

## Research Article

# A Game Theoretic Analysis of the Traditional Juvenile Justice Methods in Korea and Suggestions for Transformative Interventions

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**Abstract:** This study presents a different methodology for theoretically identifying the effects of various factors on juvenile delinquency rates. Using game theory and the subgame perfect Nash equilibrium, the payoff for each decision is calculated. We obtained juvenile delinquency statistics from the Korean Statistical Information Service (KOSIS) to perform an empirical analysis. The results successfully anticipated a change after the 2008 juvenile law adjustment, which lowered recidivism and crime rates. However, after performing an exhaustive simulation using the evolutionary game theoretical model, we found that this phenomenon may be transient. Higher law enforcement costs constantly force lower law enforcement rates; hence, more sustainable solutions are required.

**Keywords:** Juvenile delinquency, Game Theory, Nash Equilibrium, Criminology.

## 1. Introduction

Based on Article 1 of Law No. 23 of 2002 on Child Protection, any criminal acts that have been committed by juveniles under the age of 18 are referred to as juvenile delinquency. There is a massive global concern regarding juvenile delinquency. Specifically in Korea, juvenile delinquency among Korean adolescents has now surfaced among younger adolescents, who are more violent, and the delinquent behavior among girls has also increased (Ministry of Culture and Sports, 1996; Legal Research and Training Institute, 1994). Thus, sufficient research has been conducted on the constituting factors of juvenile delinquency, such as family relationships, peer behaviors, and the level of education received.

Early youth development has emotional, intellectual, social, and physical aspects with the child's family at the roots of this type of development. Therefore, family structure plays a significant role in shaping a child's morals, values, and life skills. A study found that 78% of juvenile offenders came from families that experience physical violence and child abuse whereas the other 22% of offenders belonged to families that did not experience child violence (Sarantakos, 1997). However, there are no formal studies on the payoffs of juvenile law enforcements that determine whether the changes in the penal system lead to a significant impact on the issue. In particular, Korea has faced a sharp rise in juvenile crime since 2005, which was faced with an attempt at addressing the uprising in 2008 through the enforcement of the juvenile law. To anticipate future laws and adjustments, it is crucial to analyze this particular change that will provide us with a better understanding of the impact it has had on Korean society.

In this paper, the literature review is split into two unique sections: one section concerns the sociological approach to juvenile delinquency and the other section deals with the economic approach. The sociological approach discusses the issue through the structure of society, suggesting

that any delinquent behavior among juveniles is attributable to the society. The economic approach addresses the issue through a rational approach by analyzing the delinquents' likelihoods and reason for their decisions in society, whether to commit a crime. The costs of committing a crime are further analyzed by constructing a game-theoretic model comprising juvenile delinquents characterized as high-and low-risk offenders. High-risk offenders find it easier to commit violent crimes than low-risk offenders. This follows three assumptions regarding the criminals' likelihood of committing a crime, cost of imprisoning these juvenile criminals for the police, the perception that jailed criminals cannot commit any more crimes, and those under protection can decide to recommit. Through backward induction, the suboptimal Nash equilibrium is for each game to determine the best possible outcome for each scenario involving a juvenile criminal and police/government.

To test these game theory scenarios, data were obtained from the Korean Statistical Data Service (KOSIS). The data from the online portal for KOSIS were thereafter inputted into Pandas, a software library for Python programming language, which was used to analyze the criminal statistics from 1993 to 2020.

## **2. Literature and background**

### **2.1 Juvenile delinquency in Korea**

According to the 2007 Act No.8722, which was later enforced on June 22, 2008, the juvenile protection law serves to help young juveniles grow soundly by taking necessary measures, such as protective and constructive measures for environmental adjustment and behavior correction, and special measures related to criminal dispositions for antisocial juveniles. In Korea, the first ever "Chosun Juvenile Ordinance" was established in February 1942, which was abolished by the enactment of the juvenile law in 1958. Over the past decade, the number of juvenile criminal offenders subject to criminal punishment has increased, with the juvenile act enforcement showing no evidence of criminal deterrent. The decrease in the number of 10–13 year old criminal minors indicates an increase in the mean age of juvenile crimes (KOSTAT, 2019). These statistics show that it is difficult to determine whether previous law enforcement and enactment have been effective in changing the existing issue of juvenile delinquency in South Korea.

