Peer Effects in Prison*

Julian Vedeler Johnsen,† and Laura Khoury‡

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Abstract

This paper provides a more comprehensive understanding of peer effects among prison inmates, shedding light on how to reduce recidivism and network formation through changes in the composition of inmates. We causally identify peer effects in prison using rich register data on over 150,000 prison spells in Norway and leveraging within-prison facility variation in peers over time. We find that inmates are more likely to reoffend when exposed to co-inmates with higher levels of criminal experience, and that this peer effect is stronger for co-inmates of similar age and country of birth. Our findings suggest that the formation of criminal networks among inmates plays a significant role in these peer effects. This research provides valuable insights for policymakers seeking to reduce recidivism and disrupt criminal networks within prison populations.

JEL Codes: K14, K42
Keywords:Criminal behavior, criminal networks, recidivism

*Preliminary version - Please do not circulate

†University of Bergen. Email: julian.johnsen@uib.no
‡University Paris Dauphine-PSL. Email: laura.khoury@dauphine.psl.eu

1 Introduction

Peers influence each other. This has important bearings on the optimal allocation of individuals to groups. However, decision makers will often lack knowledge of the peer effects at play, leading to sub-optimal group compositions. For instance, studies on peer effects in the education context show that school administrators could have improved students' outcomes by reallocating students and teachers (see e.g. Graham et al. (2020)).

Understanding peer effects is of particular importance in the context of criminal behavior. First, peer interactions are likely more important in the criminal sector due to its secretive nature and lack of formal institutions. Second, a large part of criminal peer exposure happens in prison, and is thus directly under the influence of policy makers and prison administrators. Third, peer effects in prison have been shown to affect the severe problem of recidivism among released prisoners.

The central aim of this paper is to provide a more complete understanding of peer effects among prison inmates. We start by estimating the peer effect of co-inmates' criminal experience on own recidivism. Then, to more directly address the question of optimal peer allocation, we show that the peer effects depend on the homophily of inmates in terms of age and country of origin. Finally, we explore the mechanisms of peer effects in prison, in particular the channel of criminal networks, in itself a topic of considerable importance.

There is now a growing literature on peer effects in crime. While the criminology literature has long emphasized that criminal behavior can be shaped by peers such as co-inmates (Clemmer, 1950; Glueck and Glueck, 1950), such peer effects has also gained increasing attention in economics during the last decade. Bayer et al. (2009) find evidence of reinforcement, but not branching out among inmate peers: juvenile criminals exposed to co-inmates serving time for the same type of crime are more likely to reoffend. Also examining juvenile offenders in Florida, Stevenson (2017) finds that the most influential peers are not those with more criminal experience or gang connections, but those with emotional and temperamental problems. There is less evidence on peer effects among

non-juvenile prison inmates, but Ouss (2011) finds peer effects in skill-intensive crime in the French setting. There is also some evidence that spending time in prison can lead to lasting network formation. Drago and Galbiati (2012) use a 2006 Italian prison pardon to provide evidence that co-inmates' incentives to reoffend can affect own recidivism, while Mastrobuoni and Rialland (2020) find that Italian co-inmates of similar age and nationality are more likely to co-offend after release (as proxied by reoffending on the same date).

We contribute to the existing literature by making use of rich and detailed data on the characteristics of prison inmates linked to more than 150 thousand prison spells in Norway. Compared to what has previously been possible, our detailed data allows for a more thorough exploration of peer effects along different dimensions and of heterogeneity in peer effects for different inmates. The identification of such detailed heterogeneous peer effects is absolutely key for informing policy makers on how to optimally allocate offenders to prisons. Furthermore, our data allows us to provide novel evidence on network formation in prison as an important channel of peer effects, as we have access to complete data on co-offending.

Our empirical framework utilizes within-prison facility variation in peers over time. We provide evidence on the validity of the identifying assumption: within a facility and limited time window, characteristics of peers entering and exiting that facility are as good as random.

We find that inmates are more likely to reoffend when exposed to co-inmates with higher levels of criminal experience. A one SD increase in the past number of police-reported suspected crimes increases the number of future charges by 6 percent. This peer effect is stronger for co-inmates of similar age and country of birth. Furthermore, the peer effect is stronger for criminals with a higher level of own criminal experience. Finally, we find that the peer effect is partly driven by the formation of criminal networks among prison inmates. Spending time together in prison increases the likelihood of co-offending in the future by 38 percent.

2 Setting and data

2.1 Institutional setting

Norway has a total of 56 prisons housing a stock of around 3000 inmates. Prison sizes vary considerably, with number of inmates ranging from 10 to 392 inmates. The allocation of prisoners to these facilities is based on two main criteria: the severity of the offense and proximity to the offender's home. Low-level offenders are typically sent to "low-security" or open prisons, where they have wide freedom to move around the facility. More serious offenders are sent to "high-security" or closed prisons, where they are mostly confined to their cells but are allowed to spend some time in common areas. However, inmates in closed prisons are often transferred to open prisons as they near the end of their sentence.

When considering peer effects among inmates in Norway, it is important to note that Norway has a strict policy of one prisoner per cell. Therefore, the relevant measure of peers is at the prison level, not the cell level. Despite the one cell policy, there is still ample opportunity for interactions between inmates at the prison level due to the relatively low number of inmates and their freedom to roam and interact with one another.

Inmates in the Norwegian prison system are required to participate in work, education, training, and/or rehabilitation programs as part of their sentencing. Around one-third of inmates participate in training / rehabilitation programs, while those do not to must work within prison. Inmates also have access to a library and the right to daily physical exercise.

Overall, incarceration in Norwegian prisons has been found to reduce the likelihood of reoffending for criminals at the margin of being sentenced to prison or community work / being fined (Bhuller et al., 2020).

2.2 Data sources

Our analysis draws on a comprehensive range of administrative registers containing a rich set of information. To construct our prison peer groups, we use the Norwegian prison

register, covering the period 1992 to 2019. This register contains individual-level data on all prison spells in Norway, including information on crime type and date, sentence length, and prison entry and exit dates. Crucially, the register also includes a facility identifier. Together with the information on the timing of the prison spells, this allows for the construction of peer groups of inmates overlapping in the same facility.

To facilitate our analysis of peer effects, we use a unique individual identifier to link the prison registers to centralized police registers that hold data on all reported crimes. This data includes information on the type, date, and location of the crime, as well as individual identifiers for those arrested or charged in relation to the crime. These data enable us to reconstruct the complete criminal record of each prison inmate, as well as post-incarceration criminal behavior.

