DISCUSSION PAPER SERIES

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Julian Vedeler Johnsen
Laura Khoury

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Julian Vedeler Johnsen
University of Bergen

Laura Khoury
Paris Dauphine University-PSL and IZA

ABSTRACT

Peer Effects in Prison*

Peer interactions play a key role in the criminal sector due to its secrecy and lack of formal institutions. A significant part of criminal peer exposure happens in prison, directly influenced by policymakers. This paper provides a broader understanding of how peer effects shape criminal behavior among prison inmates, focusing on co-inmate impacts on recidivism and criminal network formation. Using Norwegian register data on over 140,000 prison spells, we causally identify peer effects through within-prison variation in peers over time. Our analysis reveals several new insights. First, exposure to more experienced co-inmates increases recidivism. Second, exposure to "top criminals" (i.e. those with extreme levels of criminal experience) plays a distinctive role in shaping these recidivism patterns. Third, inmates form lasting criminal networks, as proxied by post-incarceration co-offending. Fourth, homophily intensifies these peer effects. These findings contribute to the theoretical understanding of peer influences in criminal activities and offer practical insights for reducing recidivism through strategic inmate grouping and prison management policies.

Corresponding author:
Laura Khoury
PSL Université Paris Dauphine
Pl. du Maréchal de Lattre de Tassigny
75016 Paris
France
E-mail: laura.khoury@dauphine.psl.eu

1 Introduction

Peer interactions likely play an especially important role in the criminal sector due to its secretive nature and lack of formal institutions. As a result, peer effects in crime have captured the attention of scholars across several fields, including economics, sociology, and criminology. The central idea–that exposure to peers with a history of criminal behavior can increase an individual's propensity to commit crimes–traces its roots to Bentham (1830). He cautioned that 'the indiscriminate association of prisoners' could turn prisons into 'schools of crime'. In addition to this skill transfer mechanism, peers can impact criminal behavior through network formation or the transmission of certain traits or behaviors (Stevenson, 2017). Empirically, the causal relationship between own and peer criminal behavior is documented in many studies (see e.g. Bayer et al. (2009); Dustmann and Landersø (2021).[1] This underscores the particular importance of shedding light on these peer effects, not only for its theoretical implications for understanding criminal behavior, but also to inform practical policy decisions.[2] Importantly, a large part of criminal peer exposure happens in prison, and is thus directly under the influence of policy-makers and prison administrators. This presents an opportunity for interventions targeted at peer interactions among prison inmates that could reduce recidivism.[3]

The central aim of this paper is to provide a more complete understanding of peer effects among prison inmates. More specifically, we explore how the characteristics and interactions of prison inmates influence post-incarceration recidivism, emphasizing the role of co-inmates' prior criminal experience. We focus not only on peers' average criminal experience, but also highlight the important role played by those with extreme levels of criminal experience–'top criminals'.[4] By exploring the heterogeneous nature of these peer effects, our findings shed light on the mechanisms at play and provide actionable

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[1]The empirical literature on the strong association between own and peer criminal behavior dates back to at least Glueck and Glueck (1950).

[2]For a theoretical model on how social interactions can help explain observed patterns in criminal behavior, see Glaeser et al. (1996).

[3]Related to this, 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)).

[4]The pivotal role of peers at the extreme of the ability distribution has previously been highlighted in the context of peer effects among classmates (see, e.g., Balestra et al. (2023); Lavy et al. (2012b,a)).

insights for policymakers on how recidivism could be reduced by rearranging the group composition among prison inmates. Finally, we provide novel evidence on criminal network formation as one mechanism through which peer effects operate in prison. More specifically, we investigate whether co-incarceration affects future co-offending. Understanding the role of co-offending has long been thought to be key to comprehending the causes of crime and the impact of various intervention strategies (Reiss Jr, 1988).

To estimate prison peer effects, we adopt the research design outlined by Bayer et al. (2009), and leverage the variability in peer composition within prison facilities over time. The identifying assumption is that conditional on facility-by-year fixed effects there is no systematic bias in inmates' admissions to a given facility that would confound our results. To validate this assumption, we show that peer characteristics are conditionally orthogonal to pre-determined traits predictive of recidivism. When studying network formation, we compare the post-incarceration co-offending of two sets of inmates who are similar except in one aspect: one set overlapped in prison, while the other did not. Similar to the first design, we here exploit the variation in peers over time within the same facility and a limited time window.

We present four key findings. First, exposure to more experienced peers (as measured by number of past arrests) increases recidivism. This is true both along the extensive margin (the likelihood of re-offending) and the intensive margin (the number of future charges).[5] Specifically, a one SD increase in peers' criminal experience increases the likelihood of recidivism within five years by 1.5 percent and the number of future charges within five years by 6 percent. Second, we find that exposure to 'top criminals' has a distinct effect on recidivism patterns even when controlling for the average criminal experience of co-inmates: A one standard deviation increase in the number days spent with a co-inmate in the top 10% of the criminal experience distribution increases the likelihood

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[5]We acknowledge that measures such as prior arrests and future charges reflect not only the actual extent of criminal experience and behavior but also the probability of being arrested and/or charged. This makes our definition of criminal experience somewhat imperfect, as more skilled criminals may have a lower chance of getting caught. However, it remains a useful indicator as long as the likelihood of arrest increases with the frequency of criminal acts. Furthermore, to the extent that peers' criminal experience improves own skills in evading arrests and charges, our results underestimate the true increase in criminal activity caused by exposure to more experienced criminals.

of re-offending within five years by 0.7 percent. Third, we document the formation of criminal networks among prison co-inmates. Overlapping with a given inmate in prison increases the likelihood of future co-offending by 38 percent. Fourth, we find significant heterogeneous effects that underscore the role of homophily: the peer effects on recidivism and co-offending are more pronounced among inmates with shared attributes. Taken together, we interpret this as suggestive evidence on the mechanisms at play, hinting at the supremacy of network formation over skill acquisition.

Our findings contribute to the small but growing literature devoted to the causal identification of peer effects among prison inmates. The seminal paper by Bayer et al. (2009) studied juvenile inmates in Florida and found evidence of peer effects that reinforce criminal behavior within crime types: Exposure to peers with experience in a particular crime type increases recidivism within this crime type, but only for inmates with prior experience in the given crime type. Damm and Gorinas (2020) found similar, but smaller reinforcing peer effects for young first-time offenders in Danish prisons.[6] They further found that these reinforcing peer effects are increasing in the criminal experience of co-inmates. In the French setting, Philippe (2024) finds that exposure to an additional cellmate incarcerated for drug or property crimes increases recidivism within that type of crime, regardless of own prior experience within that crime type.[7] Returning to juvenile inmates in Florida, Stevenson (2017) compared the effect of peers' criminal experience, gang connections, and traits associated with criminal behavior and found that for inmates who were released into physically distant locations, recidivism is affected only by peers' crime-related traits, while for inmates who were released into proximate locations, recidivism is affected by peers' criminal experience and gang connections. Relative to the previous literature, we emphasize the role of peers' overall criminal experience, not just within a certain type of crime. Criminal experience has previously been shown to be the best predictor of future crime (Stevenson, 2017).[8] Furthermore, we highlight the

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[6]While Bayer et al. (2009) found this pattern for six out of ten crime types (burglary, larceny, assault, and drug- and sex-related crimes), Damm and Gorinas (2020) found this pattern for three of seven crime types (drug crime, threats, and vandalism and arson).