In Korea, '형사미성년자' refers to a criminal minor who is under the age of 14 and is not guilty of a crime under the Criminal Act even if he/she commits a crime. Whether a juvenile is a "criminal minor" is determined based on the time of the illegal act. '소년법' refers to the juvenile act, which confers special status for correcting and rehabilitating a juvenile rather than punishing juveniles in antisocial circumstances. It provides "preferential treatment" to juvenile offenders. In Korea, when a juvenile commits a crime, this law is popularly brought up in defense of the crime. People are easily confused between the Juvenile Act and the Juvenile Protection Act; however, these are completely different laws. The Juvenile Act serves to help young juveniles grow soundly by taking necessary measures, such as protective and constructive measures for environmental adjustment and behavior correction, and special measures related to criminal dispositions for antisocial juveniles. The Juvenile Protection Act, meanwhile, prepares a social environment to protect juveniles in an open society. A juvenile between the ages of 10 and 14 who commits an act in violation of the penal code will be considered a juvenile protection case (Article 4, Paragraph 1, Item 2 of the Juvenile Act). These juveniles are referred to as a "촉법소년(criminal minor)," which has the same meaning as a '형사미성년자'. It is true that there is no "punishment," but the juvenile may spend up to two years in a juvenile detention center through protective measures.

The juvenile law was edited several times, in December 1977, December 1988, January 2008, and June 2008. The revised juvenile law of 2008 is characterized by a stronger policy against juvenile offenders and stronger caution toward prosecution in the prosecution office. The juvenile law was enforced for reasons such as an increase in juvenile recidivism rates, increase in the fertility of

juvenile crime, and decrease in the mean age of juvenile offenders. The 2008 adjustment included the following changes:

- ✓ Change in the upper age limit of “juvenile protection” from 20 to 19 years old.
- ✓ Change in the lower age limit from 12 years old or older to 10 years old or older.
- ✓ Provision of education and psychological counseling to juvenile delinquents.
- ✓ Increased restrictions on juveniles being allowed to go out of surveillance.
- ✓ Extension of the short-term probation period from six months to one year.

After the Juvenile Law was revised in 2008, the total number of juvenile offenders decreased until 2017. During this period, the juvenile crime rate dropped, as did the proportion of juvenile criminal offenders. The number of convicted juveniles remained constant between 2018 and 2020 (66,259 in 2018, 66,024 in 2019, and 64,595 in 2020) despite a decrease in the juvenile criminal rate in previous years. The number of criminal minors was 7,364 in 2018, 8,615 in 2019, and 9,606 in 2020. Among these convicted juveniles, 39,694 were sent to juvenile detention centers over the past five years.

## **2.2 Juvenile delinquency in the academic literature**

Juvenile delinquency is a global issue that is discussed to varying extents in different cultures. Juvenile crime is defined differently across countries, because the magnitude of a crime and the age of legal juveniles depend on the country’s judicial system. Similarly, the treatment that juvenile delinquents receive, whether they are sanctioned, under probation, or rehabilitated, is extremely different depending on the country’s juvenile treatment system. A juvenile delinquent is defined as a person under the legal age of a country (usually below 18 years), who is found to have committed a crime in states that have declared by law that a minor lacks responsibility and thus may not be sentenced as an adult (Hill and Hill, 2002). Juvenile delinquency covers a plethora of irresponsible acts committed by juveniles, which may be due to causes, such as issues associated with family, past psychological trauma, and drug addiction. Society is becoming increasingly worried about rising juvenile crime rates, making this global issue perplexing and prevalent.

One approach to juvenile delinquency is both psychological and sociological. A sociological approach searches for the breakdown of social institutions and the capabilities of society to address criminal issues, suggesting that society as a whole is to blame (Seigel & Senna, 1981). Juvenile delinquency is recognized as a reflection of inadequate external social control and internalized social values that create space for delinquency to occur (Flowers, 2002). Social institutions play a significant role in shaping the environment in which juveniles grow, which affects their future behavior. Furthermore, the responsibility of combating and treating these delinquents’ rests on the society.