Our data contains important information not found in other data sources used in the previous literature. First, it is unique in including information of police-reported suspicions of crime, which includes arrests not leading to charges. This provides a more complete picture of criminal activity than relying solely on charge or prison data. Second, the unique individual identifier associated with each criminal case enables us to link criminal cases across multiple perpetrators. This linkage facilitates the approximation of criminal networks by identifying co-offenders who were suspected of involvement in the same criminal case. Overall, these unique features of our data offer valuable insights that are not readily available from other sources.

Finally, in order to explore the heterogeneity of prison peer effects along different dimensions of peer characteristics, we merge in supplemental information from administrative registers provided by Statistics Norway. These registers include yearly demographic information, such as sex, age, marital status, for each Norwegian resident from 1967 to 2019.

2.3 Sample construction

To ensure that we observe individuals in several years both before and after each prison spell, we restrict our baseline sample to individuals who were incarcerated between 2000

and 2010. This baseline sample includes 76,485 inmates who served 154,441 unique prison spells in 56 prisons. For each of these focal inmates, we define co-inmates as individuals incarcerated in the same prison as the focal inmate, with at least one day of overlapping prison spells. For each unique prison spell, we then compute the weighted average of the co-inmates' characteristics, where each co-inmate is weighted by the number of days he is overlapping with the focal inmate.This data is then collapsed the data at the inmate $\times$ spell level.

To investigate the role of network formation among all potential pairs of co-inmates, we also construct a second sample that links each focal inmate to all overlapping *and non-overlapping* co-inmates. In this expanded data set, the unit of observation is a unique focal inmate - co-inmate pair. This approach enables us to investigate whether the likelihood of co-offending among a given pair is affected by whether the pair overlapped in prison. To ensure the comparability between overlapping and non-overlapping co-inmates, we restrict the pool of non-overlapping co-inmates to those who were incarcerated in the same prison as the focal inmate and who entered prison either four months before the focal inmate's prison entry or four months after the focal inmate's prison exit.

2.4 Descriptive statistics

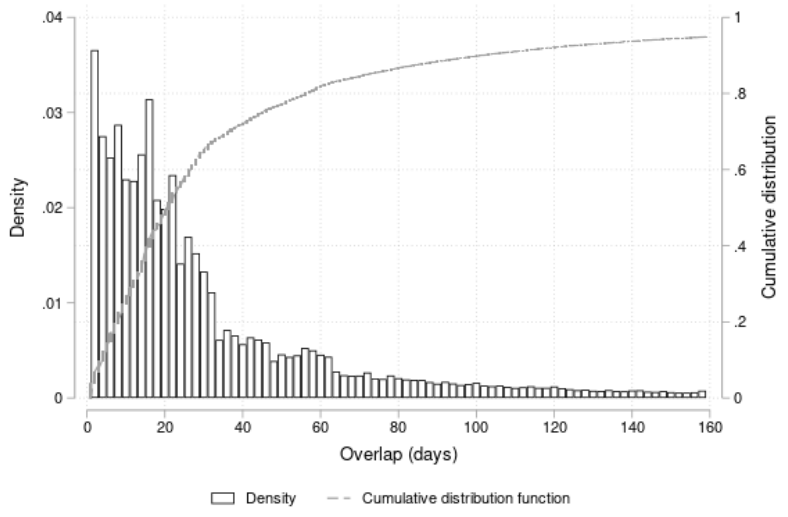
Table 1 provides a describtion of the characteristics of the focal inmates and their prison spells. As expected, the majority of focal inmates are young, unmarried men. On average, focal inmates also have extensive criminal records, with a mean (median) of 19 (9) arrests in the five years prior to incarceration. They were incarcerated for a variety of crimes, most commonly violent crime, property crime, traffic offenses, and drug crime (each about 20% of total crime). The median spell length of their prison spells is one month. Because of the short duration of the spells and the high turnover of inmates, a focal inmate overlaps with 194 peers on average. The distribution of the number of days of overlap is presented in Figure 1, with a median overlap duration of 20 days.

Table 1: Descriptive statistics

	Focal inmate characteristics				
	mean	p10	p50	p75	sd
Age	32.4	20	30	39	10.8
Female	0.077				0.27
Married	0.091				0.29
Foreign-born	0.131				0.34
Number of charges years 1 to 5 before spell	19	1	9	26	35
Own violent crime	0.21				0.41
Own property crime	0.20				0.40
Own economic crime	0.09				0.28
Own drug crime	0.19				0.40
Own other crime	0.11				0.31
Own traffic crime	0.20				0.40
	Spell characteristics				
Prison spell length (days)	79	9	31	74	158
Number of peers	194	38	132	224	236
Observations	154441				

This table provides descriptive statistics of focal inmates in our main sample and their prison spells. The sample is restricted to prison spells that started between 2000 and 2010.

Figure 1: Distribution of the number of days of overlap



NOTE: This figure shows the distribution of number of days of overlap between the focal inmate and a co-inmate who overlapped with the focal inmate. The sample is restricted to prison spells that started between 2000 and 2010.

3 Empirical methodology

A naive regression of outcomes on peer characteristics would likely yield biased estimates due to the non-random allocation of inmates to prison facilities. To address this issue, our methodology exploits only within-facility variation in peers over time. However, this within-facility variation in peer characteristics may still be endogenous if the assignment of inmates to facilities changes over time. To mitigate this concern, our methodology only compares focal inmates who are incarcerated at a similar time. Specifically, to identify the peer effect of co-inmates' average characteristics, we use OLS to estimate the following equation:

$$Y_{ifyc} = \beta_0 + \beta_1 P_{ifyc} + \beta_2 X_{i(s)} + \beta_3 \widetilde{X}_{j(s')} + \alpha_{fcy} + \nu_{ifyc} \ , \tag{1}$$

where Y_{ifyc} is the outcome of inmate i who entered prison f in year y for type of crime c. Our coefficient of interest, β_1, identifies the causal effect of P_{ifyc}, the weighted average of co-inmate characteristics. Importantly for the causal identification of this parameter, the equation includes a facility-by-type-of-crime-by-year fixed effect, α_{fcy}. The inclusion of this accounts for the fact that criminals are not allocated randomly to facilities, and that there may be time trends specific to types of crime or facilities. To further control for potential confounding differences between focal inmates exposed to differing peer characteristics, we include $X_{i(s)}$, a set of individual pre-determined characteristics (i.e. age, sex, married, spell length, severity of the crime, type of crime, number of charges in the past 5 years), and $\widetilde{X}_{j(s')}$ the weighted averages of the same set of characteristics for the peers.[1] Standard errors are clustered at the prison facility level.