[7]Ouss (2011) also studies similar effects in the French setting, but in her study the evidence suggests that the variation in peer exposure is (conditionally) endogenous.

[8]This dimension also captures connectivity or criminal networks, as criminal experience is strongly

potency of exposure to 'top criminals', i.e., those at the top of the criminal experience distribution. This allows us to explore popular beliefs surrounding the influence of the "kingpin" in shaping collective criminal behavior. Finally, our rich and detailed linked administrative registers provide data on more than 140 thousand prison spells in Norway, which allow for a more thorough exploration of peer effects than previously possible. This is key for informing policymakers on how to optimally allocate offenders to prisons.

We also advance the existing literature by providing robust evidence on the formation of criminal networks among prison inmates. Several prior studies have indicated that this might be an important mechanism for prison peer effects. For instance, Stevenson (2017) found that recidivism was influenced by peers' criminal experience and gang connections for those who were released into nearby locations, suggesting a potential role for criminal network formation. Other studies also provide suggestive evidence that co-inmates form lasting criminal networks. Drago and Galbiati (2012) use a 2006 Italian prison pardon to show that prior co-inmates' incentives to re-offend can affect own recidivism. Mastrobuoni and Rialland (2020) find that Italian co-inmates of similar age and nationality are more likely to re-offend on the same date, which likely indicates co-offending. While these previous studies hint at the potentially important role of this mechanism in explaining observed peer effects, none have documented this mechanism with data on co-offending.

Our study also contributes to the broader literature on peer effects in criminal behavior. This literature has documented the existence of peer effects in crime among classmates (Billings and Hoekstra, 2023; Kim and Fletcher, 2018), friends (Corno, 2017), family members (Bhuller et al., 2018b,a; Dobbie et al., 2018; Hjalmarsson and Lindquist, 2012), and within neighborhoods (Case and Katz, 1991; Dustmann and Landersø, 2021; Billings and Schnepel, 2022; Kling et al., 2005; Ludwig et al., 2001; Ludwig and Kling, 2007). Our study also relates to the literature on the impact of incarceration and prison conditions on post-incarceration recidivism. This literature has found that incarceration, as opposed to community work or fines, lowers recidivism for the marginal inmate in the Norwegian context (Bhuller et al., 2020). Other studies show that harsher prison

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correlated with the number of observed criminal connections (see Appendix Figure A1).

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conditions may lead to higher recidivism rates (Chen and Shapiro, 2007; Drago et al., 2011; Mastrobuoni and Terlizzese, 2022; Tobón, 2022). We complement these findings by demonstrating that open prisons are associated with stronger peer effects among inmates compared to closed prisons.

The remainder of the paper proceeds as follows. Section 2 outlines the necessary details of the institutional context, data sources, and sample construction. It also provides descriptive evidence on the characteristics of the inmates in our sample and their prison spells. Section 3 presents our empirical framework and provides evidence in favor of our identifying assumptions. In Section 4, we discuss our findings, including the effects of peers' average criminal experience, exposure to top criminals, and the network formation effect of overlapping prison time on future co-offending. We conclude the paper with some final remarks in Section 5.

2 Setting and data

2.1 Institutional setting

According to the Penal Code of Norway, prison sentences can range from 14 days to 30 years.[9] All prisons in Norway are public, with the Correctional Service ("Kriminalomsorgen") operating 56 prisons facilities in our period of study with a total inmate population of approximately 3,000 at any given time. The sizes of these facilities vary considerably, with capacities ranging from 10 to 392 inmates. Norwegian prisons prioritize rehabilitation, adhering to the "principle of normality" established by the Directorate of Norwegian Correctional Services. This principle ensures that life in prison mirrors life outside as closely as possible.

There are three types of prison facilities in Norway: high-security facilities, low-security facilities, and halfway houses. Inmates are allocated to these different types of facilities based primarily on the severity of their offense, but also on geographical proximity to their home address and the available space at each facility. Low-level of-

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[9]For references on the institutional details of prison in Norway, see Evensen et al. (2024).

fenders are generally placed in the low-security 'open prisons', which offer inmates the freedom of movement within the facility premises. These facilities resemble dormitory settings rather than traditional barred cells. In contrast, those convicted of more severe crimes are incarcerated in the high-security 'closed prisons'. In these facilities, inmates are mostly confined to their cells, although they are permitted to spend some limited time in communal areas. Inmates who start their sentence in a high-security facility will often be transferred to a low-security facility or halfway house toward the end of their sentence with the goal of gradual reintegration into society.

An important aspect to consider in terms of peer interactions among inmates in the Norwegian prison system is the strict policy of housing only one inmate per cell. Therefore, the relevant measure of peers is at the prison level, not the cell level. It is important to note that at the prison level, the overall prison environment encourages frequent interactions among inmates due to the relatively small inmate population and, in open prisons, their freedom to move around within the prison premises and engage with each other.

A cornerstone of the Norwegian prison system is inmates' engagement in activities. All inmates are mandated to partake in work, education, training, or rehabilitation programs as part of their sentencing. Approximately one-third of the inmate population enrolls in training or rehabilitation programs, while the remainder work on various tasks within the prison. Additionally, inmates have access to libraries and are entitled to daily physical exercise. Post-release, emphasis is placed on reintegration, with programs to assist ex-inmates in securing employment and accessing social services, including housing support.[10]

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

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[10]The execution of prison sentences is regulated by the Correctional Services Act, which details inmates' rights and obligations. This law also outlines the various ways a prison sentence can be implemented.

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. Importantly, 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, including post-incarceration criminal behavior.

Our data contains important information not found in other data sources used in the previous literature. First, it uniquely includes information on police-reported suspicions of crime, which encompasses 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, to explore the heterogeneity of prison peer effects across different dimensions of peer characteristics, we integrate supplemental information from administrative registers provided by Statistics Norway. These registers include yearly demographic information, such as sex, age, marital status, and level of education, 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 those incarcerated between 2000 and 2010. This

baseline sample comprises 68,272 inmates who collectively account for 141,018 unique prison spells across 56 prison facilities. For each unique prison spell of these focal inmates, we define co-inmates as individuals who were incarcerated with the focal inmate for at least one day during that spell (at the same time and in the same prison facility). For all unique prison spells of the focal inmates, we then compute a weighted average of the co-inmates' characteristics. The weight assigned to each co-inmate is equal to the number of days he overlapped with the focal inmate in that unique prison spell.[11] This leaves us with a main data set containing information on the weighted average characteristics of the co-inmates the focal inmate is exposed to in each separate unique prison spell.

