0$ and $\partial T_t/\partial A_t < 0$.

III. STATISTICAL ANALYSIS

In order to estimate eqs. (2-1) and (2-4), indexes of accumulated criminal and police activities need to be constructed. Crime data at the municipal level is not available until 1967 and is unreliable until 1970. Hence, it is diffucult to calculate the stocks of criminal and police activities, Q_t and A_t, respectively. Therefore, we assume that the effect of the cumulative variables is of the distributed lag type. Q_t and A_t are weighted indexes of past criminal and police activities, respectively, where the weights diminish exponentially with time.

The distributed lag version of the criminal's production function, eq. (2.1), is presented as:

$$(3\text{-}1)\quad q_t = \gamma + \alpha q_{t-1} + \alpha^2 q_{t-2} + \alpha^3 q_{t-3} + \ldots + \beta_1 P_t + \beta_2 Y_t + \beta_3 U_t + \beta_4 D_t + \beta_5 M$$

or,

$$(3\text{-}1')\qquad q_t = \gamma + \sum_{i=1}^{\infty} \alpha^i q_{t-i} + \beta_1 P_t + \beta_2 Y_t + \beta_3 U_t + \beta_4 D_t + \beta_5 M$$

where $0 < \alpha < 1$.

Since $0 < \alpha < 1$, the effect of past criminal activity, q_{t-i}, on current crime diminishes with the passage of time. The long-run effect of the accumulated number of crimes on the current level is given by:

$$\sum_{i=1}^{\infty} \alpha^i = \frac{\alpha}{1-\alpha}.$$

The effect of past criminal experience expands to an infinite number of past periods. Distant periods have a smaller impact on the current level of criminal activity. Weighting each period t by the coefficient α^t we obtain the mean lag, which represents the average number of periods that the criminal benefits from a change in any of the right hand side variables. The mean lag is defined as:

$$\frac{\sum_{i=1}^{\infty} i\alpha^i}{\sum_{i=1}^{\infty} \alpha^i} = \frac{1}{1-\alpha}.$$

One can also calculate the number of periods which must elapse before the criminal accrues half the benefit from a change in his accumulated past experience. In other words, for which value of t will the sum of the lag weights be equal to one half the long-run impact? The median lag is thus found by solving the following equation for t :

$$\alpha + \alpha^2 + \alpha^3 + \ldots + \alpha^t = \frac{0.5\alpha}{1-\alpha}.$$

The solution to the equation is

$$t = \frac{\log 0.5}{\log \alpha}.$$

The problem of estimating the coefficients in a model with an infinite lag is resolved by lagging the model one period, multiplying by α, and subtracting from (3-1). This allows eq. (3.1) to be rewritten as:

$$\begin{aligned} q_t =& \gamma(1-\alpha) + 2\alpha q_{t-1} + \beta_1(P_t - \alpha P_{t-1}) + \beta_2(Y_t - \alpha Y_{t-1}) \\ &+ \beta_3(U_t - \alpha U_{t-1}) + \beta_4(D_t - \alpha D_{t-1}) + \beta_5(M - \alpha M). \end{aligned} \qquad (3\text{-}2)$$

The effect of $q_{t-i}(i = 1, ..., \infty)$ is condensed into the coefficient of q_{t-1}. The other socio-economic variables and police effectiveness appear as partial first differences.

To estimate LBP, we assume the following police cost function:

$$T_t = \delta + \theta a_t - (\lambda a_{t-1} + \lambda^2 a_{t-2} + ...) \tag{3-3}$$

or,

$$T_t = \delta + \theta a_t - \sum_{i=1}^{\infty} \lambda^i a_{t-i} \tag{3-3'}$$

where $0 < \lambda < 1$. In the short run, the effect of a on T is given by the marginal cost θ, a positive number. In the long-run, the police learn from their efforts so the current increase in cost is subsequently reduced by:

$$\sum_{i=1}^{\infty} \lambda^i = \frac{\lambda}{1 - \lambda}.$$

To find the average number of periods that the municipality benefits from the reduction in cost resulting from an additional arrest we calculate the mean lag:

$$\frac{\sum_{i=1}^{\infty} i\lambda^i}{\sum_{i=1}^{\infty} \lambda^i} = \frac{1}{1 - \lambda}.$$