In different specifications of equation 1, we vary the outcome and peer characteristcs Y_{ifyc} and P_{ifyc}. Our main outcome of interest is recidivism, which we measure as either the probability of being charged or as the number of charges within one to five years

[1] Except for the number of charges in the past 5 years as this would be almost perfectly collinear with the number of arrests in the last five years, which is our main variable of interest, captured by P_{ifyc}.

after entering prison. Our main peer characteristic of interest is criminal experience, defined as the number of past arrests in the five years before incarceration. We choose to focus on criminal experience as it encompasses several dimensions that can influence peer behavior, such as age, the likelihood of reoffending, and the severity of the crime. Criminal experience is also easily observable to policymakers and can thus readily be used as a criteria to decide on the allocation of inmates across prisons.

3.1 Identifying assumptions

The validity of our research design is based on the identifying assumption that, within the same facility and limited time window, the timing of inmates' entry to a given facility is conditionally random. To test this assumption, we conduct a randomization check in two steps, following the approach of (Bayer et al., 2009). In the first step, we predict the outcome of interest, e.g. the probability of being charged within five years after prison entry, using characteristics of the focal inmate (age, sex, marital status and crime severity), as well as the fixed effects included in equation 1. In the second step, we regress this prediction on the weighted average of the peer characteristic of interest, e.g. the number of arrests in the past five years. This test provides evidence on whether the characteristics of the peers are conditionally orthogonal to pre-determined characteristics of the focal inmate that are predictive of recidivism.

We report the results of the second step in Table 2. The first three columns run the naive test without any fixed effects, and show a positive correlation between the weighted average of peers' suspected crimes and the predicted recidivism risk in the five years after incarceration of the focal inmate. Reassuringly, we find that, once fixed effect are included, this correlation vanishes. This lack of correlation holds regardless of whether we include facility-by-year fixed effects or the more demanding facility-by-type-of-crime-by-year fixed effects, and whether we include various prison spell characteristics and criminal history in the first stage of the randomization check. Therefore, we conclude that the provides suggestive evidence that our identifying assumption is holds, and we will interpret our findings as causal estimates of peer effects of co-inmates' average characteristics

on recidivism.

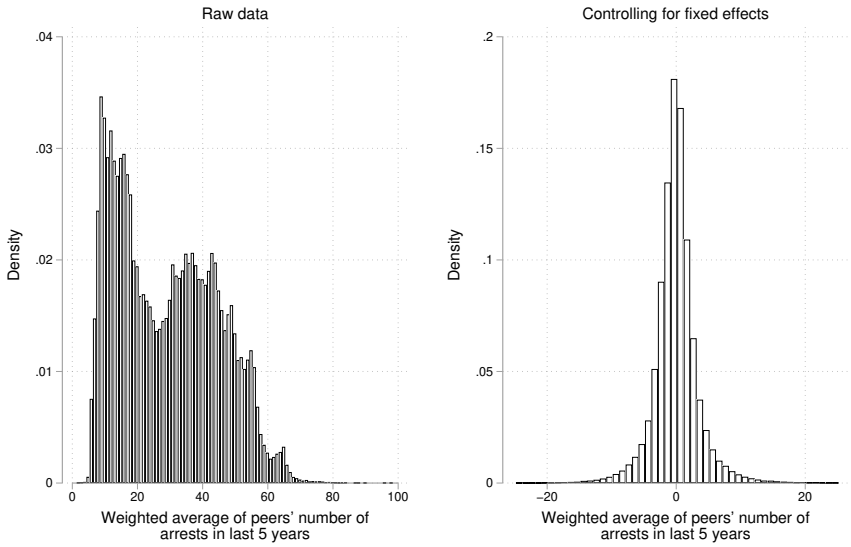
Table 2: Randomization test

	Pr(Charged within 5 years after incarceration)								
Weighted average of peers' suspected crimes in the last 5y	0.00055***	0.00342***	0.00236***	-0.00009	0.00034	-0.00016	-0.00011	0.00009	-0.00019
	(0.00016)	(0.00026)	(0.00015)	(0.00010)	(0.00026)	(0.00027)	(0.00007)	(0.00012)	(0.00020)
Socio-Demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current Spell Characteristics	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
Crime History	-	-	Yes	-	-	Yes	-	-	Yes
Facility-by-Year FE	-	-	-	Yes	Yes	Yes	-	-	-
Facility-by-Type-of-crime-by-Year FE	-	-	-	-	-	-	Yes	Yes	Yes
Outcome mean	0.7006	0.7031	0.7031	-0.2680	-0.3289	-0.2374	-0.2310	-0.3380	-0.2853
Observations	149541	145012	145012	149541	145012	145012	144920	144920	144920

** p<0.1, ** p<0.05, *** p<0.01. Standard errors clustered at the prison level in parentheses.*
Sample of prison spells that started between 2000 and 2010. The probability of being charged within five years after incarceration is predicted using facility-by-year fixed effects in the first three columns, whereas the last three use facility-by-type-of-crime-by-year fixed effects. In columns (1) and (4), on top of the fixed effects, the prediction uses only socio-demographics, while current prison spell characteristics are added in columns (2) and (5), and crime history variables are further included in columns (3) and (6). The table reports the coefficients and standard errors from the regression of the predicted probability on the weighted average of peers' number of suspected crimes in the last five years.

Although the interacted fixed effects ensure that peers' allocation is as good as random, this approach reduces the available variation in the peers' characteristics. Figure 2 illustrates the distribution of the main peer characteristic of interest, the number of arrests in the five years before incarceration. The left-hand panel shows the raw data, with the density plot exhibiting the largest spike around eight arrests and a smaller one around 37 arrests. On the right-hand panel, we present the distribution of residuals after controlling for most exhaustive set of fixed effects, showing that there is still significant conditional variation in the peers' characteristics.

Figure 2: Distribution of peers' crime experience



NOTE: Sample of prison spells that started between 2000 and 2010. The left hand-side figure displays the distribution of the weighted average of peers' number of suspected crimes in the last five years. The right hand-side figure shows the distribution of the residuals of the same variable after controlling for prison-by-type-of-crime-by-year fixed effects.