The decrease in the quality of a society results in corruption, poverty, unequal distribution of wealth, and a weaker social justice system, all of which are at the roots of this detrimental issue. These roots lead to children being forced to work and supplement family income, missing out on the opportunity to receive proper education, and learning about the basic morals and values within a society. An integrated theoretical perspective on antisocial behavior was presented through the issue of juvenile delinquency. Social psychology, evolutionary psychology, and behavioral genetics are relevant factors that explain the antisocial behavior of delinquents. These three fields stress that Darwinian theory can be intensively studied to provide ultimate explanations of antisocial behavior, and through integrated theories, can also provide insights into the differences between male and female delinquency rates, changes in antisocial behavior across one’s lifespan, and predictions to prevent the future antisocial behavior of delinquents (Skillin *et al.*, 2003). Less social control automatically contributes to a rising juvenile crime rate (Trojanowicz, 1992). A fine line of distinction exists between delinquent and non-delinquent behavior; therefore, juvenile delinquency is defined by various social norms and variables that can influence the nature of a juvenile crime and the punishment received by these delinquents (Maharjan, 2021).

Another approach to juvenile delinquency is economics. The economic approach is based on the idea of rational choice theories, which have advanced considerably in the social sciences, particularly economics, political science, and law (e.g., Morrow, 1994; Posner, 1998; Sunstein, 1999). An empirical puzzle for rational choice theory is controlling juvenile criminal behavior. In criminology, the rational choice framework implies that the behavior of a delinquent can be determined by weighing the costs and benefits associated with criminal offending (McCarthy, 2002). The costs of offending compete with their returns. Individuals may seek social recognition and personal (emotional and visceral) rewards from committing a criminal offense (Nagin & Paternoster, 1993). Some examples include the emotional rush gained from criminal activity, pleasure in gaining social status, and societal recognition. Previous studies have revealed that individuals are sensitive to the rewards of participating in criminal activity to the point where the perceived benefit serves to increase the likelihood of crime beyond the sanctioned threats of the judicial system (Piquero & Tibbetts, 1996). Offenders are sensitive to the likelihood of detection; thus, they may turn to “easier” targeted crimes based on the probability of reward (Decker *et al.*, 1995).

### **3. Game theoretic model and hypotheses**

#### **3.1 Baseline model**

In this section, we analyze a multi-period model of the effect of changes in punishment on the recidivism rate of juveniles. Our baseline model involves two players: juvenile delinquents and the police. Juveniles obtain positive utility from committing crimes, and police aim to minimize the rates of recidivism. Juveniles are categorized into two types: high- and low-risk. Intuitively, high-risk offenders find it easier to commit violent crimes than low-risk offenders. In particular, however, police can only observe the criminal act and not whether the juvenile is a high- or low-risk offender. The timeline of the game is as follows:

- 1) At  $t = 0$ , nature decides whether a juvenile delinquent is a high- or low-risk offender.
- 2) At  $t = 1$ , the juvenile delinquent decides to commit a high- or low-violence crime.
- 3) At  $t = 2$ , the police decide to put the juvenile delinquent under protection or in prison. Once imprisoned, the juvenile delinquent cannot commit a repeat offense but may choose to commit another crime if the delinquent is under protection.

We make several assumptions regarding this game. First, we assume that high-risk juveniles find it easier to commit violent crimes than low-risk juveniles. Additionally, we assume that highly violent crimes yield greater utility than low-violence crimes, and that this difference is greater for high-risk juveniles. These assumptions are consistent with the biological and genetic factors linked to juvenile delinquency (Rutter *et al.*, 1990, Di Lalla and Gottesman, 1991).

Second, we assume that the police incur positive jailing costs. While sending juvenile delinquents to protective facilities does incur a cost (Mendel, 2018), correction facilities include significant labor costs, pensions, financing, capital spending, and operational expenses (McDonald, 1989).

