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The Effect of Additional Police Force on Crime Rate: Evidence from Women's Japan Basketball League

Hiroya Kawashima
Osaka School of International Public policy, Osaka University

Abstract

This paper analyzes influence of an additional referee on number of fouls by using the data from Women's Japan Basketball League (WJBL) in order to examine whether number of police officers affects the crime rate. For the season of 2010-2011, the upper league of the WJBL introduced three-referee system for the adaption of the international standard. Using this natural experiment, the Difference in Difference and the Instrumental Variable method are used to remove endogeneity. The results indicate that increased number of referees decrease number of fouls after considering both reverse causality and unobservable heterogeneity.

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Contact: Hiroya Kawashima - h-kawashima@osipp.osaka-u.ac.jp.
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1. Introduction

Backer's (1968) economic theory of crime predicts that crime rates decrease when police resources increase because of the rise in the criminal's expected cost of being arrested. However, it is difficult to validate this theory empirically because most police officers are employed in crime-ridden areas. Hence, reverse causality biases the estimation.

Studies in which attempts have been made to overcome this endogeneity problem can be categorized into four types. In the first type, which is the most common, the instrumental variable method is used, as in Cornwell and Trumbull (1994), Levitt (1997), Evans and Owens (2007), Lin (2009) and Worrall and Kavandzic (2010). In the second type, information on the allocation of police officers following terrorist attacks, independently of the crime rate, is used, as in Klick and Tabarrork (2004), Draca, Machin and Witt (2011). In the third type, monthly data are used, as in Corman and Mocan (2000); the logic behind this is that decisions to increase police numbers take longer than a month to implement. In the fourth type, which is the approach adopted in this paper, data on sporting events are used.

The seminal study in which data on sporting events are used is by McCormick and Tollison (1984), who use data from the Atlantic Coast Conference (ACC) basketball tournament. Their analysis is based on the natural experiment that arose from the ACC changing to a three-referee system from a two-referee system in 1979. By regarding referees as police officers, and fouls as illegal activities, they examine whether increasing the number of referees (police officers) decreases the number of fouls (illegal activities). This approach successfully overcomes the issue of reverse causality because a natural experiment involving a random increase in the number of referees is used. Although Hutchinson and Yates (2007) admit that their study is affected by data-coding errors, McCormick and Tollison (2007) then shows that the number of referees affects the number of fouls is robust to such errors. However, Hutchinson and Yates (2006) were unable to confirm this finding from a box-score analysis of an extended data set based on additional ACC tournament data from subsequent years.

Other data, such as that from the National Hockey League, have also been used to analyze other sports. During the 1998–1999 season, the National Hockey League randomly increased the number of referees per game by 20%. Levitt (2002), Allen (2002), and Heckleman and Yates (2003) uses this natural experiment to investigate the effect of increasing the number of referees. Heckleman and Yates (2003) uses the instrumental variable method to divide this effect into a monitoring effect and a deterrent effect. There is no evidence that the number of referees has a significant effect in these studies using data from the National Hockey League.