Additionally, to investigate the role of network formation, we construct a secondary sample linking each focal inmate to both 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 study whether the likelihood of co-offending among a given pair is affected by whether the pair overlapped in prison. To maintain comparability between overlapping and non-overlapping co-inmates, we restrict the pool of non-overlapping co-inmates to those who entered the same facility as the focal inmate either four months before or four months after the focal inmate's incarceration period.

2.4 Descriptive statistics

Table 1 provides a detailed overview of the characteristics of the focal inmates and their prison spells. The focal inmates are predominantly young, unmarried males, a trend consistent with broader incarceration demographics. They also have extensive criminal records, averaging 20 charges in the five years preceding their incarceration. The main type of crime they were incarcerated for varies, with violent crimes, property crimes, traffic offenses, and drug-related crimes each making up about 20% of all cases. Most serve short sentences, with the median prison spell lasting one month. Due to these short

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[11]This weighting system implicitly assumes that the intensity of exposure is equivalent to the duration of overlapping time, disregarding whether inmates engaged in actual interaction. We believe this system is appropriate because direct interactions between inmates within prison settings are not readily observed nor are they (conditionally) random. The estimates based on this weighing system can be thought of as intention-to-treat estimates.

durations and the frequent inmate turnover, a focal inmate overlaps with 189 peers on average. Figure 1 illustrates the distribution of overlap durations, with a median overlap of 20 days.

Table 1: Descriptive statistics of focal inmates and their prison spells

| | Focal inmate characteristics | | | | |
	mean	p10	p50	p75	sd
Age	32.3	20	30	39	10.8
Female	0.075				0.26
Married	0.089				0.28
Foreign-born	0.10				0.30
Years of education	10	8	10	12	3.4
Charges in the 5 years preceding incarceration	20	1	9	28	36
Incarcerated for...					
...violent crime	0.21				0.41
...property crime	0.20				0.40
...economic crime	0.09				0.28
...drug crime	0.19				0.39
...other crime	0.11				0.31
...traffic crime	0.20				0.40
	Spell characteristics				
Prison spell length (days)	77	10	31	74	152
Number of peers	189	37	132	220	226
Observations	141018				

This table provides descriptive statistics of focal inmates in our main sample and their prison spells. The sample includes prison spells that began between 2000 and 2010.

3   Empirical framework

A naive regression of outcomes on peer characteristics would likely yield biased estimates due to the non-random allocation of inmates to prison facilities.[12] To address this potential bias, our methodology exploits only the within-facility variation in peer characteristics over time. This within-facility variation in peer characteristics may still be endogenous to the focal inmate's potential outcomes if the assignment of inmates to facilities varies over

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[12]The criteria for allocating inmates across prisons are the severity of the crime, distance to their home address, and gender.

Figure 1: Distribution of the number of days of overlap
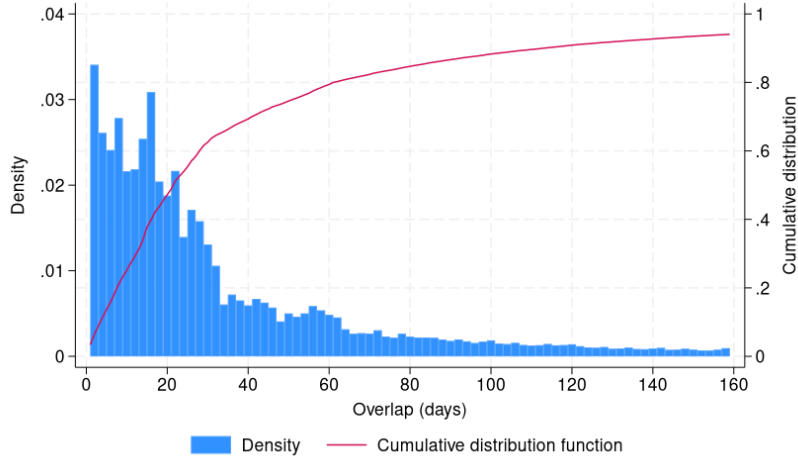
NOTE: This figure shows the distribution of number of days of overlap between the focal inmate and a co-inmate who overlapped with the focal inmate. The sample is restricted to prison spells that began between 2000 and 2010.

time. To circumvent this, our methodology relies only on the comparison of focal inmates who are incarcerated not only in the same facility but also at a similar time. Specifically, to identify the peer effects of co-inmates' average characteristics, we use OLS to estimate the following equation:[13]

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

where Y_{ifyc} represents the outcome for inmate i who entered prison facility f in year y for crime type c. Our coefficient of interest, β_1, identifies the causal effect of P_{ifyc}, the weighted average of co-inmate characteristics. We rely solely on co-inmate characteristics that are determined prior to incarceration. Importantly for the causal identification of β_1, the equation includes facility-by-type-of-crime-by-year fixed effects, α_{fcy}. These fixed effects account both for the non-random allocation of inmates to prison facilities and potential time-trends in this allocation that are specific to crime type or facilities. To further control for potential confounding differences between focal inmates who are exposed to differing peer characteristics, the equation includes $X_{i(s)}$, a set of pre-determined

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[13]We also show that our main results are robust to a logistic regression estimated by MLE.

individual characteristics (i.e. age, sex, marital status, years of education, spell length, severity of the crime, type of crime, number of charges in the past 5 years), and $\widetilde{X}_{j(s')}$, the weighted average of the same set of characteristics for the peers.[14] As is standard in the literature, we cluster standard errors at the prison facility level to account for potential non-independence of individual errors among inmates within the same prison facility.

In various specifications of equation 1, we alter the outcome and peer characteristics Y_{ifyc} and P_{ifyc}. Our main outcome of interest is recidivism, measured either as the likelihood of being charged or as the number of charges within one to five years after entering prison. Our main peer characteristic of interest is criminal experience, defined as the number of prior arrests in the five years leading to incarceration.[15] We focus on criminal experience because it encompasses several dimensions that can influence peer behavior, such as age, likelihood of reoffending, and crime severity. An inmate's criminal experience is also strongly correlated with the size of his criminal network, as shown in Appendix Figure A1. Criminal experience is also easily observable to policymakers and can thus readily be used as a criterion for deciding on the allocation of inmates across prisons. For our analysis of the specific role of 'top criminals'—those with the most extensive criminal experience—we define P_{ifyc} as the number of days of exposure to a criminal ranked within the top 10% or 1% in terms of criminal experience.