Third, we assume that once jailed, neither type of juvenile delinquent can re-commit a crime, but when under protection, they may commit a repeat offense. The average prosecution of juvenile delinquents amounts to 2 years 3.7 months in jail, and 3 years 3.9 months of probation (SBS News, 2020). However, most recidivism occurs within a year, and juvenile delinquents most frequently receive warnings and are reprimanded upon committing crimes (Choi, 2018). In the following subsections, we solve for the Nash equilibrium of this game using backward induction. First, we solve for the perfect information benchmark in which the police are able to observe the type of criminal. Thereafter, we solve for the second-best outcomes in which the police cannot determine the type of criminal.

#### **3.2 Perfect information benchmark**

For the perfect information benchmark, backward induction was used. At  $t = 2$ , because the police can determine the type of criminal, they imprison all high-risk offenders but not low-risk offenders,

incurring jailing costs. At  $t = 1$ , because low-risk offenders know that they will be released, they commit violent crimes. Similarly, because high-risk offenders are unsure of their jail convictions, they may choose to commit less violent crimes.

**3.3 Second-best (Imperfect information-what the police do because they cannot identify low/high risk offenders)**

For the imperfect information benchmark, when the police face a situation that is inconsistent with the presumed equilibrium being played, they may also be forced to form beliefs about the offender's characteristics as either a high-or low-risk offender (Ohio State University). These assumptions are often crucial in evaluating whether the ensuing play is rational. At  $t = 2$ , the police may not be able to correctly observe the criminal's type owing to imperfect information, which may offset the anticipated results when  $t = 1$ .

**3.4 Predictions on the effect of the 2008 change on recidivism and crime rates**

We can make the general prediction that the 2008 juvenile law adjustment will lower recidivism and crime rates because of the enforcement of the punishment that these juvenile offenders would receive. A decrease in the lower age limit for convicted juveniles implies that more juveniles who committed delinquent acts are eligible to receive punishment by law. This would lead to more cautious behavior among juveniles who would have committed violent crimes if they were eligible for punishment, thus decreasing crime rates. Furthermore, more education and psychological counseling for juvenile delinquents can prevent further acts of crime.

**3.5 Evolutionary game theory approach**

As assumed in Section 3.1, suppose that the juvenile population is divided into two different types of people: high-and low-risk offenders. In addition, suppose that the police comprise two groups: law and non-law enforcing officers. First, we initiated an experiment in which each member of the population changed their strategy after determining whether members of other categories were doing better. In other words, people emigrate from their initial strategy when they deem that the opposite strategy is more profitable.

The layout of the experiment is as follows: We performed a simulation that involved two equal-sized juvenile groups and two equal-sized police groups. After every iteration, 10% of the population in each group, where they performed less proficiently than another group, changed their strategy. This process was repeated until they equilibrated or 100 iterations were passed.

For a payout matrix, a range value spanning from  $-10$  to  $10$  was consistently maintained, and the experiment was conducted using an exhaustive search algorithm. The experiment was conducted using a CentOS Linux machine with an Intel Xeon E5-2680 V3 (@ 2.50GHz) dual-core CPU paired with 256 GB of memory.

**Table 1. Payout matrix**

	<b>Law-enforcing officers</b>	<b>Non-law-enforcing officers</b>
<b>High-risk offenders</b>	a b	c d
<b>Low-risk offenders</b>	e f	g h

The results exhibited the following pattern: Increasing the expected penalty decreased the frequency of law enforcement in the short run. However, after the officer discovered the change in criminal behavior, they modified their strategy to reduce the frequency of law enforcement. These results prove that our initial assumption was correct—if the police enforce the law, criminals will stop violating it. However, in reality, criminals and officers are exposed to each other and modify their strategies accordingly. Therefore, an increase in the penalty has no impact on criminal behavior in the long run.

## **4. Empirical analysis**

### **4.1 Data and methods**

We obtained juvenile delinquency statistics from the Korean Statistical Information Service (KOSIS). The KOSIS is a stratified statistical database that was first created in 1976. This database offers easy access to a wide range of domestic and international statistics. Over 120 statistical agencies that cover more than 500 subject matter produce statistics for KOSIS. In addition, they cover international finance data from international organizations, such as the IMF and the World Bank. The site utilizes convenient search functions, which make it easy for general users to comprehend and facilitate in a much more efficient way.

