OSIPP Discussion Paper : DP-2012-E-011

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

November 27, 2012

Hiroya Kawashima*

Ph.D. student, Osaka School of International Public Policy (OSIPP)

【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 3 referees 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.

【Key Words】Police, Crime, Basketball

【JEL Classification Codes】D0, K0

*Address: 1-31 Machikaneyama, Toyonaka, Osaka 560-0043 E-mail: h-kawashima@osipp.osaka-u.ac.jp

I would like to thank Miki Kohara (Osaka University) and Nobuo Akai (Osaka University) for providing valuable comments.

This Discussion Paper was made by permission of Nobuo Akai, who is my advisor at OSIPP.

1. Introduction

Backer (1968)'s economic theory of crime shows that crime rate decreases when police resource increase due to the rise in expected cost to be arrested. However, it is difficult to prove that empirically because it is often the case that police officers are employed more in a crime-ridden area. Hence, the reverse causality causes bias in the estimation.

Previous studies that have strived to overcome endogeneity problem are categorized into four. Firstly, the most frequently used approach is to use the Instrumental Variable method as in Cornwell and Trumbull (1994), Levitt (1997), Evans and Owens (2007), Lin (2009) and Worrall and Kavandzic (2010). Secondly, there are studies used the allocation of police officers after the terrorism regardless the crime rate as in Klick and Tabarrork (2004), Draca, Machin and Witt (2011). Additionally, some researchers analyze by using monthly data sets as it takes time to actually increase the number of police force after the decision is made to an increase such as Corman and Mocan (2000). Finally, there are studies conducted by using data sets of sports match, which is the approach of this paper.

The seminal work using the data of sports match is McCormick and Tollison (1984).Their paper uses the data from the Atlantic Coast Conference (ACC) Basketball Tournament. It uses the natural experiment that the ACC introduced three referees system from two referees system in 1979. By regarding referees as police officers, and fouls as illegal activities, it examines whether the increase of referees (police officers) decreases the number of fouls (illegal activities). This approach successfully overcomes the issue of above mentioned reverse causality by using the natural experiment that the number of referee is increased randomly. Although Hutchinson and Yates (2007) points out data-coding error for this work, McCormick and Tollison (2007) shows the similar result that the number of referees affects the number of fouls even after correcting the data-coding error. However, Hutchinson and Yates (2006) claims that the number of referees does not influence the number of fouls by analyzing the data set that is created by adding data from subsequent years of the ACC tournament on the data set used by McCormick and Tollison (1984) as well as using box score.

Other than the basketball, several researches also conduct analyses by using the data of the National Hockey League (NHL). During 1998-99 season, the NHL randomly increased number of referees in 20% of total number of game match. Levitt (2002), Allen (2002), and Heckleman and Yates (2003) uses this natural experiment to investigate the influence of referee increase. Heckleman and Yates (2003) uses the Instrumental Variable method to divide the effect into

monitoring effect and deterrent effect. These researches using the data of the NHL find no significant influence.