3.1 Identifying assumptions

The validity of our research design relies 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. In other words, we assume that, once we condition on the facility-by-type-of-crime-by-year fixed effects, there is no systematic bias in the timing of inmates' entry to a given prison facility that would confound our results. This core assumption underpins our ability to make causal claims about the influence of co-inmate peer characteristics on the focal inmates' outcomes.

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[14]However, for peers we exclude the average number of charges in the past 5 years as this would be almost perfectly co-linear with our primary variable of interest; arrests in the past five years.

[15]We alternatively try the number of prior charges in the five years leading up to incarceration as a measure of peers' criminal experience. Both measures lead to very similar results.

To test the plausibility of this assumption, we conduct a two-step randomization check 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. For the prediction, we use the pre-determined characteristics of the focal inmate and the fixed effects specified 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. If the peer characteristic of interest is uncorrelated with the predicted outcome, this two-step test provides suggestive evidence that the characteristics of the peers are conditionally orthogonal to the 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 show that if we do not condition on any fixed effects, the weighted average of peers' criminal experience is indeed positively correlated with the focal inmate's predicted recidivism, as suspected given the sorting of inmates to facilities described in Section 2.1. However, this correlation disappears once we condition on the facility-by-year or facility-by-type-of-crime-by-year fixed effects (Columns (4) to (9)), a reassuring observation. The lack of correlation persists irrespective of the granularity of the fixed effects (whether just facility-by-year or the more granular facility-by-type-of-crime-by-year fixed effects) or the details of prison spell and criminal history data included in the first stage of the randomization check. To be conservative, we will report results from a specification that includes facility-by-type-of-crime-by-year fixed effects. However, all our results hold when using the less demanding specification that includes only facility-by-year fixed effects.

To further assess the credibility of our identification strategy, we investigate whether prison peers' criminal history is associated with the focal inmate's own criminal behavior in the years preceding incarceration. If the composition of prison peers is conditionally random, the characteristics of these peers should be uncorrelated with pre-incarceration outcomes. We present evidence that this is indeed the case in Appendix Figure A2, which displays the β_1 coefficient from the estimation of Equation 1 with the pre-incarceration probability of being charged as the outcome. Reassuringly, the findings indicate that

peers' criminal experience is conditionally orthogonal to an individual's likelihood of incurring a criminal charge in the four years leading up to incarceration.

Consequently, the evidence suggests that the timing of inmates' entry to a given facility is conditionally random, thereby supporting our identifying assumption. Thus, we will interpret our findings as causal estimates of the peer effects of co-inmates' average characteristics on focal inmates' recidivism.

Table 2: Randomization test: Peers' Weighted Average Criminal Experience is Uncorrelated with Predicted Re-Offending

| | Pr(Charged within 5 years after incarceration) | | | | | | | | |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Weighted average of peers' suspected crimes in the last 5y	0.00097***	0.00367***	0.00264***	0.00000	0.00038	-0.00009	-0.00006	0.00012	-0.00015
	(0.00014)	(0.00025)	(0.00014)	(0.00011)	(0.00026)	(0.00026)	(0.00007)	(0.00012)	(0.00019)
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	0.7074	0.7074	0.7074	0.7074	0.7074	0.7074	0.7074	0.7074	0.7074
Observations	141018	141018	141018	141018	141018	141018	141018	141018	141018

This table reports the coefficients and standard errors from the regression of the focal inmate's predicted probability of re-offending on peers' weighted average criminal history (i.e., peers' number of arrests in the last five years weighted by the number of days each peer overlapped with the focal inmate in prison). The probability of being charged within five years after incarceration is predicted using no fixed effects in the first three columns, facility-by-year fixed effects in columns (4) to (6), while the last three use facility-by-type-of-crime-by-year fixed effects. In columns (1), (4), and (7), the prediction uses only socio-demographics in addition to the fixed effects, while current prison spell characteristics are added in columns (2), (5), and (8). Criminal history variables are further included in columns (3), (6), and (9). The analysis is based on a sample of prison spells that began between 2000 and 2010.
* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

Although the inclusion of facility-by-year fixed effects in the regression model ensures that the allocation of peers is conditionally random, it also reduces the available variation in peers' characteristics. Figure 2 illustrates the distribution of the main peer characteristic of interest, the number of arrests in the five years leading up to incarceration. The left panel of the figure displays the raw data. The density plot reveals two notable peaks: a dominant one around eight arrests and a smaller one around 40 arrests. In contrast, the right panel presents the distribution of residuals after controlling for facility-by-type-of-crime-by-year fixed effects. Here, the distribution is centered around zero with similar tails on each side. This zero-centering is expected if peer composition is random when

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conditioning on facility-by-year fixed effects. Furthermore, the panel indicates that even after controlling for the most exhaustive set of fixed effects, there is still significant variation in peers' characteristics, enabling us to identify their effect on the focal inmates' outcomes.

Figure 2: Distribution of peers' criminal experience
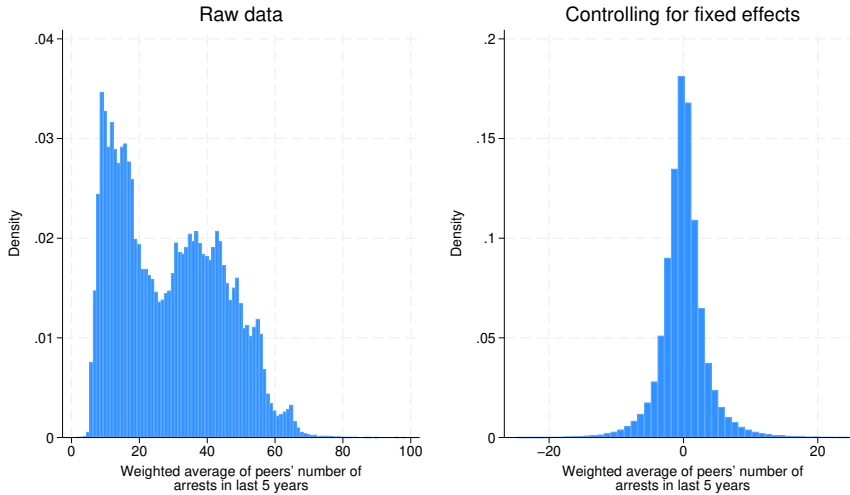
NOTE: The left-hand side figure displays the distribution of the weighted average of peers' number of suspected arrests in the last five years. The right-hand side figure shows the distribution of the residuals of the same variable after controlling for facility-by-type-of-crime-by-year fixed effects. This analysis is based on a sample of prison spells that began between 2000 and 2010.