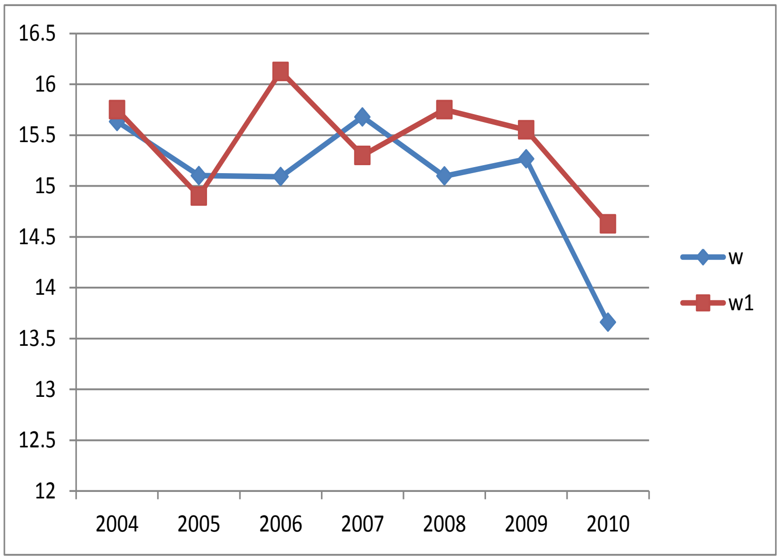
Hence, several researchers have used sports data to deal with the issue of reverse causality in estimating the effect of increased police numbers on crime. However, in the context of investigating the relationship between crime and police numbers, reverse causality is not the only source of endogeneity; it can also be caused by unobservable factors being correlated with both police numbers and crime. Such factors, for example, include the recognition of, and reactions to, increased risk, and abilities to commit crimes undetected by the police. These issues also arise in the analysis of sports data. Therefore, in this paper, based on data from the Women's Japan Basketball League (WJBL), the first step in the analysis is to use difference-in-differences (DD) estimation to deal with reverse causality. Then, the instrumental variable method is used to control for unobservable heterogeneity among players. Based on difference-in-differences estimation, which deals only with reverse causality, there is no evidence that the number of referees significantly affects the number of fouls. This result is consistent with previous research. However, based on instrumental variable estimation, which deals with both reverse causality and unobservable heterogeneity among players, there is evidence that an increase in the number of referees reduces the number of fouls.

This paper is organized as follows. The natural experiment of WJBL and the data are presented in the following section. The difference-in-difference estimation is in section three. The instrumental variable estimation is presented in section four. Finally, section five concludes.

2. The WJBL Experiment and Data

The WJBL comprises the upper league (the W League) and the lower league (the W1 League). Before the 2009–10 season, both leagues used the two-referee system; the three-referee system was only used during the playoffs. In the 2010–2011 season, the three-referee system was introduced into the W League only. This new system was introduced to bring the WJBL into line with international standards. Hence, the number of referees was increased exogenously. Figure 1 shows numbers of fouls per game over the past seven years. Numbers of fouls are similar for both leagues; there is no tendency for more fouls to be committed in the upper league.

Figure 1 Numbers of fouls per game over the past seven years



The two leagues to be compared are homogenous throughout the period between seasons 2009–2010 and 2010–2011, in that only one team moved from one league to the other. Moreover, players can only be transferred at the end of each season, and foreign players are basically excluded. Hence, the treatment and control groups are close to homogeneous through time.

This natural experiment forms the basis of this paper's analysis of whether increasing the number of referees reduces the number of fouls. Player statistics from the WJBL for seasons 2009–2010 and 2010–2011 constitute the data used for analysis. These data are available from the WJBL website. Although box scores (data on each game) can be obtained, it is impossible to identify the corresponding games in successive years. Hence, panel data cannot be constructed. In addition, box scores are highly sensitive to unobservable heterogeneity between games. Nevertheless, data on two successive seasons were not only less affected by heterogeneity among games but also have the merits of panel data. Table 1 reports the descriptive statistics.

Table 1 Descriptive statistics

Variable	number of sample	average	standard error	minimum	maximum
Dependent variable					
logarithm of fouls per game	293	0.144	0.725	-2.485	1.273
Independent variable					
W league dummy	293	0.608	0.489	0.000	1.000
number of game match	293	17.567	7.966	1.000	28.000
success rate of two-point goal of other teams in the same league	293	0.453	0.022	0.409	0.492
success rate three-point field goal of other teams in the same league	293	0.311	0.016	0.293	0.343
success rate free throws of other teams in the same league	293	0.752	0.015	0.719	0.774
average score of each game	293	6.372	4.406	0.000	20.140
the gap between the average height of players	293	-172.569	7.216	-191.253	-153.240
the age differences between the head coaches	293	0.000	0.006	-0.010	0.014
position dummies					
Positiion: Center dummy	293	0.123	0.329	0.000	1.000
Positiion:Center Forward dummy	293	0.232	0.423	0.000	1.000
Positiion:Small Forward dummy	293	0.263	0.441	0.000	1.000
Positiion:Guard dummy	293	0.191	0.394	0.000	1.000
Positiion: Shooting Guard dummy	293	0.177	0.383	0.000	1.000
Positiion: Point Guard dummy	293	0.014	0.116	0.000	1.000

The dependent variable is the log of the number of fouls per game. In addition to the number of referees, the following variables referring from McCormick and Tollison (1984) are used as independent variables: the number of games played; success rates for two-point goals, three-point field goals and free throws by other teams in the league; average score per game; each player's height difference from the average height of players in the league; and the head coach's age difference from other head coaches in the league (to proxy years of experience). Position dummies are also used.