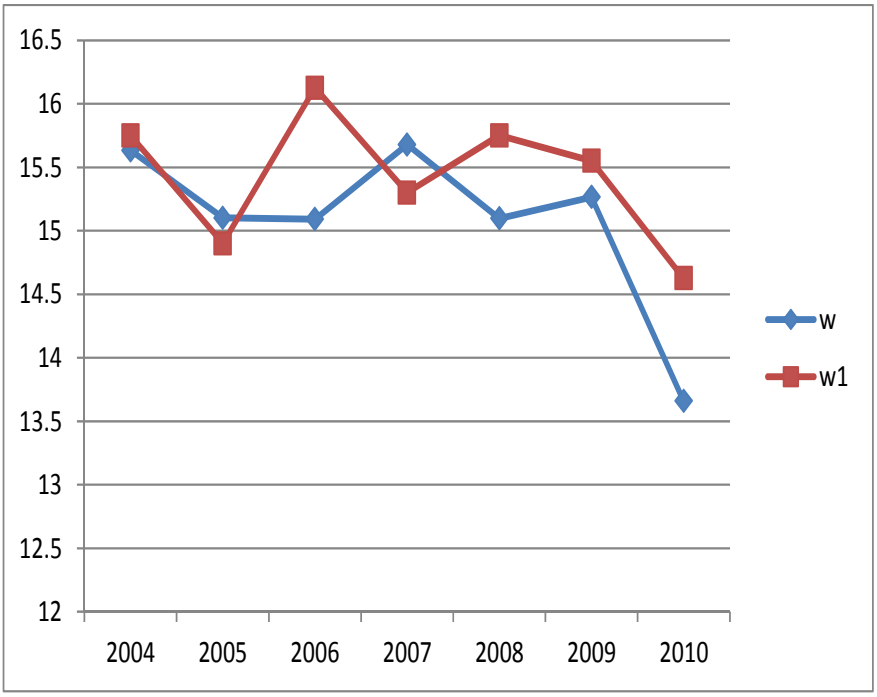
As seen, several researchers have already investigated the effect of the increased police presences on crime by using sports data in order to consider reverse causality. Nevertheless, endogeneity problem between crime and police occurs not only because of the issue of above mentioned reverse causality, but also unobservable factors that correlate with both police force and crime such as recognition and reaction to the increased risk or the ability to commit a crime without being noticed by the police. These issues also exist in the analysis by using the data of sports match. Therefore, this paper firstly carries outs the analysis by using the Difference in Difference estimation for the purpose of considering the reverse causality by using the WJBL data. Then, this paper conducts the second analysis by using Instrumental variable method in order to control for unobservable heterogeneity among players. As a result, the Difference in Difference estimation, which considers only the reverse causalities, shows no significant influence of increased number of referees on the number of fouls. This result is consistent with the many previous researches. Nonetheless, when both reverse causality and unobservable heterogeneity among players are considered by using Instrumental Variable estimation, the rise in the number of referees decreases the number of fouls.

This paper is organized as follows. The natural experiment of the WJBL and the data are presented in the following section. The Difference in Difference estimation is presented in section three. The Instrumental Variable estimation is presented in section four. Finally, section five concludes.

2. The WJBL experiment and data

The WJBL has the upper league (W league) and the lower league (W1 league). Before 2009-2010 season, both leagues basically had two referees system, and used three referees system only during playoff. In the season of 2010-2011, the new system of three referees was only introduced to the W league. This new system was introduced for the purpose of adapting the rule to the international standard. So the number of referee was increased exogenously. Figure 1 show the number of fouls per game for the past seven years. The number of fouls in both the W league and the W1 league is the same level. So there isn’t the situation that more fouls are likely to be observed in the games for the upper league.

FIGURE 1 Number of fouls per game for the past seven years



When it comes to the homogeneity of the W league and the W1 league throughout the time, between the season 2009-2010 and the season 2010-2011, there was only one exchange in league members. Moreover, transfers of players only happen after each season, and registrations of foreign players are basically not admitted. Therefore, the treatment group and the control group are almost homogeneous throughout the time.

This paper uses this natural experiment to investigate whether the increased number of referees decreases the number of fouls. Data set to be used in the paper is the players' statistics of the WJBL 2009-2010 and the WJBL 2010-2011. They are available from the website of the WJBL. Although box score (data of each game) can be obtained, it is impossible to identify games that categorized as same in the analysis throughout two years. Hence, panel data cannot be constructed. Additionally, box scores are more influenced by unobservable heterogeneity among games. On the other hand, the data set of the seasons enable analysis to estimate the effect of the increased number of referees without being less affected by heterogeneity among each game, as well as utilizing the merit of panel data. Table 1 shows 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

As for the dependent variable, the log of number of fouls per game is used. As for independent variables, in addition to the number of referees, variables referring McCormick and Tollison (1984) are used. They are: number of game match, success rate of two-point goal, three-point field goal and free throws of other teams in the same league, average score of each game, the gap between the average height of players belongs to other teams in the same league and the height of each player, the age differences between the head coach of other teams in the same league and the head coach of the team each player belongs to as a proxy for years of experience. And the position dummies are also used.

