Returns From Cooperation in Criminal Activity: Estimating Crime Production Function and Returns to Scale

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Abstract

How does the damage produced in a criminal activity depend on the number of offenders? If offenders maximize the crime damage as a proxy for their production, and they share it equally, we would expect that their production function exhibits increasing or constant returns to scale. Using the rich-in-characteristics dataset of the Police of the Czech Republic spanning from 2004 to 2016, fixed-effects models of the production function of damage and the probability of accusations are estimated while controlling for heterogeneity among criminal activities. The results reject both the possibility of non-decreasing returns to scale of crime production function and the possibility of compensation of decreasing damage per person by a lower probability of accusation. Likely explanation is that the criminal opportunities for a single offender give the highest earnings because they are not always available - otherwise, everyone would prefer to work alone. These results are highly consistent with Levitt and Venkatesh (2000).

Key words: economics of crime, crime production function, criminal cooperation, sample-selection bias, returns to scale

JEL Code: K14, D01, D22

Introduction

Ever since Becker's (1968) seminal paper "Crime and Punishment: An Economic Approach", Economics of Crime has been a fruitful area for research. In the last decades, promising results have been made in the analysis of the demand-side of crime and individual choice between criminal and legal activities (excellent review provided in Lee and McCrary, 2009; Heckmann, 2015). Still, no significant interest has been allocated in analyzing the supply-side of crime - such as to the production function of crime with respect to the number of offenders (Polinsky and Shavell, 2005).

However, criminals may and do commit crimes by themselves, in pairs or groups. So far, only Levitt and Venkatesh (2000) researched the composition and remuneration of criminals within a large gang organization, and more recently, Gavrilova (2017) examined, based on Becker's

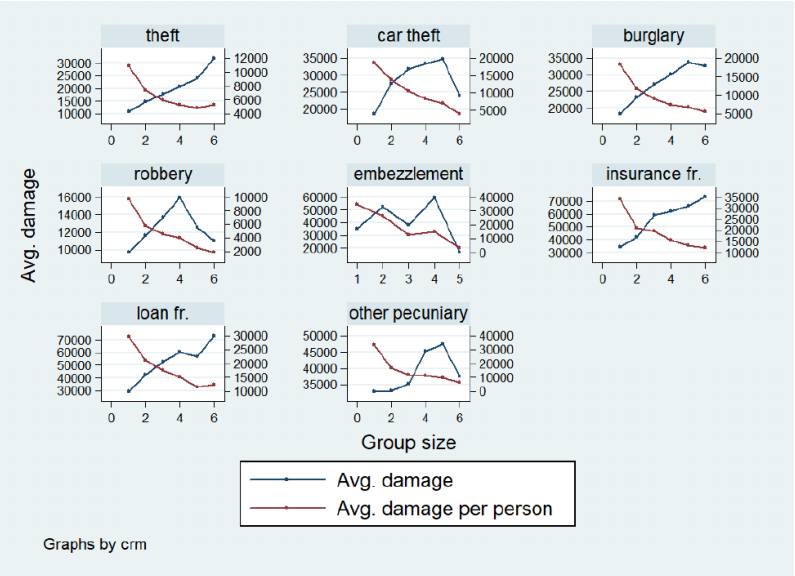
(1974) theory of assortative matching, how criminals match with each other into pairs. Mastrobuoni (2015) looked into the value of connections in Italian-American Mafia during 1950's and 1960s using the tools of network theory. These papers motivated the research topic of this study.

1 Research question and hypothesis

The research question of how the criminal production depends on the number of offenders is in this study seen through the optic of a simple assumption – that criminals share their loot equally (i.e. in the ratio of 1/n for each participant). While this might not be true for larger criminal organizations and gangs, the scope of this study is, similarly to Levitt and Venkatesh (2000), on the crimes committed by the formations of up to six offenders. Crimes with more offenders might likely have some division of labor and therefore might have a non-equal division of the loot. This is also convenient given the fact that data about detected crimes committed by a large number of offenders are scarce. For the sake of this study, it is also convenient to divide crimes into eight distinct categories – theft, car theft, burglary, robbery, embezzlement, insurance fraud, loan fraud, and the category of other pecuniary crimes. Such division is rather standard in economic literature (e.g. Bilings, 2016). The production function is more suitable concept in this topic than the profit function because the criminal formations can be thought of as a production team rather than a firm. Product in this study is proxied as a total damage made in the crime (monetary value the criminals get from the activity plus an auxiliary damage made to get such monetary value). The main costs associated with the production is a punishment – more accurately it's probability. The fact that criminals do count with the probability of punishment has been widely documented in the international research on the economics of crime, especially in the US (Imai & Krishna, 2004; Merlo and Wolpin, 2009). The data on punishment are not part of the data on criminal activity but are instead part of the datasets owned by Czech Ministry of Justice but fortunately, the probability of punishment can be in this study proxied by the probability of accusations, which is in a Czech context almost a perfect predictor of punishment.