3. Difference-in-Difference Estimation

Difference-in-difference estimation is used to deal with reverse causality. The empirical model is as follows:

$$\ln Foul_{it} = \alpha' YearDummy_t + \beta' WLeagueDummy_i + \gamma' DD_{it} + \delta' X_{it} + u_{it} \qquad (1)$$

where i indicates the player, t indicates the year, $YearDummy_t$ represents a vector of year dummies, $WLeagueDummy_i$ represents a vector of W-league dummies, and DD_{it} represents a vector of difference-in-difference estimator. The coefficient on DD_{it} represents the effect of an increase in the number of referees on the number of fouls. The vector X_{it} contains other independent variables.

Table 2 Difference in Difference Estimation

	(1)	(2)
DD estimator	5.9955	5.9673
	(5.9169)	(5.7111)
2010 dummy	-1.3619	-1.3769
	(1.0351)	(1.0089)
W league dummy	-5.9360	-5.9128
	(5.4898)	(5.2830)
number of game match	0.0408***	0.0409***
	(0.0058)	(0.0063)
success rate of two-point goal of other teams in the same league	5.0594	4.3732
	(8.8016)	(8.5159)
success rate three-point field goal of other teams in the same league	130.5237	129.2365
	(143.5017)	(137.9341)
success rate free throws of other teams in the same league	15.7396***	16.5888***
	(4.2518)	(4.3472)
average score of each game	0.0686***	0.0684***
	(0.0075)	(0.0074)
the gap between the average height of players	-0.0085	-0.0127
	(0.0061)	(0.0161)
the age differences between the head coaches	101.0160	98.5985
	(122.5971)	(118.6231)
Positiion: Center dummy		0.1023
		(0.1182)
Positiion:Center Forward dummy		-0.0098
		(0.1494)
Positiion:Small Forward dummy		0.1601
		(0.2626)
Positiion: Shooting Guard dummy		0.0565
		(0.1609)
Positiion: Point Guard dummy		0.1212
		(0.1855)
Constant	-54.7879	-55.4952
	(45.4912)	(43.5010)
Observations	293	293
R-squared	0.55	0.56

Note 1. Cluster robust standard errors in parentheses
2. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2 reports the difference-in-difference estimates. The coefficient of interest (on DD_{it}), which represents the effect of an increase in the number of referees on the number of fouls, is not significant in either specification at the 10% level. This means that increasing the number of referees does not affect the number of fouls.

4. Instrumental Variable Estimation

In the difference-in-difference model, there exists the possibility of a correlation between the number of referees and the error term if unobservable heterogeneity among players, which may affect the number of fouls, changes over time. For example, there is the possibility that a player can violate a rule without being called. If the players have such an ability, the number of fouls decreases. Moreover, if such players are expected to have better ball technique and positioning, they are more likely to play in the upper league (the W League), which increased the number of referees. Hence, the estimated effect of the increased number of referees appears small.

To control for such unobservable heterogeneity among players, instrumental variable estimation is performed by using panel data on players who played in both seasons. The underlying model is as follows:

$$\ln Foul_{it} = Referee_{it}^{'}\beta + X_{it}^{'}\gamma + u_{it} \quad (2)$$

where *i* indicates the player and *t* indicates the year. The error term is $u_{it} = \mu_i + v_{it}$, in which μ_i represents unobserved heterogeneity among players, and v_{it} is $v_{it} \sim iid(0, \sigma_v^2)$ and is uncorrelated with both X_{it} and $Referee_{it}$. After taking first differences of equation (2) to remove the effect of μ_i, the following basic econometric specification is obtained:

$$\Delta \ln Foul_{it} = \Delta Referee_{it}^{'}\beta + \Delta X_{it}^{'}\gamma + \Delta u_{it.} \quad (3)$$

To deal with the endogeneity arising from the correlation between $Referee_{it}$ and $Foul_{it}$, the number of players registered by each team in the previous season is used as an instrumental variable. Because teams with larger numbers of players tend to have more financial resources and better players, these teams are more likely to play in the upper league (the W League) in the following year, and therefore to be subject to the three-referee system.

