Unobserved heterogeneity bias when estimating the economic model of crime

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Using unique and unpublished panel data from selected US cities, the paper investigates the consequences of ignoring unobserved heterogeneity in the unit of observation when estimating the economic model of crime. Results confirm that neglecting to control for unobserved heterogeneity overstates the ability of sanctions to deter criminal activity. Further, this upward bias is found to vary significantly across crime types. Interestingly, heterogeneity is insignificant in the tightly reported crimes of murder and auto-theft while being significant in assault, robbery, burglary and larceny where individuals and police have greater discretion in reporting.

I. INTRODUCTION

The notion that individuals respond to incentives in both legitimate and illegitimate activity goes back at least to Bentham's Principles of Penal Law (1862). Becker (1968) formalized the deterrence hypothesis by introducing an economic theory explaining the inherent uncertainty of criminal behaviour. Since Becker's seminal paper, an immense collection of empirical work has accumulated with results consistently suggesting deterrent effects from criminal sanctions. However, unsettled caveats raise concerns regarding the results. Due to the extreme cost of obtaining reliable individual-level data, one issue arises from the use of aggregate data. Unobserved heterogeneity in the unit of observation may lead to spurious relationships that incorrectly imply or exaggerate deterrent effects. Cornwell and Trumbull (1994) first examined the consequences of ignoring heterogeneity and found that doing so overstates the deterrent effects for overall criminal activity.

This study extends their approach by examining unobserved heterogeneity bias for individual crimes. Given individual crimes have varying degrees of discipline in reporting, heterogeneity and the resulting bias should differ across crimes. For example, reporting practices of murder should be more homogeneous across jurisdictions than burglary and larceny. Results suggest that unobserved heterogeneity bias varies significantly across individual crime types. Further, jurisdiction effects are insignificant in tightly reported crimes while being significant in the crimes where police and individuals have greater discretion in reporting.

II. UNOBSERVED HETEROGENEITY BIAS

Variances across jurisdictions introduce noise into the analysis which may bias results towards a deterrent effect. The most noted concern is the underreporting of crimes by individuals and police, where it is estimated that approximately 50% of crimes are unreported to the FBI (Myers, 1980). Unreported offences lead to underestimates of crime rates and overestimates of police department clearance rates (ratio of arrests to crimes). Intentional non-reporting by police departments magnifies the problem. Often judged by its clearance rate, police departments may adopt loose...
reporting practices for political reasons. Departments can improve their ‘effectiveness’ by decreasing the number of reported offences or increasing the number of cleared offences, with the former easier to achieve. Police departments can also inflate their clearance rate by offering leniency to those arrested if they confess to unsolved crimes.

For example, suppose there are two criminal justice departments. Department A follows strict accounting practices that report high percentages of crimes, while department B is more lenient and reports lower percentages. Noting that certainty of sanctions is typically measured by the clearance rate, this disparity causes a problem when the reported data from the two jurisdictions are analysed. Even if both departments clear approximately the same portion of actual crimes, department B appears more effective with an overestimated clearance rate. Thus, department B has a greater clearance rate and a lower reported crime rate compared to department A. This indicates the presence of a deterrent effect when both jurisdictions may actually have similar actual rates with no obvious deterrent effect.3

III. MODEL

The economic model of crime proposes that individuals participating in criminal activity can be thought of as rational economic beings acting under uncertainty. Therefore, to curb criminal activity, the theory suggests decreasing its expected return. Given that marginal utility of income is positive, the certainty and severity of sanctions are inversely related to expected utility, and thus, criminal activity (Becker, 1968).

At the aggregate level, the number of offences can be stated as a function of the probability and cost of apprehension. The following crime equation is estimated with panel data:

\[ C_{it} = \alpha_i + \beta' D_{it} + \theta' L_{it} + \psi' X_{it} + \epsilon_{it} \]

where \( C_{it} \) denotes the crime rate of municipality \( i \) at time \( t \), \( D_{it} \) contains deterrent variables, \( L_{it} \) contains labour market variables, and \( X_{it} \) contains related socio-economic variables. Unobserved municipality effects are captured by \( \alpha_i \).4 The disturbance terms follow a normal distribution with zero mean and constant variance.

Estimation of the panel data with standard cross-sectional techniques assumes homogeneity in the unit of observation by restricting the \( \alpha_i \)s to equal each other. This pooled model would be appropriate only when municipality effects are homogeneous; otherwise it yields inconsistent and biased estimates. An appropriate effects model (fixed or random) controls for heterogeneity and provides consistent and efficient estimates in the presence of heterogeneity. The consequences of assuming homogeneity across individual crimes is examined by comparing the results from the pooled model and the appropriate effects model.

IV. RESULTS

Crime, law enforcement and socio-economic data from selected US cities provide the sample. Following Sjoquist (1973), the sample includes municipalities having populations between 50000 and 200000 and populations greater than 50% of their total Standard Metropolitan Statistical Area (SMSA).5 After eliminating the cities not meeting the criterion or not having sufficient information, 44 municipalities over the census years 1970, 1980 and 1990 provided the panel of 132 observations.

Table 1 provides the definitions and means for the variables used in estimating the crime functions. Given that more than one arrest is possible for a single crime, it is not surprising that the mean clearance rate for the tightly reported murder category exceeds one (1.09). The clearance rate represents the probability of arrest, i.e. certainty of sanctions. Sentence length is measured by the ratio of total prison population to new commitments and indicates the severity of sanctions. Income per capita and the unemployment rate proxy available returns from the labour market. Municipal population and the proportion that is minority are included to capture additional variation across crimes.