Figure 1 shows that in all of the 8 crime categories, the total damage is usually increasing but at the same time the damage per person is decreasing. This already suggests that the returns to scale might be decreasing.

Fig. 1: Total damage and damage per person



Source: Police of the Czech Republic

However, this graph does not show whether the decreasing returns to scale can be balanced/counteracted by the decreasing probability of accusations. Such a simple graph also fails to control for the crime, time and location, and personal characteristics other than one of 8 crime categories. Although the graph suggests decreasing returns to scale, based on the economic theory (and intuition) we would still expect that the returns from crime should exhibit increasing returns to scale or that the decreasing returns should be compensated by a decreasing probability of punishment. Evidence that Czech criminals tend to use at least some basic axioms of economic theory can be found e.g. in Montag & Brabenec (2016). Based on these stylized facts and discussion, I posit following research hypotheses:

H1: Crime production function exhibits increasing returns to scale.

H2: If the crime production function exhibits decreasing returns to scale, it can be explained by a decreasing probability of accusation.

2 Empirical evidence

a. Data

The dataset of offenders on the individual-level basis was acquired from the Police of the Czech Republic. The data span from 2004 to 2016. They include information about the criminal case, time and location of the crime and the personal characteristics of the offender.

b. Methods

This study employs models for two dependent variables – damage per person and the probability of accusation – described in the research hypothesis. Both models follow a high-dimensional linear regression approach suggested in Correira (2015). Damage per person is estimated using following equation:

$$DamagePerPerson_{i,n,t,j} = \sum_{i=1}^{8}\sum_{n=1}^{6} \beta_{i,n} I_{i,n} + \lambda_c + \lambda_l + \lambda_t + \lambda_j + \gamma X_{c,l,t,j} + \epsilon_{i,n}$$

Where explanatory variable is a number of offenders ($n = 1-6$) in one of the 8 crime types (denoted by i) – i.e. $I_{i=1-8,n=1-6}$ (this is also called non-parametric regression approach). Control variables are grouped into four categories: i) case controls which are captured through λ_c: object of crime, paragraph, date of opening the case, and date of final decision; ii) geographic location control which is captured through λ_l; iii) time controls which are captured through λ_t: year, day phase, hour, crime district, police unit ; and iv) personal controls which are captured through λ_t : number of individual's previous convictions, age, education, and gender.

Probability of accusation is estimated using analogous specification, only the dependent variable changes and is now restricted to a binary format (not accused=0, accused =1). The following model is then a type of a linear probability model:

$$Accusation_{i,n,t,j} = \sum_{i=1}^{8}\sum_{n=1}^{6} \beta_{i,n} I_{i,n} + \lambda_c + \lambda_l + \lambda_t + \lambda_j + \gamma X_{c,l,t,j} + \epsilon_{i,n}$$

c. Results

Table 1 shows how the damage per person changes with an increasing group size - marginal damage per person (marginal effect in the regression framework) is almost always negative. The reason why the marginal damage is negative even though the total product is mostly increasing is the fact that total product usually increases less proportionately than does the number of offenders. The returns to scale of this production function are therefore decreasing.

Tab. 1: Estimated damage per person, 2004-2016 individual-level dataset, fixed effects model, marginal effects (CZK)

Dep. var. : *Dmg.p.p.*	(1) theft	(2) car theft	(3) burglary	(4) robbery	(5) embezz.	(6) insurance fr.	(7) loan fr.	(8) other fr.	(9) all
Number of offenders = 2	-4,944***	-19,592***	-6,729***	-4,523***	-11,049***	-35,570***	-8,456***	-18,603***	-7,734***
	(116.4)	(944.9)	(170.4)	(316.7)	(2,473)	(2,818)	(540.0)	(621.0)	(114.9)
Number of offenders = 3	-6,890***	-26,204***	-8,761***	-5,199***	-36,719***	-53,218***	-15,032***	-25,048***	-10,451***
	(183.1)	(1,323)	(219.1)	(407.2)	(7,682)	(3,916)	(899.1)	(1,149)	(166.8)
Number of offenders = 4	-7,537***	-28,169***	-9,627***	-5,780***	15,714	-56,073***	-19,694***	-24,064***	-11,300***
	(305.7)	(2,431)	(334.8)	(622.1)	(35,323)	(6,069)	(1,832)	(2,217)	(273.4)
Number of offenders = 5	-8,459***	-32,936***	-10,255***	-5,396***	-34,021	-68,979***	-22,456***	-23,462***	-12,724***
	(560.3)	(4,041)	(593.5)	(1,085)	(22,109)	(8,278)	(3,353)	(3,562)	(487.5)
Number of offenders = 6	-7,425***	-41,336***	-11,227***	-7,192***	-26,823	-61,857***	-26,578*	-39,573***	-13,615***
	(1,022)	(9,457)	(1,067)	(1,744)	(21,769)	(13,637)	(15,868)	(6,456)	(893.1)
Observations	49,449	6,159	35,967	12,189	3,484	1,276	38,235	27,777	174,536
R-squared	0.145	0.189	0.123	0.153	0.196	0.397	0.166	0.138	0.217
Case controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time, location controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personal Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Police of the Czech Republic

Table 2 shows that partnering with one additional offender increases the probability of accusation by five percentage points and cooperating with more offenders keeps increasing it.