Table 3 Instrumental Variable Estimation

	(1)	(2)
number of referees	-2.9020**	-2.5417*
	(1.2815)	(1.1926)
number of game match	0.0308***	0.0300***
	(0.0080)	(0.0080)
success rate of two-point goal of other	6.1069	3.2689
teams in the same league	(13.4472)	(12.6536)
success rate three-point field goal of	332.7990**	304.2878**
other teams in the same league	(120.6080)	(103.6706)
success rate free throws of other teams	-41.9051**	-36.5209**
in the same league	(17.8380)	(15.7843)
average score of each game	0.0870***	0.0863***
	(0.0168)	(0.0168)
the gap between the average height of	-234.9237**	-214.8362**
players	(88.2572)	(76.2010)
the age differences between the head	259.4096**	236.9946**
coaches	(103.8170)	(87.9387)
Positiion: Center dummy		0.3369***
		(0.1043)
Positiion:Center Forward dummy		0.0000
		(0.0000)
Positiion:Small Forward dummy		0.1621***
		(0.0468)
Positiion: Shooting Guard dummy		0.0000
		(0.0000)
Positiion: Point Guard dummy		0.0000
		(0.0000)
Constant	5.2500**	4.7683**
	(1.9850)	(1.7174)
Observations	113	113
R-squared	0.40	0.41

Note 1. Cluster robust standard errors in parentheses
2. * significant at 10%; ** significant at 5%; *** significant at 1%

The instrumental variable estimates reported in Table 3 show that the coefficient on the variable representing the number of referees is statistically significant at the 5% and 10% levels. This means that, when reverse causality and unobserved heterogeneity among players are controlled for, an increase in the number of referees reduces the number of fouls.

5. Conclusion

In this paper, data from the WJBL were used to estimate the effect on the number of fouls of increasing the number of referees. The empirical problem of endogeneity arises because of the relationship between police numbers (referees) and the crime rate (fouls). This is mainly because police numbers are increased more in crime-ridden areas. Moreover, unobservable factors correlated with both police numbers and the crime rate bias the estimation. In this paper, the problem of reverse causality was dealt with by exploiting the natural experiment conducted in the WJBL. In addition, instrumental variable estimation was used to control for unobservable factors that are correlated with both the number of fouls and the number of referees.

Based on the difference-in-difference estimates, the number of referees does not have a significant effect on the number of fouls. This is consistent with results from previous studies in which sports data are used. However, the difference-in-difference estimation deals only with reverse causality. Therefore, instrumental variable estimation was used to control for unobservable heterogeneity among players. Based on the instrumental variable estimates, increasing the number of referees reduces the number of fouls. This result is consistent with the prediction of the economic theory of crime.

The results of this paper, which control for both reverse causality and unobservable heterogeneity, suggest that increasing police numbers would reduce the crime rate. Increasing police numbers would be particularly effective in preventing crimes committed using quick judgment, as are fouls in basketball. Even when making rash judgments, people mentally calculate the expected costs and benefits and would be less likely to commit crimes were police numbers to increase because this would raise the expected costs of crime.

Several issues remain. First, it was not possible to distinguish between monitoring effects and deterrent effects. However, this paper's finding that increasing the number of referees reduces the number of fouls suggests that the deterrent effect dominates. Increasing police numbers has both effects, and consequently reduces crime. Second, the expected costs and benefits of top players and those on the verge of promotion to the upper league or relegation to the lower league may differ from those of other players. Third, because of data limitations, it was not possible to distinguish between premeditated and spontaneous crimes. These issues invite future analysis.

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