4 Results

4.1 Effects of peers' criminal experience

Effect of peers' average criminal experience on recidivism. We start by estimating equation 1 for the outcomes of recidivism within one to five years after prison entry. We report the coefficient of interest, β_1, which estimates the effect of the weighted criminal record of the co-inmates. We define criminal record as the average number of arrests in the past five years

Table 3 reports our findings when using Equation 1 to estimate the effect of co-inmates' criminal experience on the focal inmate's recidivism at the extensive margin (i.e., being charged with any crime in the given time period after incarceration). Panel A displays the estimated β_1 coefficient when the outcome is measured over the first year after incarceration, while Panel B displays the estimated coefficient when the outcome is measured over five years after incarceration. As shown, the baseline recidivism rates are high: 44% within one year and 70% within five years after incarceration. In Column

1, we report the estimated coefficient from the naive specification without controls and facility fixed effects. Column 2 displays the estimated coefficients from our preferred specification, which includes facility fixed effects interacted with type of crime and year of prison entry fixed effects, as well as a comprehensive set of controls for characteristics of the focal inmate, such as age, gender, marital status, severity of the crime, spell length and number of charges in the last five years of the focal inmate, and co-inmate characteristics such as average age, proportion of females, distribution of type of crime, and proportion married. In Column 3, we report estimates from the same specification as column 2, but with the explanatory variable normalized to have a mean of zero and a standard deviation of one. Focusing on Column 3, Panel A indicates that a one standard-deviation increase in the weighted average of peers' criminal experience increases the focal inmate's probability of re-offending within one year by 1.4 percentage points, or 3.2% relative to the baseline probability. Looking at the five-year time horizon, the effect drops to 1.56%.

Table 4 provides further results from the estimation of Equation 1, this time on future recidivism at intensive margin (i.e. number of post-incarceration charges). Panel A displays the estimated effect on number of charges within one year after incarceration, while Panel B displays the estimated effect on number of charges within five years after incarceration. As in Table 3, Column 1 presents results from the naive specification, while Columns 2 and 3 present results from the preferred specification with facility fixed effects and other controls. Notably, when focusing on the standardized effects reported in Column 3, we see that the effects of peers' criminal experience are larger on the intensive margin than on the extensive margin. In particular, a one standard-deviation increase in peers' criminal experience leads to a 10.4% increase in the number of charges in the short run (Panel A, column 3), and a 6% increase in the number of charges in the longer run (Panel B, column 3).

Table 3: Extensive margin: Effect of peers' criminal experience on probability of future charges

	(1)	(2)	(3) Standardized
Panel A: Pr(Ever charged in year 1 after prison entry)			
Weighted average of peers' suspected crimes in the last 5y	0.00863***	0.00090***	0.01413***
	(0.00008)	(0.00031)	(0.00494)
Outcome mean	0.4433	0.4433	0.4433
Panel B: Pr(Ever charged in years 1 to 5 after prison entry)			
Weighted average of peers' suspected crimes in the last 5y	0.00734***	0.00070***	0.01108***
	(0.00007)	(0.00022)	(0.00344)
Controls	-	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	-	Yes	Yes
Outcome mean	0.7032	0.7032	0.7032
Observations	144760	144756	144756

** p<0.1, ** p<0.05, *** p<0.01. Standard errors clustered at the prison level in parentheses.*
Sample of prison spells in 2000-2010. Controls include age, gender, marital status, severity of the crime, spell length and number of charges in the last five years of the focal inmate, and controls for the average age, proportion of females, distribution of type of crime and proportion of married co-inmates.

Table 4: Intensive margin: Effect of peers' criminal experience on number of future charges

	(1)	(2)	(3) Standardized
Panel A: Number of charges in year 1 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.09319***	0.01788*	0.28182*
	(0.00186)	(0.01060)	(0.16700)
Outcome mean	2.704	2.704	2.704
Panel B: Number of charges in years 1 to 5 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.39151***	0.04816***	0.75903***
	(0.00502)	(0.01723)	(0.27150)
Controls	-	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	-	Yes	Yes
Outcome mean	12.2421	12.2418	12.2418
Observations	144760	144756	144756

** p<0.1, ** p<0.05, *** p<0.01. Standard errors clustered at the prison level in parentheses.*
Sample of prison spells in 2000-2010. Controls include age, gender, marital status, severity of the crime, spell length and number of charges in the last five years of the focal inmate, and controls for the average age, proportion of females, distribution of type of crime and proportion of married co-inmates.

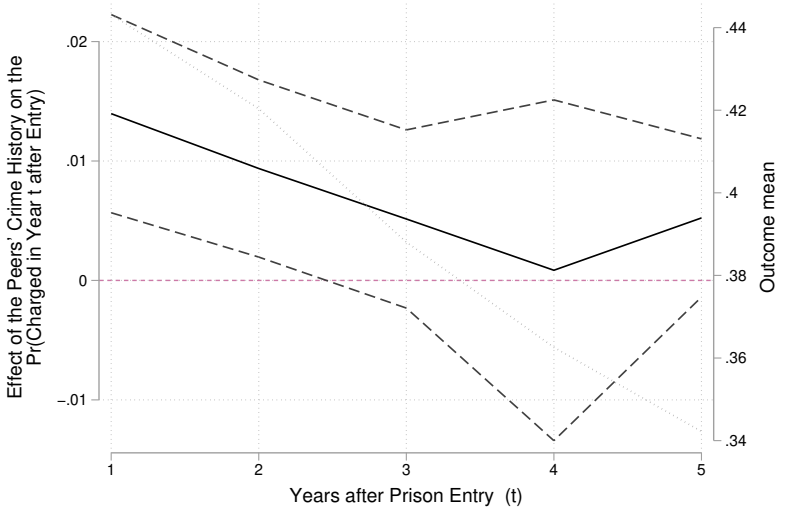
The results in Tables 3 and 4 suggest that the effect of peers' criminal experience on

recidivism fades in the longer run. Therefore, we illustrate the full dynamics of the effects in Figures 3 and 4. These figures report standardized β_1 coefficients and the associated 90% confidence intervals for the outcome measured each year from year one to year five after incarceration. The figures depict the estimated effect of peers' past number of arrests when using the most demanding specification, which includes facility-by-type-of-crime-by-year fixed effects, and the same controls as in Tables 3 and 4. The results confirm those in Tables 3 and 4: there is a positive effect of peers' past criminal experience on recidivism of the focal inmate, both at the extensive and intensive margins, but it declines over time. With regards to the extensive margin, the effect on the yearly probability of being charged is significant in the first two years but diminishes almost linearly over time (Figure 3). With regards to the intensive margin, results on the number of future charges follow a similar decreasing trend, except for the drop in the effect at year two (Figure 4). This overall pattern of declining effect is consistent with the idea that the influence of co-inmate peers weakens as time goes by and the focal inmate meets new peers.[2]