This suggests that the decreasing damage per person is not balanced by a decreasing probability of accusation.

Tab. 2: Estimated probability of accusations, 2004-2016 individual-level dataset, fixed effects model, marginal effects (CZK)

Dep. var. : p_A	(1) theft	(2) car theft	(3) burglary	(4) robbery	(5) embezz.	(6) insurance fr.	(7) loan fr.	(8) other fr.	(9) all
Number of offenders = 2,	0.0553***	0.122***	0.0487***	0.0204***	0.0684***	0.0182*	0.0376***	0.0457***	0.0494***
	(0.00142)	(0.00572)	(0.00159)	(0.00288)	(0.0164)	(0.0101)	(0.00305)	(0.00336)	(0.000906)
Number of offenders = 3	0.0618***	0.130***	0.0535***	0.0228***	-0.0529	0.0504***	0.0639***	0.0673***	0.0555***
	(0.00223)	(0.00801)	(0.00205)	(0.00370)	(0.0509)	(0.0141)	(0.00508)	(0.00621)	(0.00131)
Number of offenders = 4	0.0554***	0.135***	0.0501***	0.00235	0.230	0.0763***	0.0872***	0.0617***	0.0491***
	(0.00373)	(0.0147)	(0.00313)	(0.00565)	(0.234)	(0.0218)	(0.0103)	(0.0120)	(0.00216)
Number of offenders = 5	0.0521***	0.113***	-0.0187***	0.00472	0.0728	0.0661**	0.0575***	0.0732***	0.0161***
	(0.00683)	(0.0245)	(0.00554)	(0.00986)	(0.146)	(0.0298)	(0.0189)	(0.0193)	(0.00384)
Number of offenders = 6	0.0402***	-0.0110	-0.0750***	0.0379**	0.210	0.113**	0.0503	0.115***	-0.0162**
	(0.0125)	(0.0573)	(0.00997)	(0.0158)	(0.144)	(0.0491)	(0.0896)	(0.0349)	(0.00704)
Observations	49,449	6,159	35,967	12,189	3,484	1,276	38,235	27,777	174,536
R-squared	0.141	0.163	0.171	0.277	0.115	0.322	0.148	0.090	0.120
Case controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time, Location controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personal Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Police of the Czech Republic

3 Discussion

There are two possible explanations for decreasing damage per person when the probability of accusation simultaneously increases:

1) Opportunities with more offenders are more available than single-offender opportunities but also yield lower damage per person. By this reasoning, there are some high-yield opportunities which are exclusively used by single offenders, and they do the greatest damage per person. This is in line with the previously discussed stylized facts -the average number of offenders is over time decreasing. That can be a rational response to the shrinking pool of high-yield criminal opportunities with a required higher input of offenders.

2) Earnings are not shared equally. Although the total product in crimes with higher input is mostly increasing, some of the offenders might only make a little contribution. Thus, their share cannot be compared to the individuals who bear a higher risk. The 1/n rule does not have to hold for bigger groups, but it is hard to imagine couples and 3-people groups where all the participants bear the risk but do not share the loot equally. This is perhaps even more surprising in robberies where the risk pooling might not be possible (all of the three robbers do the approximately equally harmful activity and might face the same legal consequences). And as we have seen in the estimations, the probability of accusation increases with an increasing number of offenders.

The likely reason for the decreasing damage per person is then the availability of criminal opportunities. In any case, the hypothesis H1 is rejected – the returns to scale of the crime production function are not increasing. The hypothesis H2 is also rejected – decreasing returns to scale can't be explained by a decreasing probability of accusation.

Conclusion

This study provides the evidence that crime production function of Czech offenders does not necessarily need to exhibit increasing returns to scale. Right on the contrary, even after employing an empirical strategy rather rich in the dimension of control variables, the damage per person still seems to be lower for crimes with higher number of offenders. These "losses" in the productivity also don't seem to be compensated by a decreasing probability of punishment as proxied by accusation in this study. Right on the contrary, again, the marginal probabilities of accusation tend to be positive with regards to an increasing number of offenders. Both hypothesis of this study then had been rejected. Although this study presents a rather though-trough attempt to tackle numerous (self-)selection biases, it would still greatly benefit

from a discussion of other possible endogenous effects. Overall, the research of " criminal production teams" seems to be a fruitful, untamed area for future research in the domain of economics of crime.

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