To process the data, we utilized the online portal for KOSIS and Pandas library in Python. Pandas is a software library written in Python programming language, particularly for data manipulation and analysis. By default, KOSIS provides data in a “wide” format (each column is a year). We used pivot tables and the stack () and unstack () commands to create a “long” format data with yearly observations of crime statistics.

The main outcome (dependent variable) was the number of juvenile delinquents. Specifically, we collect the following statistics from 1990 to 2020: Prosecuted juveniles (기소), not prosecuted (불기소), and placed under juvenile protection (소년보호송치). In particular, we collected information on whether the juvenile had a criminal record (전과) and whether the criminal was a repeat offender (전과). Finally, we collected information about the juvenile accomplices (공범관계), as well as the different types of crimes committed by juveniles.

Next, our main explanatory variables (independent variables) we are the years, and as well as the crime type. We created a “dummy” variable named Post2008 equal to 1 if the observed data are in on or after 2008, and 0 otherwise. For crime types, we collected information about juveniles prosecuted under criminal law (형법) and under special law (특별법). Generally, more violent crimes fall under Criminal Law, whereas while Special Law criminals are less violent.

We used a combination of Python and Stata to create plots and regression tables [May need to re-do using Excel or something that is more manageable].

Our main analysis utilizes an ordinary least squares (OLS) regression. Regression analysis is frequently used in the social sciences to analyze the relationship between two variables. Compared to machine learning, OLS is more interpretable and efficient than machine learning. Most of our analysis consists of comprises single-variable linear regression, where the main independent variable is Post2008, an indicator equaling to one if the observation is on or after 2008. Thus, our regression specification is as follows:

$$Y_t = \alpha + \beta \text{Post2008}_t + \epsilon_t$$

The coefficient of interest is  $\beta$ , which measures the effect of the new juvenile delinquent regulations on the our outcome variable  $Y_t$ . Technically, the coefficient measures how much of the extent to which the covariance between  $\text{Post2008}_t$  and  $Y_t$  can be explained by the variation in Post2008, since because

$$\beta = \text{COV}(Y, \text{Post2008}) / \text{VAR}(\text{Post2008})$$

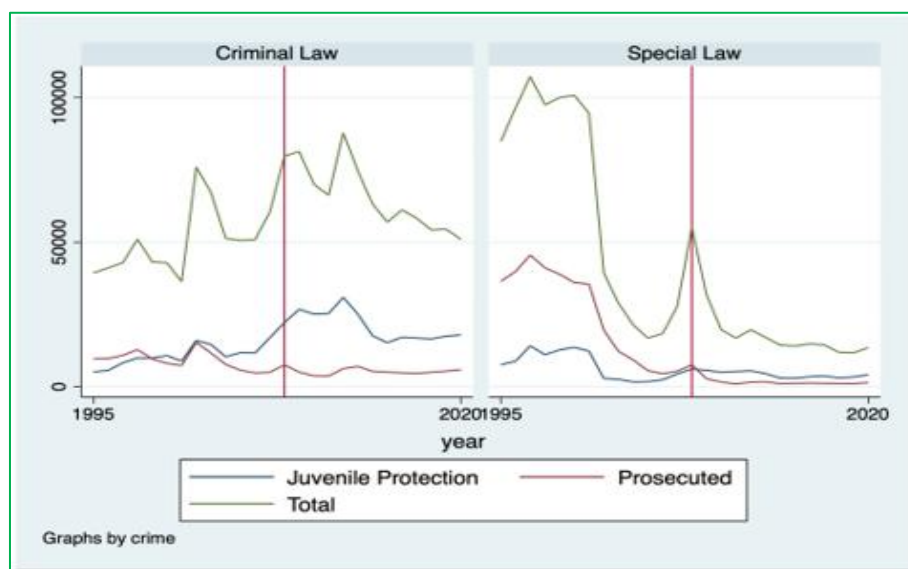
### **4.2 Graphs and Results**

First, we present summary statistics for our main variables.