Our findings complement previous studies from other countries that have focused on the prison peer effects along other peer characteristics. For example, Bayer et al. (2009) and Damm and Gorinas (2020) used research designs similar to ours to investigate the effect "reinforcing" effect of exposure to co-inmates convicted for similar crimes on recidivism. Specifically, they find that, for focal inmates convicted of drug crimes, a one-standard-deviation increase in the exposure to peers who committed drug crimes increased the drug-related recidivism rate by 10.5% in the US setting Bayer et al. (2009) and 1.3% in the Danish setting Damm and Gorinas (2020). While we do not focus on type of crime peer effects but rather criminal experience peer effects, our extensive margin estimate of a 3.2% increase in the probability of reoffending within one year seems reasonable compared to these earlier findings. When comparing our findings, it is worth noting that that peer effects may be larger in drug-crime recidivism as drug crime may be more prone to reinforcing effects through skill transmission and network effects.

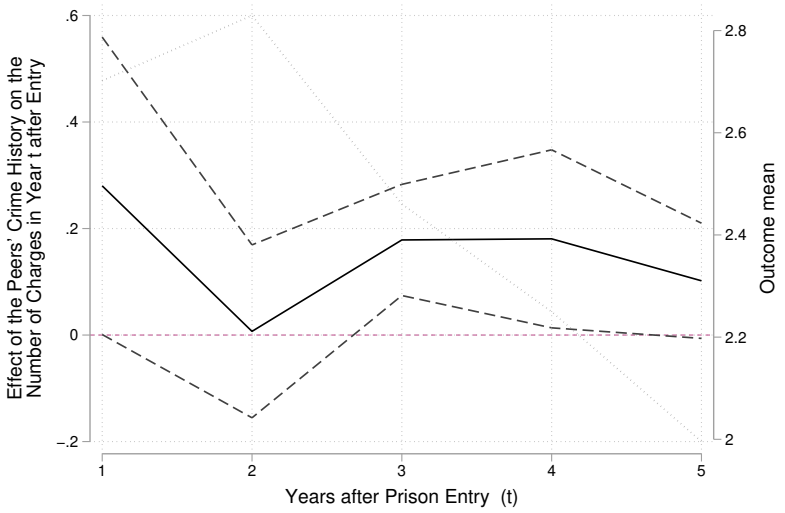
[2]The corresponding effects on cumulative outcomes are shown in Figures 7 and 8 in Appendix A. Consistent with the yearly estimates, the cumulative effect increases in the first year after incarceration and remains fairly stable over time in absolute terms.

Figure 3: Extensive margin: Effect of peers' criminal experience on probability of future charges



NOTE: Sample of prison spells that started between 2000 and 2010. The black solid line depicts the β_1 coefficients from the estimation of Eq. 1 on the probability of being charged each year, with the corresponding 90% confidence intervals in black dashed line. Standardized independent variable. The light gray line corresponds to the outcome mean each year.

Figure 4: Intensive margin: Effect of peers' criminal experience on number of future charges



NOTE: Sample of prison spells that started between 2000 and 2010. The black solid line depicts the β_1 coefficients from the estimation of Eq. 1 on the number of charges each year, with the corresponding 90% confidence intervals in black dashed line. Standardized independent variable. The light gray line corresponds to the outcome mean each year.

Non-linear effects. So far, we have exposure to prison peers with a higher weighted average of criminal experience increases the likelihood of recidivism along the extensive and intensive margin. We now further investigate whether this effect of average criminal experience is non-proportionally driven by exposure to extremely experienced peers ("top criminals"). Our hypothesis is that in two peer groups with the same average criminal experience, being exposed to a few top criminals, rather an homogeneous group with medium-level criminal experience, could matter more for future recidivism. This hypothesis particularly fits the Norwegian context where prisons are small and the focal inmate is likely to interact with every co-inmate. In this context, the presence of one highly experienced criminal could be sufficient for the focal inmate to learn new skills or establish new criminal connections.

To test the effect of exposure to highly experienced criminals, we compute alternative measures of peers' characteristics which define exposure to highly experienced co-inmates. These measures identify whether a focal inmate is exposed to a top criminal, i.e. a co-inmate belonging to the top 10% or top 1% of criminal experience.[3] Table 5 reports the effect of being incarcerated with these top criminals on the probability of being ever charged within five years after incarceration. In Panel A, Column (1) reproduces our main estimate of the effect of the weighted average of peers' suspected crimes in the last five years. Columns (2) and (3) of Panel A report estimates of the effect of being exposed to a top 10% or top 1% criminal, respectively. The results indicate that being exposed to a top 1% criminal increases likelihood of re-offending within five years by around 1%. The estimate for being exposed to a top 10% criminal is similar in magnitude but less statistically significant.

To further explore the significance of exposure to top criminals in driving the observed peer effects of criminal experience, we first define exposure to top criminals as the total days of exposure to a top 10% criminal or a top 1% criminal (Columns 4 and

[3]We define top criminals based on the distribution of criminal experience across all years and facilities. Hence, we measure the effect of being incarcerated with most experienced criminals in Norway in the time period. Alternatively, we could have uses the distribution of criminal experience among co-inmates in a given facility in a given year, which would measure the effect of being exposed to a top criminal relative to the pool of potential co-inmates. However, this measure of top criminals is less relevant if the objective is to minimize recidivism through alternative allocations of inmates to facilities.

5, respectively). When defined like this, the effect of exposure to top criminals stays positive and is statistically significant for both top 10% and top 1% criminals. Second, while the results reported in Panel A comes from a specification which includes only the top criminals variables, we also report results in Panel B from a specification that further controls for the weighted average of peers' criminal experience. This specification explicitly tests for whether exposure to top criminals matter even when fixing the average level of peers' criminal experience. All the continuous independent variables (columns (1), (4), (5)) have been standardized. The results reported in Panel B indicate that even when controlling for the weighted average of peers' criminal experience, being exposed to a top criminal further increases the likelihood of recidivism.