4 Results

4.1 Effects of peers' criminal experience on recidivism

This section examines how the criminal experience of co-inmates affects recidivism rates of focal inmates from one to five years post-prison entry. As detailed in Section 3, we rely on facility-by-type-of-crime-by-year fixed effects (and various control variables) to isolate the peer influence from confounding factors. Specifically, we estimate equation 1 with peers' weighted average criminal experience (i.e. average number of arrests over the preceding five years) as the key explanatory variable. In the following tables, we will report the coefficient, β_1, on this first main explanatory variable of interest. Our reported results should be interpreted as a lower bound of the true effect, as peers' criminal experience

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may improve the focal inmate's skills in evading arrests and charges.

We begin by looking at the peer effect on the focal inmate's recidivism at the extensive margin. Here, the outcome variable is a binary indicator for whether the focal inmate was charged with any criminal offense in a given time period following their prison entry. Table 3 reports our findings. We look at recidivism both within one year (Panel A) and within five years (Panel B) of prison entry. As shown, the baseline recidivism rates are high: 45% of focal inmates face at least one criminal charge within one year of prison entry, a rate that increases to 71% within five years.[16] In Column 1 of Table 3, we report the estimated β_1 coefficient from a naive specification of equation 1, which omits both the facility-by-type-of-crime-by-year fixed effects and other controls. This reveals a strong correlation between recidivism rates and the weighted average of peers' criminal experience. As this correlation could be driven by the non-random allocation of inmates to prison facilities, we next include first facility-by-type-of-crime-by-year fixed effects (Column 2), and then an extensive set of controls variables for both the focal inmates and their co-inmates (Column 3). Our findings indicate a causal impact of peers' criminal experience on recidivism that is insensitive to the inclusion of individual, spell, and peer controls. To ease the interpretation of these causal estimates, we report standardized estimates in Column 4, using the same model specification as in Column 3. Focusing on this fourth column, we see that a one standard deviation increase in the weighted average of peers' criminal experience increases the probability of recidivism within a year of prison entry by 1.4 percentage points, an increase of 3.2% relative to the baseline rate.[17] Over a five-year period, this effect diminishes to a 1.5% increase relative to the baseline.[18]

Next, Table 4 provides additional results on the peer effect on the focal inmate's re-

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[16]The incapacitation effect of the initial imprisonment and any potential returns to prison restrict the potential for inmates to incur criminal charges. While this implies that our coefficients are underestimated, the issue should be minor. First, the median incarceration duration for our focal inmates is only one month. Second, only 37% of our focal inmates have multiple prison spells over the full 2000-2010 period. Our findings are very similar when we estimate Equation 1 on the sub-sample of the 63% of focal inmates with only one prison spell in the 2000-2010 period.

[17]For comparison, Stevenson (2017) finds effect of criminal experience on post-incarceration recidivism only for juveniles who are in proximate locations after/during incarceration. As the inmates in our setting are often incarcerated in a local prison, this highlights the potentially important role of post-incarceration proximity for peer effects among prison inmates.

[18]As shown in Appendix Table A1, these results remain robust when applying logistic regression analysis.

cidivism at the intensive margin. Here, the outcome variable is the focal inmate's number of post-incarceration charges. Similar to above, Panel A displays the estimated effect on the number of charges within one year after prison entry, while Panel B displays the estimated effect on number of charges within five years of prison entry. As in Table 3, Column 1 presents results from the naive specification, Column 2 adds facility-by-type-of-crime-by year fixed effects, and Column 3 further adds individual, spell, and peer controls. Column 4 presents standardized coefficients from our preferred specification with fixed effects and other controls. Notably, the influence of peers' criminal experience on recidivism is more pronounced at the intensive margin than at the extensive margin. In particular, a one standard deviation increase in peers' criminal experience causes a 6% increase in the number of charges over the longer term, as shown in Panel B, Column 4.[19]

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

	(1)	(2)	(3)	(4) Standardized
Panel A: Pr(Charged within one year of prison entry)				
Peers' weighted average criminal experience	0.00872***	0.00085***	0.00087***	0.01369***
	(0.00008)	(0.00031)	(0.00031)	(0.00490)
Outcome mean	0.4464	0.4464	0.4464	0.4464
Panel B: Pr(Charged within five years of prison entry)				
Peers' weighted average criminal experience	0.00744***	0.00056**	0.00066***	0.01033***
	(0.00008)	(0.00025)	(0.00021)	(0.00324)
Outcome mean	0.7074	0.7074	0.7074	0.7074
Controls	-	-	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	-	Yes	Yes	Yes
Observations	141018	141018	141018	141018

This table reports the coefficients and standard errors from the regression of the focal inmate's probability of reoffending on peers' weighted average criminal history (i.e., peers' number of arrests in the past five years weighted by the number of days each peer overlapped with the focal inmate in prison). The outcome variable is a binary indicator for having been charged with a criminal offense within one year (Panel A) or five years (Panel B) after incarceration. Controls include age, gender, marital status, number of years of education, severity of the crime, spell length, and number of charges in the past five years of the focal inmate, and controls for the average age, proportion of females, average number of years of education, distribution of type of crime, and proportion of married co-inmates. The analysis is based on a sample of prison spells that started between 2000 and 2010.
* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

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[19]While the short-term increase (10.4%) is larger, it is not statistically significant (Panel A, Column 4).

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

	(1)	(2)	(3)	(4) Standardized
Panel A: Number of charges within one year of prison entry				
Peers' weighted average criminal experience	0.09426***	0.01721	0.01803	0.28425
	(0.00190)	(0.01269)	(0.01113)	(0.17547)
Outcome mean	2.730	2.730	2.730	2.730
Panel B: Number of charges within five years of prison entry				
Peers' weighted average criminal experience	0.39802***	0.02087	0.04401**	0.69385**
	(0.00513)	(0.02111)	(0.01827)	(0.28801)
Outcome mean	12.4149	12.4149	12.4149	12.4149
Controls	-	-	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	-	Yes	Yes	Yes
Observations	141018	141018	141018	141018

This table reports the coefficients and standard errors from the regression of the focal inmate's number of criminal charges on peers' weighted average criminal history (i.e., peers' number of arrests in the past five years weighted by the number of days each peer overlapped with the focal inmate in prison). The outcome variable is the number of times the focal inmate has been charged with a criminal offense within one year (Panel A) or five years (Panel B) after incarceration. Controls include age, gender, marital status, number of years of education, severity of the crime, spell length, and number of charges in the past five years of the focal inmate, and controls for the average age, proportion of females, average number of years of education, distribution of type of crime, and proportion of married co-inmates. The analysis is based on a sample of prison spells that started between 2000 and 2010.
* p<0.1, ** p<0.05, *** p<0.01. Standard errors clustered at the prison level in parentheses.