Tables 2 and 3 present estimates of the pooled and effects models. In addition, Table 3 provides the Hausman statistics used to determine the appropriate effects model for each crime. Except in the cases of murder and rape, Hausman tests fail to reject orthogonality between the regressors and random effects. Thus, a fixed effects approach is appropriate for murder and rape while the random effects model is appropriate for the remaining crimes. Following previous research, each model is specified as log-linear so that the estimated coefficients are elasticities. Results indicate that the probability of arrest has a significant deterrent effect across all crime types while sentence length fails to provide any significant relationships (as in Avio and Clark, 1978). Police has the typical positive

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3 Similarly, the issue of heterogeneity bias exists when the certainty of sanctions is measured by the ratio of convictions to reported crimes. Given the discretion of conviction falls upon a different branch of the criminal justice system from the discretion of arrest, the resulting bias of the two sources of unobserved heterogeneity likely varies.

4 Time effects were controlled for in all estimations leaving the analysis to focus on heterogeneity bias related to the unit of observation.

5 This criteria was to reduce spillover effects from neighbouring communities.
relationship with crime rates, indicating the possible presence of a simultaneous relationship. Generally, results concerning labour market and socio-economic variables follow previous research.

Given the insignificance of sentence length, the focus of this study rests on comparing the probability of arrest elasticities across the pooled and effects procedures. In doing so, there is evidence of a bias in the pooled estimates which fail to account for unobserved heterogeneity. This result corresponds to Cornell and Trumbull (1994), however, this study extends the analysis and finds that the bias varies significantly across crime types. The upward bias in the probability of arrest elasticities (absolute values) ranged from 70% for the burglary model to almost zero for the robbery model. For example, estimated elasticities for the individual crime of assault are 0.289 for the pooled model and 0.214 for the effect model. In this case, failing to account for heterogeneity overstates the deterrence from certainty of sanctions by 35%. For overall crime, deterrence is overstated by 20% when failing to control for heterogeneity. Interestingly, F-tests reveal that jurisdiction fixed effects are not significant in the tightly reported crimes of murder and auto-theft while being significant in the crimes of assault, robbery, burglary and larceny where individuals and police have greater discretion in reporting.

A simultaneous analysis revealed similar findings and was excluded from the presentation for succinctness.
Table 3. Random/fixed effects results of crime function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Index</th>
<th>Murder*</th>
<th>Rape*</th>
<th>Assault</th>
<th>Robbery</th>
<th>Burglary</th>
<th>Larceny</th>
<th>Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.389</td>
<td>-2.014</td>
<td>-3.357</td>
<td>-18.508</td>
<td>-2.028</td>
<td>-0.965</td>
<td>1.683</td>
<td>-6.997*</td>
</tr>
<tr>
<td>P(arrest)</td>
<td>-0.169</td>
<td>-0.221†</td>
<td>-0.128†</td>
<td>-0.214†</td>
<td>-0.297†</td>
<td>-0.119†</td>
<td>-0.069†</td>
<td>-0.118†</td>
</tr>
<tr>
<td>Sentence</td>
<td>0.048</td>
<td>0.032</td>
<td>0.035</td>
<td>-0.108</td>
<td>0.062</td>
<td>-0.069</td>
<td>0.090</td>
<td>0.268†</td>
</tr>
<tr>
<td>Police</td>
<td>0.470†</td>
<td>0.640†</td>
<td>0.309</td>
<td>1.336</td>
<td>1.292</td>
<td>0.786</td>
<td>0.346</td>
<td>0.878</td>
</tr>
<tr>
<td>Income</td>
<td>0.255</td>
<td>-0.663</td>
<td>0.036</td>
<td>1.178†</td>
<td>-0.131</td>
<td>0.056</td>
<td>0.269</td>
<td>0.681*</td>
</tr>
<tr>
<td>Unemploy.</td>
<td>0.115</td>
<td>0.011</td>
<td>0.074</td>
<td>0.456†</td>
<td>-0.103</td>
<td>0.230†</td>
<td>0.205</td>
<td>0.008</td>
</tr>
<tr>
<td>Population</td>
<td>0.120†</td>
<td>0.365†</td>
<td>0.144</td>
<td>0.509</td>
<td>0.078</td>
<td>0.203†</td>
<td>0.039</td>
<td>0.197*</td>
</tr>
<tr>
<td>Minority</td>
<td>0.070†</td>
<td>0.458†</td>
<td>0.293†</td>
<td>0.399†</td>
<td>0.405†</td>
<td>0.124†</td>
<td>-0.004</td>
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<td>0.124†</td>
<td>-0.004</td>
<td>-0.028</td>
</tr>
<tr>
<td>R²</td>
<td>0.810</td>
<td>0.581</td>
<td>0.624</td>
<td>0.684</td>
<td>0.543</td>
<td>0.586</td>
<td>0.365</td>
<td>0.412</td>
</tr>
</tbody>
</table>

Standard errors in parentheses unless otherwise noted.
* significance at the 10% level; † at the 5% level; ‡ at the 1% level.
* Fixed effects estimates; otherwise random effects.

V. SUMMARY

This study examines unobserved heterogeneity bias when estimating the economic model of crime. Previous work has shown the existence of this bias when analysing overall crime. This paper confirms that result and extends the analysis by finding significant variation in the bias across crime categories. Municipality effects are found to be insignificant in tightly reported crimes and significant in ‘loosely’ reported crimes. Results imply that estimates failing to address unobserved heterogeneity overstate the potential deterrent effects from criminal sanctions, but that this effect is not constant across individual crimes.

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REFERENCES

Estimating the economic model of crime