Table 5: Effect of extreme values of peers' characteristics on Pr(Charged) within 5 years after incarceration

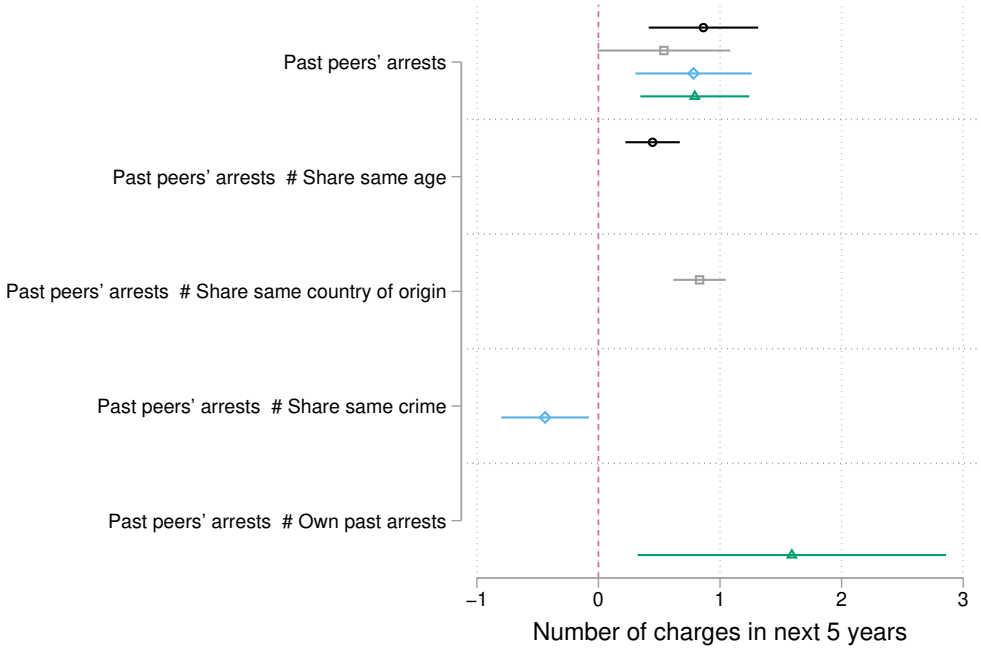
		Dummy: exposed to		**# days of exposure to**	
	Baseline	**a top 10% criminal**	**a top 1% criminal**	**top 10% criminals**	**top 1% criminals**
Panel A: Extreme values of peers' suspected crimes in the last 5y					
Extreme values	0.01108***	0.00557	0.00680**	0.00425**	0.00264**
	(0.00344)	(0.00404)	(0.00287)	(0.00180)	(0.00121)
Panel B: Extreme values of peers' suspected crimes in the last 5y controlling for the average					
Extreme values	-	0.00411	0.00573*	0.00429**	0.00268**
	-	(0.00416)	(0.00289)	(0.00179)	(0.00120)
Weighted average	-	0.00068***	0.00064***	0.00071***	0.00071***
	-	(0.00022)	(0.00022)	(0.00021)	(0.00021)
Controls	Yes	Yes	Yes	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	Yes	Yes	Yes	Yes	Yes
Outcome mean	0.7032	0.7032	0.7032	0.7032	0.7032
Observations	144756	144753	144753	144756	144756

** p<0.1, ** p<0.05, *** p<0.01. Standard errors clustered at the prison level in parentheses.*
This table reports the coefficients measuring the effect of different measure of peers' criminal experience on the probability that the focal inmate is charged within 5 years after incarceration. Continuous independent variables (columns (1), (4)-(5)) are standardized.

Heterogeneity analyses. The peer effect of co-inmates' criminal experience could operate through various channels: (i) skill acquisition, if inmates learn more from more experienced co-inmates; (ii) from the transmission of preferences and norms, especially in terms of risky behaviors; (iii) from the formation of criminal networks that reinforces criminal behavior e.g. through increased criminal opportunities. To better understand the specific mechanisms at play, we run a heterogeneity analysis in which we interact

peers' criminal experience with variables measuring the share of co-inmates belonging to the same peer group as the focal inmate. These peers groups are defined by age, country of origin, or type of crime. Additionally, we looked at the interaction between peers' criminal experience and the focal inmate's own criminal experience. Our aim is to determine whether the peer effects are stronger when peers share specific characteristics, which would shed light on the underlying channels at work.[4]

Figure 5: Effect of peers' crime experience on probability of future charges - by peer group



NOTE: Sample of prison spells that started between 2000 and 2010. 90% confidence intervals. Standardized independent variable.

We report the results from this heterogeneity analysis in Figure 5. The figure displays the coefficient on peers' criminal experience as well as the interaction terms with various peer characteristics. All these independent variables have been standardized. Each interaction term is examined in a separate regression which includes controls and fixed effects specified in Equation 1. The results indicate that the impact of peers' criminal experience is stronger the higher the share of peers in the same age bracket or from the same country

[4]Note, however, that the analysis is still run at the aggregate level and not at the pair level. It means that we do not actually test whether the effect is larger if two given peers share a specific characteristic, but if the share of co-inmates sharing a specific characteristic with the focal inmate is higher.

of origin. These effects suggests that homophily plays a role, where peers sharing specific characteristics are more likely to interact. Determining which heterogeneity dimensions are most significant is essential in informing policy makers on how to optimally allocate offenders to prisons. Interestingly, and in contrast to the findings of previous studies, we found that the share of peers having committed the same type of crime, classified across six broad categories, does not seem to reinforce the effect of peers' criminal experience. However, the interaction between peers' criminal experience and the focal inmate's own crime experience is positive. These findings are more compatible the channel of network formation than a that of skill acquisition. Indeed, skills are mostly crime-specific and would rather be transmitted among peers who committed the same type of crime and who do not have a long criminal experience.