3. Difference in Difference Estimation

Firstly, the Difference in Difference is used to overcome the reverse causality. Empirical model is as follows.

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

Where i indicates a player, t indicates year. $\mathrm{YearDummy_t}$ denotes a vector of year dummies, $\mathrm{WLeagueDummy_i}$ is the vector of W league dummies. $\mathrm{DD_{it}}$ is the vector of Difference in Difference estimator. There *DD* term measures the effect of increased referees on the number of fouls. A vector X_{it} indicates other independent variables.

Table2 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 presents the result obtained by the Difference in Difference estimation. The focus of this paper, the coefficient of the *DD* term which measures the effect of increased referees on the number of fouls does not show the significant influence for both specifications even at 10% level. This means increase in the number of referees does not influence the number of fouls.

4. Instrumental Variable Estimation

The above Difference in Difference estimation has the possibility of correlation between the variable of the number of referees and the error term if unobservable heterogeneity among players, which may affect the number of fouls, changes over time. For instance, there is individual ability that a player can make rule violation without being called. If she has the high ability of deceiving referees, the number of fouls decreases. Moreover, it is expected that these individuals have higher technique of ball handling and positioning. Consequently, these players are likely to play in the upper league (W league) which has increased the number of referees. If this is the case, the influence of increased number of referees appears to be small in the estimation.

In order to control for such unobservable heterogeneity among players, panel data of players who are existed for both seasons is constructed and the Instrumental Variable estimation is conducted. The base model is as follows.

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

Where *i* indicates a player, *t* indicates year. Error term is described as $u_{it} = \mu_i + v_{it}$. μ_i is unobserved heterogeneity among players. v_{it} is $v_{it} \sim iid(0, \sigma_v^2)$ and does not correlate with $\mathrm{X_{it}}$ and $\mathrm{Referee_{it}}$. In order to remove the effect of μ_i, the first difference of (2) is taken. So the basic econometric specification is as follows.

$$\Delta \ln Foul_{it} = \Delta Referee_{it}^{'}\beta + \Delta X_{it}^{'}\gamma + \Delta u_{it}$$

Furthermore, for the purpose of taking endogeneity, which exists between $\mathrm{Referee_{it}}$ and $\mathrm{Foul_{it}}$, into consideration, the number of players registered by each team in the previous season is used as the instrumental variable. Because the teams with larger number of players tend to have richer financial resources and better players, these teams are likely to play in the upper league (W league) in the following year, and to be the 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 teams in the same league	6.1069	3.2689
	(13.4472)	(12.6536)
success rate three-point field goal of other teams in the same league	332.7990**	304.2878**
	(120.6080)	(103.6706)
success rate free throws of other teams in the same league	-41.9051**	-36.5209**
	(17.8380)	(15.7843)
average score of each game	0.0870***	0.0863***
	(0.0168)	(0.0168)
the gap between the average height of players	-234.9237**	-214.8362**
	(88.2572)	(76.2010)
the age differences between the head coaches	259.4096**	236.9946**
	(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%

Table3 shows the result of the Instrumental Variable estimation. This result shows that the coefficient of the variable of the increased number of referees is statistically significant at 5% and 10% level, respectively. This means the increase of referees decreases the number of fouls when the reverse causality and unobserved heterogeneity among player are considered.

5. Conclusion

This paper analyzes influence of an additional referee on number of fouls by using the data from WJBL. The difficult problem of the empirical analysis of the relationship between the police existence and the crime rate is endogeneity problem. It is often the case that crime ridden area increases the number of police officers. Moreover, unobservable factors, which correlate with both number of police officers and crime rate, could cause bias in estimation. This paper uses the natural experiment conducted in WJBL to overcome reverse causality. Additionally, the Instrumental Variable estimation is employed to control for unobservable heterogeneity that correlate with the number of fouls and the number of referees.