In a fashion similar to the learning by criming equation, the median lag is found to be

$$t = \frac{\log 0.5}{\log \lambda}.$$

The problem of an infinite lag is solved in the same fashion as that used for the crime equation. Lagging the model one period, multiplying by λ, and subtracting from (3-3), allows eq. (3-3) to be rewritten as:

$$T_t = \delta(1 - \lambda) + \theta a_t - (1 + \theta)\lambda a_{t-1} + \lambda T_{t-1} \tag{3-4}$$

Eqs. (3-2) and (3-4)are utilized for estimating the learning process. The results are presented in the next section.

IV. EMPIRICAL RESULTS

The statistical analysis is based on annual data for 64 New Jersey communities in the Atlantic City area for the period 1980 to 1986. Table 1 defines the variables and provides the data sources and some descriptive statistics. Based on a total of 448

observations, eqs. (3-2) and (3-4) were estimated using non-linear estimation. The results are presented in Table 2.

The significant coefficient of q_{t-1}, α, suggests that the process of learning is important in explaining the current incidence of crime. However, more recently learned behavior has a greater impact than lessons learned some time ago.

The short-run effect of the LBC process is 0.372. Suppose that there is a positive, one standard deviation shock to the crime equation, then the increase in crime due

TABLE 1

Variables and Descriptive Statistics

Variable	Definition	Units	Mean	Std. Dev.
q	Non-violent crime rate	per 100,000 population	6245.9	5862.1
P	Clearance Rate	percentage of non-violent crimes cleared by arrest	15.5	21.6
Y	State Equalized Commercial Real Estate Assessment	1976 dollars per capita	16453.4	20274.7
U	Unemployment rate	per cent	8.3	4.1
D	Density	population per SQML	1699.5	1582.8
M	Distance from Atlantic City	miles	35.3	19.0
T	Expenditure on police protection	1976 dollars per capita	339.9	330.6
a	Arrests	arrests per 1000 population	97.2	176.6

Data Sources: Annual Report of the Division Local Government Services, Statements of Financial Condition of Counties and Municipalities, State of New Jersey. Crime in New Jersey, Uniform Crime Reporting Section. New Jersey Attorney General. The clearance by arrest data was drawn from the individual municipalities annual reports which are submitted to the Uniform Crime Reporting Section of N. J. State Police.

to the learning effect that the criminal realizes in the first period after the shock is 0.372. The long-run effect is 0.592; the learning that results from the one standard deviation shock will raise the long-run average crime rate by 0.59 crimes. If the average nonviolent crime results in a gain of $1212 for the criminal (Table 3.16, Sourcebook of Criminal Justice Statistics [1990]), then the long-run incremental gain from learning is $715. The mean lag is 1.59. This means that the criminal benefits from the shock to his learning for 1.59 years. The median lag, or the time necessary to realize half of the impact of the shock, is 0.7 years.

The empirical results show that there is an obvious deterrent effect of police efforts — the coefficient on the fitted clearance rate, police effectiveness, is negative and significant. Furthermore, we see that an increase in the arrest rate by one unit will

reduce crime per 100,000 persons by 14.45 immediately, and by 35.41 in the long-run. The immediate decrease in the cost of crime is $17513, the long-run decrease is $42917 per 100,000 population.

The net effect of wealth appears to be significant and positive in explaining the supply of crime. Thus, the rewards to property crime, which are associated with opportunities available, increase more rapidly over time than do the legal opportunity costs. If wealth in a community were to rise by $1000 then there would be 24.3 more crimes immediately, and 59 more in the long-run.

TABLE 2

Estimates of the Learning Process

Variable	Coefficient	Estimate	t value[1]
Crime Equation:			
q_{t-1} LBC	α	0.3720	3.88
P_t Clearance Rate	β_1	-14.4548	-2.06
Y_t Wealth	β_2	0.0243	3.43
U_t Unemployment	β_3	179.8719	5.26
D_t Density	β_4	0.4342	4.54
M_t Distance	β_5	-14.3888	-1.80
Police Equation:			
T_{t-1} LBP	λ	0.5368	8.93
a_t Arrests	θ	1.9726	6.54

[1] The t values are based on the estimates of the coefficients asymptotic variances.