4.2 Network formation as a mechanism

The effect of overlapping in prison on the future likelihood of co-offending. While we shed some light on the importance of various underlying channels in the previous Section, we now further investigate the important channel of network formation by directly examining the probability of co-offending for two given inmates. In this analysis, we compare two pairs of inmates who are similar in all respects except that one pair overlapped in prison while the other did not. To make this comparison, we use the second sample which is structured at the pair level.[5] This allows us to compare the outcome of one pair—the focal inmate and his peer—with the outcome of different pair, made up of the same focal inmate and a different peer who is incarcerated in the same facility, but not at the same time as the focal inmate. Similar to the first design, we exploit the variation in peers over time within the same facility and a limited time window. The outcome we examine is co-offending, defined as the probability that the given pair is charged with the same criminal case in the future. Specifically, we estimate the following equation:

[5]The construction of the second sample is described in subsection 2.3. Because this dataset is structured at the pair level, we can—and do—include spell fixed effects in this analysis.

$$Y_{i(s)j(s')f} = \beta_0 + \beta_1 Overlap_{i(s)j(s')f} + \beta_2 \widetilde{X}_{j(s')} + \alpha_i(s) + \nu_{i(s)j(s')f} \ , \tag{2}$$

where $Y_{i(s)j(s')f}$ is an outcome of individual i in spell s matched with inmate j in spell s' in facility f. $\widetilde{X}_{j(s')}$ controls for the peer characteristics and $Overlap_{i(s)j(s')f}$ is a dummy equal to one if there is at least one day of overlap between both inmates. $Overlap_{i(s)j(s')f}$ can also be defined as a continuous variable that gives the number of days of overlap between the pair of inmates (including 0). We exclude peers who had common charges in the 5 years prior to incarceration as to not capture pre-existing networks.

We run a similar randomization test as in the first analysis, where we predict the probability of having a common charge within five years after prison entry using the age, sex, marital status, month of prison entry and crime severity of the peer, as well as spell fixed effects. We then regress this prediction on the overlap variable. Table 6 shows no significant relationship between overlapping—either defined as a dummy or a continuous variable—and the predicted probability of cooffending within either one or five years.

Table 6: Randomization test

	Predicted Pr(Common charge within 1 year)			
Number of days of overlap	2.17e-09		1.72e-09	
	(1.67e-09)		(1.71e-09)	
Overlap (dummy)		1.46e-07		1.22e-07
		(1.10e-07)		(1.09e-07)
	Predicted Pr(Common charge within 5 years)			
Number of days of overlap	2.60e-10		-4.76e-10	
	(4.74e-09)		(4.89e-09)	
Overlap		2.18e-07		1.84e-07
		(2.99e-07)		(2.99e-07)
Controls	Yes	Yes	Yes	Yes
Spell FE	-	-	Yes	Yes
Peer's type of crime FE	-	-	Yes	Yes
Spell-by-Peer's type of crime FE	Yes	Yes	-	-
Peer's entry month FE	Yes	Yes	Yes	Yes
Outcome mean				
Observations	47850327	47850327	47857905	47857905

** p<0.05, ** p<0.01, *** p<0.001. Standard errors clustered at the facility level in parentheses.*
Sample of prison spells that started between 2000 and 2010. This table reports the coefficients measuring the relationship between the predicted probability of two peers offending together within one year and the number of days of overlap in the same facility (columns 1 and 3) or a dummy equal to one if there is any overlap in the same facility (columns 2 and 4). Columns 1 and 2 include spell-by-peer's-type-of-crime fixed effects, and columns 3 and 4 include non-interacted spell and peers' type of crime fixed effects. All columns include peer's month of entry fixed effects. The probability is predicted using the same fixed effects and the age, sex, marital status and crime's severity of the peer. We exclude inmates who had a common charge in the past 5 years.

Table 7 reports the β_1 coefficients from Equation 2. It shows that overlapping in prison significantly increases the chances of co-offending within five years. The effect is robust to the inclusion of spell fixed effects, even when interacted with the type of crime of the peer. As the probability of co-offending is defined at the pair level, and is therefore low by construction, the coefficients are small in absolute terms. However, in relative terms, overlapping in prison increases the likelihood of cooffending by 38% in the most demanding specification (column (5)).

Table 7: Probability of having a common charge in year 1 to 5 after incarceration (dummy)

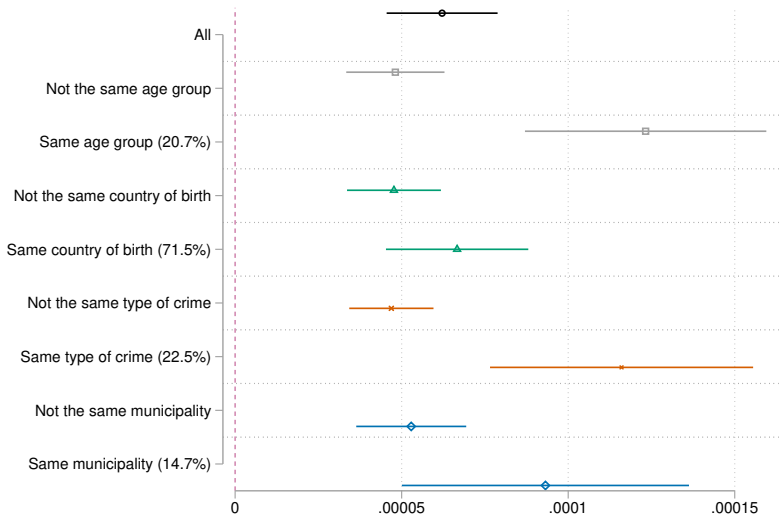
	Co-offence in years t to t+5			
Overlap (dummy)=1	0.000118***	0.000080***	0.000064***	0.000062***
	(0.000003)	(0.000004)	(0.000010)	(0.000010)
Relative effect (%)	76%	47%	39%	38%
Controls	-	Yes	Yes	Yes
Spell FE	-	-	Yes	-
Peer's type of crime FE	-	-	Yes	-
Spell-by-Peer's type of crime FE	-	-	-	Yes
Peer's entry month FE	-	-	-	Yes
Outcome mean	0.000156	0.000172	0.000164	0.000164
Observations	67985021	59068190	63251605	63245337

** p<0.05, ** p<0.01, *** p<0.001. Standard errors clustered at the prison spell level in parentheses.* Sample of prison spells that started between 2000 and 2010. This table reports the coefficients measuring the effect of the spending some time in prison (dummy variable) with an inmate on the probability of having a common charge within 5 years after incarceration. The regression is run at the pair level.

Heterogeneity analyses. To explore the heterogeneity of the cooffending effect, we define different peer groups based on characteristics that are shared between both inmates in the pair. Figure 6 reports the β_1 coefficients from the estimation of Eq. 2 on the probability of cooffending within five years after prison entry on each group separately. These estimations test two hypotheses: the first one states that peers sharing similar characteristics should interact more. It predicts a higher effect on pair of coinmates sharing some characteristics. Second, if prison has an additional effect on the development of criminal network compared to a counterfactual outside prison, we should expect a positive effect of overlapping also on pairs of inmates who share similar characteristics that make them likely to interact outside prison as well. Figures 6 confirms both hypotheses: we observe that for each of the included characteristics (i.e. age, country of birth, type of crime and municipality of residence), the effect of overlapping in prison has a positive effect the probability of cooffending within five years, and that the effect is higher than among inmates who do not share these characteristics (although confidence intervals sometimes overlap). In particular, we can imagine that pairs of inmates living in the same municipality are likely to interact outside prison. The fact that we still find a positive effect of overlapping when we focus on this group suggests that prison has an extra effect on the development of criminal networks relative to what would have happened in the absence

of prison.