First estimation using the Difference in Difference shows no significant influence of increased number of referees on the number of fouls. This is consistent with many previous studies used data of sports match. However, this estimation only deals with the reverse causality. Therefore, the second estimation uses the Instrumental Variable method to control for unobservable heterogeneity among players. This estimation revealed that increased number of referees decreases the number of fouls. This result is consistent with the result predicted in the economic theory of crime.

When applying the result of this paper to the reality of crime, the result, which is obtained from the estimation taking both reverse causality and unobservable heterogeneity among players into consideration, suggests that increasing policing force decrease crime rate. It is particularly effective to prevent crime that was unplanned and committed by the quick judgment like fouls in the basketball match.

Some issues still remain. This paper is unable to make a distinction between monitoring effect and deterrent effect. Nonetheless, it is understood that deterrent effect is greater than the monitoring effect because the total number of fouls has declined. Hence, increasing policing force has both effects, and consequently reduces crime. Also, players who are close to be a champion or not, or players who are facing to drop out to the lower league or promoted to the upper league may have different expected cost and benefit as other players. These differences need to be concerned in the future analysis.

Reference

Allen, E. D. (2002) “Crime, punishment, and recidivism: lessons from the National Hockey League.” *Journal of Sports Economics* **3**, 39-60.

Becker, G. S.(1996) “Crime and Punishment: An Economic Approach.” *Journal of Political Economy* **76**, 169-217.

Corman, H., and M. H. Naci. (2000) “A Time-Series Analysis of Crime, Deterrence, and Drug Abuse in New York City.” *The American Economic Review* **90**, 584-604.

Cornwell, C. and W. N. Trumbull. (1994) “Estimating the Economic Model of Crime with Panel Data.” *Review of Economics and Statistics* **76**, 360-366.

Draca, M., S. Machin., and R.Witt. (2011) “Panic on the Streets of London: Police, Crime, and the July 2005 Terror Attacks.” *The American Economic Review* **101**, 2157-2181.

Evans, W. N., and E. G. Owens. (2007) “COPS and Crime,” *Journal of Public Economics* **91**, 181-201.

Heclkelman, J. C., and A. J. Yates. (2003) “And a Hockey Game Broke Out: Crime and Punishment in the NHL.” *Economic Inquiry* **41**, 705-712.

Hutchinson, K. P., and A. J. Yates. (2007)“Crime on the Court: A Correction,” *Journal of Political Economy* **115**, 515-519.

Hutchinson, K. P., and A. J. Yates. (2006)“Blind as a Bat or Eyes like a Hawk: Do Additional Referees Deter Crime on the Court?” Working Paper, Soc. Sci. Res. Network, no.921036.

Klick, J., and T. Alexander. (2005) “Using Terror Alert Levels to Estimate the Effect of Police on Crime.” *Journal of Law and Economics* **48**, 336-348.

Levitt, S, D.(2002) “Testing the Economic Model of Crime: the National Hockey League’s Two Referee Experiment.” *The Berkeley Electronic Journals in Economic Analysis & Policy* **1**, 1-19.

Levitt, S, D. (2002) “Using Electoral cycles in Police Hiring to Estimate the Effect of Police on Crime: Reply.” *The American Economic Review* **92**, 1244-1250.

Levitt, S. D. (1997) “Using Electoral cycles in Police Hiring to Estimate the Effect of Police on Crime.” *The American Economic Review* **87**, 270-290.

Lin, Ming-Jen. (2009) “More Police, Less Crime: Evidence from US State Data.” *International Review of Law and Economics,* **29**, 73-80.

McCrary, J. (2002) “Using Electoral cycles in Police Hiring to Estimate the Effect of Police on Crime: Comment.” *The American Economic Review* **92**, 1236-1243.

McCormic, R. E., and R. D. Tollison. (2007) “Crime on the Court, Another Look: Reply to Hutchinson and Yates.” *Journal of Political Economy* **115**, 520-521.

McCormic, R. E., and R. D. Tollison.(1984) “Crime on the Court.” *Journal of Political Economy* **92**, 223-235.

Worrall, J. L. and V. K. Tomislav. (2010) “Police Levels and Crime Rates: An Instrumental Variable Approach.” *Social Science Research,* **39**,506-516.