The unemployment rate, which is also meant to reflect the opportunity cost of prospective criminals, is positive and significant. As the proportion of the labor force without legal sources of income rises, the incidence of crime also increases. If the unemployment rate were to increase 1% then the crime rate would increase by 1.79 per 100,000 persons in the short-run and by 4.41 in the long-run.

The population density coefficient is positive and significant. Although a higher population density is associated with greater ease in providing surveillance and security, it appears that the criminal opportunities associated with greater density cause

more nonviolent crime. If population density were to increase by one more person per square mile then the crime rate would rise by 0.43 in the short-run and by 1.06 in the long-run.

Distance from Atlantic City has a significant impact on crime. As expected, the crime rate diminishes with distance from Atlantic City. The period included in the study post-dates the introduction of casino gambling This era is marked by much higher crime rates in the close vicinity to the Atlantic City area.

If Atlantic City could be moved one mile further away from the municipalities in the study then the crime rate would fall by 14.38 in the short-run and by 35.25 in the long-run.

Turning now to the police equation, the significant coefficient of T_{t-1}, λ, supports our hypotheses of a significant LBP effect. The short-run effect of the arrest rate is given by the positive marginal cost of 1.97; if the clearance rate rises by 1% then the cost of police services will rise by $1.97 per capita. In the long-run the LBP effect of an increase in the clearance rate is to reduce the cost of apprehension by $1.17 per capita.

The mean lag is 2.17. That is, the reduction in cost accrues over 2.17 periods on average. The median lag is 1.1. That is, it takes 1.1 years before half of the gain to be realized from an increase in the clearance rate accrues to the municipality.

Suppose that the clearance rate rises by 1%. The immediate saving in reduced crime will be $17513, realized at an increased cost for the police of $197000. The change in the clearance rate produces a long-run avoided cost of $42917 per 100,000 from the direct impact of the increased clearance rate on crime. Over the course of time the cost of apprehension will be reduced by $1.16 per capita in savings accruing to the police department as a result of their learning by doing. Thus in the average community the net effect of a 1% change in the arrest rate is equal to $38083 per 100,000 population, or $0.38 per person. This is an increase of about 0.1% in the per capita amount currently being spent on police in the Atlantic City region.

V. IMPLICATIONS

This paper introduces and empirically tests the processes of Learning by Criming, and Learning by Policing. The more crimes committed by the criminal and by others, the more knowledgeable and skillful they become, and more crimes are executed, ceteris paribus. Thus, over time, the level of crime increases as a result of the learning process. But learning is not limited to criminals; police also learn from their own accumulated experience. It appears that the past performance of police affects police productivity and reduces apprehension costs.

Our findings suggest significant long-run effects of learning by criminals and police. Police learning is of a larger mean lag than that of the criminal. In other words, it

appears that it takes longer for the benefits from learning to accrue to the police department than to accrue to criminals. However, as we showed in the previous section, the monetary gain to the community from police learning is far in excess of the monetary gain to criminals from their learning.

One is compelled to speculate on the reason for the difference in elapsed time to realize half the gain from learning. Presumably the police benefit from formal, well organized learning channels. The improved communication inherent in such an approach ought to be more effective than the informal and sporadic learning channels of criminals. Our conclusion on the hypothesized learning time hinges on our earlier observation that municipal police departments are in the business of solving crime after it has occurred; they operate in a reactive mode. Criminals on the other hand are aware of police practice and act pro-actively to commit crime without subsequent apprehension.

This study and previous research suggests the presence of learning by criminals. However, this study also provides evidence that there exists significant learning by police from their own experience. Many observe the police-department as a bureaucratic body which is not exposed to market forces and which makes inefficient use of its resources. It appears that formal learning processes which are an integral part of police activities do not gain the appropriate attention. Consistent data collection on crime patterns and security measures as well as analysis, evaluation and prediction of crime provides the police with lessons for future action. Hence the true marginal benefit from an increase in police outlays is greater than that perceived for the current fiscal year. Politicians tend to ignore the long term effects of learning in their budgetary decisions. This myopic view may lead to underfunding of the police.

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