While the previous literature has focused on recidivism within a year of release (Bayer et al., 2009; Stevenson, 2017),[20] our results on long-term recidivism in Tables 3 and 4 indicate that the influence of peers' criminal experience on a focal inmate's recidivism diminishes over time. To shed more light on this gradual attenuation, we illustrate the year-by-year dynamics of the effects in Figures 3 and 4. These figures display standardized β_1 coefficients and their associated 90% confidence intervals on the yearly effect from first to the fifth year post-incarceration.[21] The illustrated trends underscore a consistent decline in the impact of peers' criminal experience on recidivism rates, observable at both the extensive and intensive margins. At the extensive margin, the effect on the yearly probability of being charged is statistically significant in the first two years but diminishes

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[20]Damm and Gorinas (2020) and Philippe (2024) extend their analyses to recidivism within two and three years in robustness tables.

[21]In the estimation of these yearly effects, we have used the same specification as in Column 4 of Tables 3 and 4.

almost linearly over time (Figure 3). At the intensive margin, there is a similar decreasing trend, except for a drop in the effect at year two (Figure 4). This pattern of a declining effect is consistent with the idea that the influence of co-inmate peers gradually weakens as time progresses and as former inmates form new peer connections either outside the prison environment or in new prison spells.[22]

Figure 3: Extensive margin: Effect of peers' criminal experience on probability of future charges
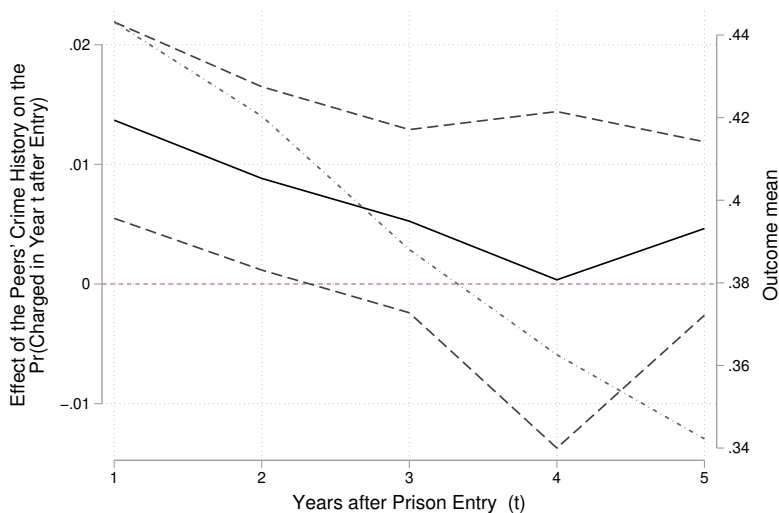
NOTE: Sample of prison spells that started between 2000 and 2010. The black solid line depicts the β_1 coefficients from the estimation of Eq. 1 on the probability of being charged each year, with the corresponding 90% confidence intervals in black dashed line. Standardized independent variable. The dashed-dotted line refers to the outcome mean (right-hand side axis).

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[22]The corresponding effects on cumulative outcomes are shown in Figures A3 and A4 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.
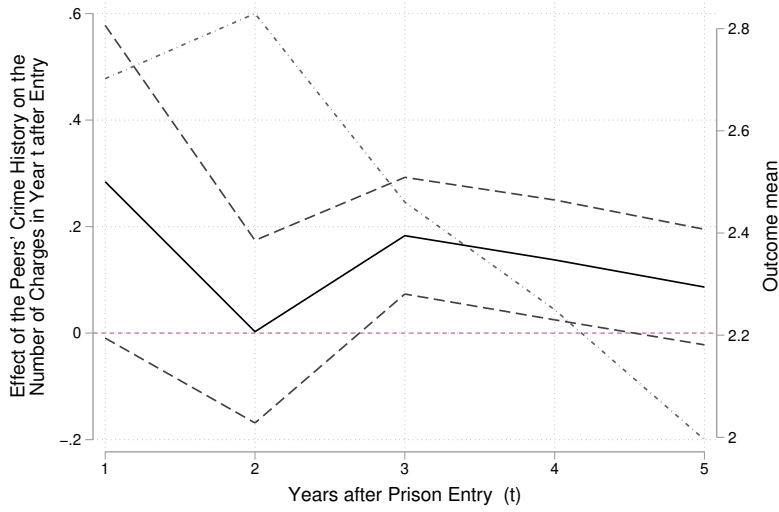
Figure 4: Intensive margin: Effect of peers' criminal
experience on number of future charges

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 dashed-dotted line refers to the outcome mean (right-hand side axis).

4.2 The role of top criminals

We have established that exposure to prison peers with more extensive criminal experience increases recidivism rates. We now further investigate whether the effect of average criminal experience is disproportionately driven by exposure to the most experienced peers, i.e. the 'top criminals'. We hypothesize several mechanisms through which these top criminals could exert a significant impact on recidivism. For instance, they may serve as mentors within the prison community, passing on especially sophisticated skills and knowledge that lead to more criminal behaviors post-release. Additionally, they might hold central roles in prison social networks, positioning them to influence multiple inmates simultaneously.[23] The potentially important role of the top criminals is particularly pertinent in settings like Norway's smaller prisons with large freedom of movement, where inmates are likely to interact closely, potentially increasing the influence of pivotal inmates.

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[23]As seen in Appendix Figure A1, the inmates with the most criminal experience are also those with the largest criminal networks.

To investigate the impact of exposure to top criminals, we develop alternative metrics for peer characteristics that determine whether a focal inmate has interacted with co-inmates who are among the top 10% or top 1% in terms of criminal experience. Our definition of top criminals is based on the distribution of criminal experience across all years and facilities, identifying interactions with Norway's most experienced criminals during the studied period. Appendix Table A2 provides comparative statistics highlighting differences between inmates within the top 10% of criminal experience and their less experienced counterparts. Notably, top criminals possess, on average, six times the criminal experience of other inmates. They are on average younger and less educated, and are also less likely to be women or born outside of Norway. Regarding the nature of their crimes, they are much more likely to be incarcerated for property crimes and are less likely to be incarcerated for all other crime types, especially violent and traffic crime.

Table 5 reports the (standardized) effect of (the number of days of) exposure to these top criminals on the likelihood of re-offending within five years of prison entry. For comparison, Column 1 of Panel A reproduces our main estimate of the effect of the weighted average of peers' criminal experience. Meanwhile, we focus on the specific impact of exposure to top criminals in Columns 2 and 3. A one standard deviation increase in the number of days of exposure to a top 10% criminal increases the likelihood of re-offending within five years by 0.5 percentage points (0.7%). We estimate a similar (0.5%) effect of exposure to a top 1% criminal. To further explore the specific influence of top criminals on the observed peer effects, we present additional findings in Panel B. Here, we test the distinct effect of exposure to top criminals while controlling for the average level of peers' criminal experience. These results confirm that the peer effect of exposure to top criminals is robust to controlling for the average criminal experience of peers.[24]

Our findings regarding the impact of exposure to top criminals on recidivism deepen our understanding of peer effects in prison settings and provide several takeaways for both theoretical understanding and practical application for policymakers and prison

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[24]As shown in Appendix Table A3, these results remain robust when applying logistic regression analysis.

administrators. The influence of top criminals highlights the importance of identifying key inmates and employing targeted prison management strategies such as specialized counseling, monitored interactions, or even segregated housing. If top criminals assume central roles within prison social networks, then disrupting these networks by strategically altering the placement of these central figures could significantly curb the propagation of criminal behaviors within the inmate population.