**Table 2. Summary statistics (1995-2020)**

	Mean	S.D.	Min	Median	Max	N
Prosecuted	10443.94	12095.5	974	5675	45533	52
Not Prosecuted	26066.02	14551.18	4890	24108.5	51111	52
Juvenile Protection	10894.71	7465.664	1673	9939.5	30938	52
No prior convictions	30405.63	18291.76	6700	30046	74156	52
Has prior conviction	16433.29	9769.668	3847	15323.5	35754	52
Conviction unknown	3191.731	2501.084	624	2052.5	13927	52
First offense	32906.96	18891.08	7202	31968	76206	52
Repeat offense	17123.69	10054.02	4541	15321.5	36404	52
Repeat different offense	9552.077	5408.775	2572	8645.5	21223	52
Repeat same offense	7571.615	4825.581	1716	6717	18091	52
Year	2007.5	7.573172	1995	2007.5	2020	52
<b>Data obtained form KOSIS</b>						

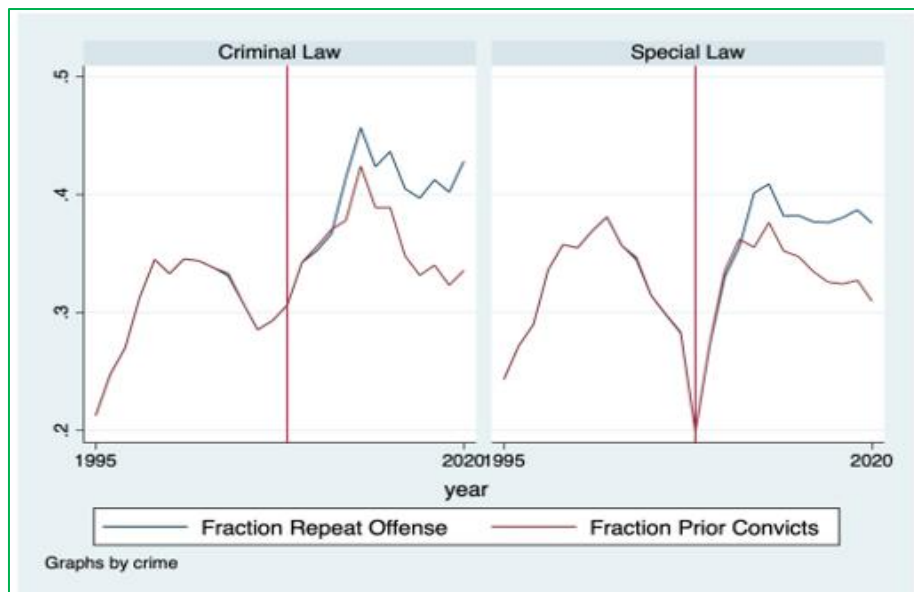
Next, we show how juvenile delinquent crime rates have changed between from 1993 -to 2020. Below, we plot the total number of Total juvenile delinquents, how many of them those were prosecuted, and how many were put under juvenile protection.



**Figure 1. Juvenile delinquent crime rate change (1993–2020)**

Interestingly, we see observe that the total number of juvenile delinquents spikes (for Special Law) in 2008, but the number of prosecuted individuals does not spike by as much show such a sharp increase. This suggests that as the 2008 regulations were being implemented, many juveniles were set free under the Special Law instead of being getting prosecuted by the full extent of the law under criminal laws. We also see observe that in past 2008, the number of juveniles put placed under protection has increased, thus giving them a correctional chance.

Next, we then compared the number of juvenile delinquents who we are repeat offenders, with and the number of juveniles those with having prior convictions. We Below, we see observe that prior before to 2008, virtually all repeat offenders had prior convictions. This suggests that juvenile delinquency laws were harsher, and frequently led to convictions. However, in past 2008, we observed see a noticeable gap between the number of juveniles with repeat offenses and the number of juveniles that with prior convictions. Thus, after 2008, juveniles were allowed more “second chances.”.



**Figure 2. Juvenile delinquent crime rate change (1993–2020)**

Next, we present the results of OLS regression on the entire sample. We observe that lowering the age of criminal liability in 2008 demonstrated the effects predicted by our model. Prosecution rates decreased by approximately 19.3 percentage points, suggesting that expanding the definition of juveniles did indeed create an increased sense of caution toward criminal acts to those who would have committed acts because they were under the age of criminal responsibility.