Figure 6: Heterogeneity: Effect of peers' criminal experience on the Pr(Ever being charged in year 1 to 5 after prison) by peer group



NOTE: Sample of prison spells that started between 2000 and 2010. The Figure reports the β_1 coefficients from the estimation of Eq. 2 on the probability of cooffending within five years after prison entry on each group separately. The share of each group in the sample is reporter in parentheses. 90% confidence intervals.

After exploring the characteristics of inmates, we investigate whether the effect of overlapping differs according to prisons' characteristics. To do so, we estimate Eq. 2 separately in each of the 56 prisons in the sample. We then define two groups: the first one includes prisons where the average effect of overlapping belongs to the top 10% of the distribution of effects at the prison level. The second one includes all the other prisons. Table 8 compares the characteristics of these two groups of prisons. Not surprisingly, we observe that prisons where we find the highest effects are significantly more likely to be open and are smaller (rows 1 and 2). Since smaller and open prisons presumably foster interactions between inmates, these results lend support to our hypothesis that our effect is driven by peers' interactions. Row 4 also indicates that prisons with a higher average index of crime severity have a higher effect of overlapping. It could be explained by the fact that peers committing more severe crimes potentially exert more influence on their peers.

Table 8: Characteristics of prisons with a high vs. low network effect

	Top10	Rest of the distribution	(1) - (2)
Closed prison	0.200	0.588	-0.388*
			(0.231)
Prison size	571.400	2972.235	-2400.835*
			(1338.324)
Share of violent offenders	0.253	0.240	0.013
			(0.037)
Prison average severity of crimes	131.110	114.511	16.599*
			(9.469)

** p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses.*
This table reports summary statistics comparing prisons where the effect of overlapping on cooffending is large versus prisons where the effect of overlapping is smaller. Prison size is measured using the total number of spells in each prison over the period.

All in all, the profile of prisons where the highest effect is found is consistent with a scenario where prisons foster the development of criminal networks. The heterogeneity analysis at the prison level can also inform the design of prisons to minimize the development of criminal networks. While it suggests that smaller and open prisons are more prone to a high network effect, we need to stay cautious in our interpretation since these characteristics are likely to have positive effects on other dimensions.[6]

5 Conclusion

In this paper, we show that peer effects in prison matter. Exploiting the within-facility variation in peers over time, we show that being incarcerated with more experienced criminals increases recidivism. This effect is stronger when the share of co-inmates of similar age or country of origin increases. Such heterogeneous effects provide insights on how to better allocate inmates across facilities to minimize recidivism. We identify network formation as an important mechanism, since, for two given inmates, spending time together in prison significantly increases the likelihood of co-offending in the future by 38 percent.

[6]For instance, Bhuller et al. (2021) show suggestive evidence that open prisons are more beneficial to the mental health of inmates in the Norwegian context.

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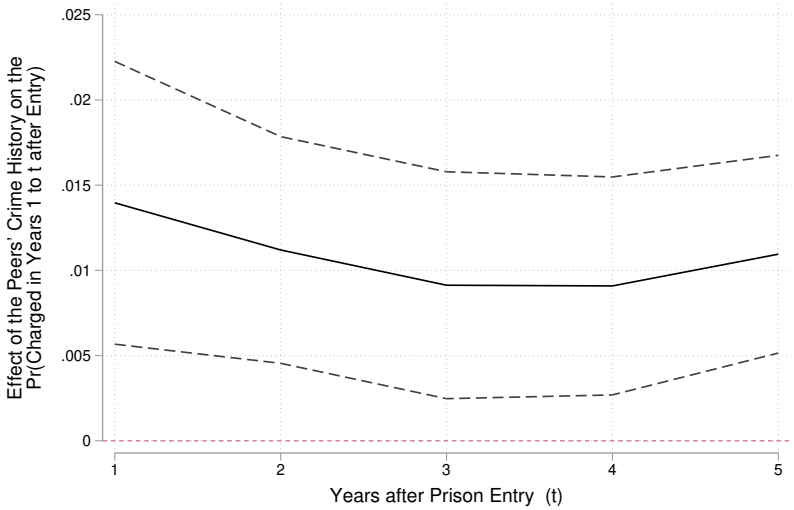
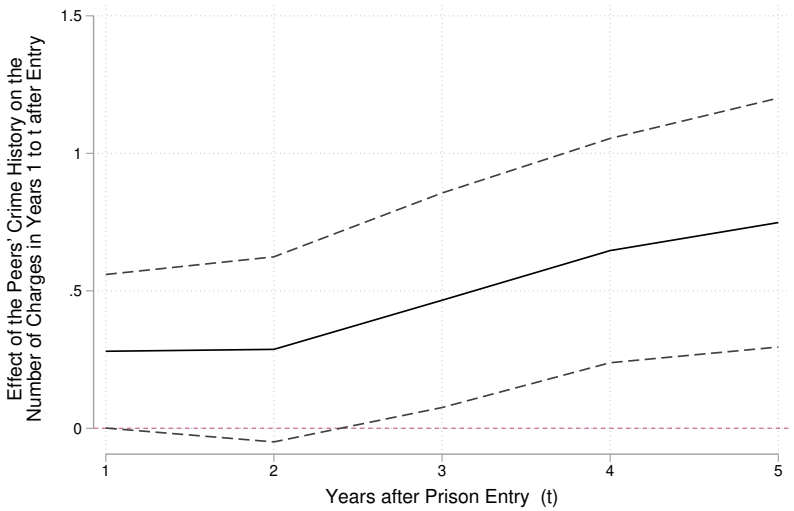
A Additional Tables and Figures

Figure 7: Extensive margin: Effect of peers' criminal experience on probability of future charges



NOTE: Sample of prison spells that started between 2000 and 2010. 90% confidence intervals. Standardized independent variable.

Figure 8: Intensive margin: Effect of peers' criminal experience on number of future charges



NOTE: Sample of prison spells that started between 2000 and 2010. 90% confidence intervals. Standardized independent variable.