Table 5: Effect of exposure to 'top criminals' on probability of being charged within five years of prison entry

| | | # days of exposure to | |
	Baseline	top 10% criminals	top 1% criminals
Panel A: Not controlling for peers' weighted average criminal experience			
Weighted average	0.0106***	-	-
	(0.0032)	-	-
Exposure to 'top criminals'	-	0.0049**	0.0033***
	-	(0.0019)	(0.0011)
Panel B: Controlling for peers' weighted average criminal experience			
Exposure to 'top criminals'	-	0.0049**	0.0033***
	-	(0.0019)	(0.0011)
Weighted average	-	0.0105***	0.0103***
	-	(0.0031)	(0.0032)
Outcome mean	0.7075	0.7075	0.7075
Controls	Yes	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	Yes	Yes	Yes
Observations	140842	140846	140846

This table reports the coefficients and standard errors from the regression of the focal inmate's probability of reoffending (a binary indicator for having been charged with a criminal offense within five years of prison entry) on different explanatory variables. The variables are standardized. In Panel A, the explanatory variable is peers' weighted average criminal history (i.e., peers' number of arrests in the past five years weighted by the number of days each peer overlapped with the focal inmate in prison) in column 1, number of days of exposure to a top 10% criminal in column 2, and number of days of exposure to a top 1% criminal in column 3. Top criminals are defined based on the distribution of criminal experience among the full population of inmates (across all years and facilities). In Panel B, we regress the outcome on both the days of exposure to top criminals and peers' weighted average criminal experience. Controls include age, gender, marital status, number of years of education, severity of the crime, spell length, and number of charges in the past five years of the focal inmate, and controls for the average age, proportion of females, average number of years of education, distribution of type of crime, and proportion of married co-inmates. The analysis is based on a sample of prison spells that started between 2000 and 2010.
*$p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

4.3 The heterogeneous nature of peer effects in prison

In this section, we explore the heterogeneity of peer effects in prison. Our aim is to better understand the underlying mechanisms at play and to provide actionable insights for policymakers focused on reducing their impact. There are several pathways through which peer inmates can influence own criminal behavior. The 'school of crime' hypothesis implies that prison inmates might transfer illicit skills or knowledge of criminal activities. According to the skill transfer hypothesis, interactions with more criminally skilled peers can increase criminal behaviors, especially within the crime types of the peers' criminal experience. Another potentially important mechanism is that inmates could form networks that impact criminal behavior through post-incarceration interactions. Network formation is particularly plausible among inmates who are released into proximate locations.[25] While we cannot identify the exact mechanisms at play, the analysis in this section will examine how the impact of criminal peers varies across different inmate demographics as well as by prison characteristics. The results shed light on the mechanisms involved by identifying which inmate populations are most susceptible to negative peer influences and under which conditions these effects are magnified.

We begin by investigating the extent to which the influence of peers' criminal experience is moderated by the focal inmate's own criminal experience. We do this by incorporating an interaction term between peers' and the focal inmate's own criminal experience into a modified version of Equation (1). The coefficients on the treatment variable and this interaction term are displayed at the bottom of Figure 5, revealing that the effect of peers' criminal experience does not vary significantly with the focal inmate's own criminal experience. This finding provides preliminary evidence against the skill transfer hypothesis, which would predict a stronger peer effect on less experienced inmates. However, it is important to note that the coefficient on the interaction term is negative and lacks precision.

Other studies highlight the influence of homophily—the tendency to associate with

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[25]Other potential mechanisms more rooted in behavioral science include the transmission of psychological traits and social behaviors that are related to criminal behavior (Stevenson, 2017).

others who share similar characteristics—on prison peer effects (Damm and Gorinas, 2020; Philippe, 2024). To understand the role of homophily in our setting, we segment the measures of peers' criminal experience by whether the inmates share observable characteristics with the focal inmate, such as location, country of birth, age, and type of crime committed. Our findings, also displayed in Figure 5, indicate that the peer effects are driven by peers from the same municipality, suggesting that network formation plays a significant role.[26] Moreover, the peer effect is considerably stronger among inmates who share the same country of birth. While the influence of peers within the same age group appears stronger, the differences are not statistically significant when compared to peers from varying age groups. These findings highlight the strong influence of shared backgrounds on peer effects, pointing to the potential benefits of segregating inmates with similar profiles.[27]

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[26]Related to this, Philippe (2024) finds that exposure to a cellmate from a specific region increases the likelihood of re-offending in that region.

[27]In terms of homophily of the peer effect of exposure to top criminals, see Appendix Figure A5.

Figure 5: Effect of peers' criminal experience on the recidivism rate within five years of prison entry - by peer group
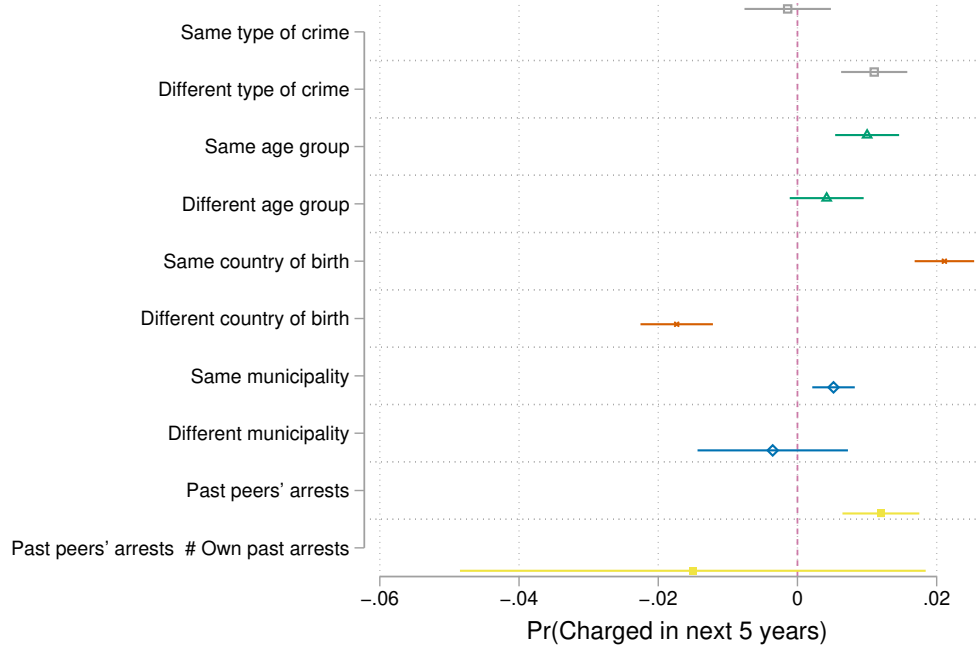
NOTE: This figure shows the effect of peers' average criminal experience separately for peers sharing a given characteristics with the focal inmate. Each peer's criminal experience variable is examined in a separate regression which includes controls and fixed effects specified in Equation 1. It includes 90% confidence intervals and uses a standardized independent variable. Same age group is defined as inmates being within +/- three years of the focal inmate's age. Crime type is classified across six broad categories: drug, property, economic, violent, traffic, and other crime.