The use of the special law in 2008 resulted in an immediate decrease in the fraction of repeat offenses and the fraction prior to convicts to 0. It is best to assume that the database regarding criminal convictions was reset in 2008 for special legal statistics. The sudden decrease in the two variables due to the Special Law in 2008 also decreased the overall levels after 2008 when compared to regular criminal law.

Korea is often criticized for exploiting the Special Law rather than revising a general law that has a wider influence because it is much simpler to impose the Special Law than a general criminal law. However, in June 2011, the Legislative and Judiciary Committee sent a letter to the chairpersons of each standing committee to refrain from enacting special laws that violated the principle of systemic legitimacy.

**Table 3. Overall effect of 2008 regulation on juvenile delinquency**

	(1) <b>Prosecution Rate</b>	(2) <b>Protection Rate</b>	(3) <b>Prior Convictions</b>	(4) <b>Recidivism</b>
<b>Post 2008</b>	-0.193*** (0.020)	0.163*** (0.017)	0.053*** (0.013)	0.082*** (0.014)
<b>Constant</b>	0.294*** (0.020)	0.162*** (0.010)	0.288*** (0.009)	0.294*** (0.009)
<b>N</b>	62	62	62	60
<b>R<sup>2</sup></b>	0.525	0.607	0.211	0.374
Standard errors in parentheses				
*p<0.05, ** p<0.01, *** p<0.001				



**Table 4. Statistical analysis results**

<b>Panel A: Special Law</b>	<b>(1) Prosecution Rate</b>	<b>(2) Protection Rate</b>	<b>(3) Prior Convictions</b>	<b>(4) Recidivism</b>
<b>Post 2008</b>	-0.289*** (0.018)	0.165*** (0.021)	0.026 (0.018)	0.052* (0.021)
<b>Constant</b>	0.392*** (0.017)	0.116*** (0.007)	0.299*** (0.013)	0.304*** (0.013)
<b>N</b>	31	31	31	30
<b>R<sup>2</sup></b>	0.869	0.726	0.064	0.191
<b>Panel B: Criminal Law</b>	<b>(1) Prosecution Rate</b>	<b>(2) Protection Rate</b>	<b>(3) Prior Convictions</b>	<b>(4) Recidivism</b>
<b>Post 2008</b>	-0.097*** (0.015)	0.161*** (0.015)	0.079*** (0.016)	0.111*** (0.017)
<b>Constant</b>	0.195*** (0.013)	0.208*** (0.011)	0.277*** (0.014)	0.285*** (0.013)
<b>N</b>	31	31	31	30
<b>R<sup>2</sup></b>	0.530	0.776	0.403	0.579
Standard errors in parentheses				
*p<0.05, ** p<0.01, *** p<0.001				

The results in Tables 3 and 4 match our initial assumption: increasing the penalty decreased the frequency of offending the law. However, as suggested in Section 3.4, this might be true only for a short period. After the officers discover the change in criminal behavior, they are going to decrease the law enforcement rate to save expenses. In turn, criminals increase their frequency of violating the law.

### 5. Conclusion

We introduced a game-theoretic approach and an empirical analysis to identify the effects of various factors that contribute to juvenile delinquency rates. In the game theoretic approach, three assumptions regarding the criminals’ likelihood of committing a crime, the cost of jailing these juvenile criminals for the police, the idea that jailed criminals cannot commit further crimes, and those under protection can decide to recommit, were made. Through backward induction, the suboptimal Nash equilibrium was calculated for each game to determine the best possible outcome for each scenario. The result from the evolutionary game theoretical model shows that the change in the criminal rate after increasing the penalty does not last for a longer period.

An empirical analysis was performed using data from the Korean Statistical Data Service (KOSIS). Using the Pandas library, we analyzed criminal statistics from 1993 to 2020 and successfully anticipated the change after the 2008 juvenile law adjustment. The results show that the overall effect of the 2008 regulation on juvenile delinquency and the use of special laws reduced the crime and recidivism rates of criminals.

However, our game-theoretical model warns that this phenomenon may be transient. Law enforcement is pressured by the increased costs. Lower crime rates will loosen law enforcement. Consequently, criminals adapt to the changed legal environment and increase crime rates. Therefore, more sustainable approaches are needed, rather than simply increasing the law enforcement rate.

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