Unlike previous literature that emphasizes the role of reinforcing peer effects in criminal behavior (Bayer et al., 2009; Damm and Gorinas, 2020), our findings (illustrated at the top of Figure 5) indicate that the peer effect in our setting is driven by peers experienced in different types of crimes than those for which the focal inmate was incarcerated. This type of effect is termed "branching out" (Bayer et al., 2009). Results from further investigation into this are detailed in Appendix Table A5. Here, we estimate the effect of peers' overall criminal experience on recidivism within the same type of crime for which the focal inmate was initially incarcerated (Panel A) versus in another type of crime (Panel B). In the short run, there is some evidence that peers' criminal experience increases within-type-of-crime recidivism for focal inmates incarcerated for property or drug crimes.[28] In the long run, there is statistically significant evidence of a similar rein-

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[28]This aligns with other studies, which find that a one-standard-deviation increase in the exposure to

forcing effect in economic crimes. For branching out effects, there is clear evidence that focal inmates incarcerated for violent or traffic offenses are more likely to commit other types of crimes after being exposed to more experienced peers, both in the short and long term.

Our findings on the different effects of peers' criminal experience on recidivism within the same type of crime versus another type of crime suggest that peer influences depend on the nature of criminal behaviors. For crime types that are skill- or network-intensive—such as drug crimes, property crimes, and economic crimes—there is some evidence that exposure to more experienced peers creates a reinforcing effect. This suggests that inmates involved in these types of crimes are likely to deepen their criminal expertise or extend their criminal networks when exposed to more experienced peers. Consequently, policymakers may want to consider inmate placement to mitigate this effect. Conversely, there is a clear branching out effect of peers' criminal experience for focal inmates incarcerated for offenses that typically do not require specific skills or networks, such as violent and traffic offenses. These inmates are more likely to commit more skill- or network-intensive types of criminal activity when exposed to more experienced peers. This suggests allocating prison inmates in a manner that prevents the acquisition of new criminal skills among inmates convicted of less skill-intensive crimes.

The evidence of branching out among inmates incarcerated for less skill- or network-intensive offenses underlines a critical vulnerability in certain segments of the prison population. We therefore turn our focus to those inmates who enter the prison system with minimal criminal backgrounds—such as first-time offenders or those incarcerated for minor offenses like traffic violations. According to the results presented in Appendix Table A4, the influence of peers' criminal experience on these "novice" inmates is markedly more pronounced, both in the short and long terms. Specifically, while the baseline result is that a one standard deviation increase in peers' criminal experience increases short- and long-term recidivism rates by 3.2% and 1.5%, the corresponding rates are 7.5% and

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drug-crime peers increases drug-related recidivism by 10.5% in the U.S. (Bayer et al., 2009) and 1.3% in Denmark (Damm and Gorinas, 2020), and that having an additional cellmate convicted of a drug (property) crime increases recidivism within that type of crime by 8.3% (5.2%) in France (Philippe, 2024).

3.5% for the first-time incarcerated, and 6.4% and 2.9% for those incarcerated for traffic offenses. These findings underscore the particular susceptibility of first-time inmates and those convicted of lesser offenses to the influences of more experienced criminals, strengthening the case for targeted interventions aimed at these particular groups.[29]

While the above findings demonstrate that peer effects in prison vary by inmates' characteristics and crime type, we now investigate how the characteristics of prison facilities themselves might exacerbate or mitigate these peer influences. To achieve this, we compute the distribution of peer effects across each of the 56 prison facilities and compare the characteristics of the facilities in the top 10% of this distribution to those of the remaining facilities. We display this comparison in Table 8. Consistent with the social nature of peer effects, we observe that the facilities exhibiting stronger peer effects among inmates are all open prisons, which allow for freedom of movement within the facility.[30] Moreover, we find that peer effects are more pronounced in facilities with a higher proportion of inmates incarcerated for violent crimes and a lower proportion of inmates incarcerated for property crimes.[31] These findings suggest that interventions to mitigate negative peer influences should be prioritized in open facilities and tailored to the specific demographic and crime profiles of the inmate populations.[32]

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[29]Such targeted interventions might include placing these at-risk inmates in separate facilities or specific units that restrict their interaction with peers who have extensive criminal backgrounds.

[30]Like Bayer et al. (2009), we find no differential effect by prison size.

[31]This finding aligns with Jacob and Lefgren (2003) who find that while school attendance boosts violent crimes, it reduces property crimes, highlighting the significant influence of social interactions in the dynamics of violent crime.

[32]Such targeted policies could involve more structured activities or stricter controls on inmate interactions in open settings or more focused rehabilitation programs that address the dynamics of certain inmates populations.

Table 6: Characteristics of facilities with a high vs. low
peer effect

	Top 10%	Rest of the distribution	(1) - (2)
Closed prison	0.000	0.600	-0.600***
			0.224
Prison size	43.623	58.214	-14.591
			25.908
Share of violent crimes	0.308	0.229	0.079**
			0.037
Share of property crimes	0.123	0.212	-0.089*
			0.045
Share of economic crimes	0.096	0.086	0.010
			0.021
Share of drug crimes	0.299	0.249	0.050
			0.047
Share of other crimes	0.083	0.101	-0.017
			0.013
Share of traffic crimes	0.090	0.123	-0.033
			0.065
Prison average severity of crimes	130.948	115.450	15.498
			9.827

This table reports summary statistics comparing facilities where the effect of peers' criminal experience on recidivism is larger with facilities where this effect is smaller. Prison size is measured as the average stock of inmates over the 2000-2010 period.
*p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses.

4.4 Network formation among co-inmates

While the previous section sheds some light on the mechanisms underlying the observed peer effects in prison, this section introduces novel and more concrete evidence on the importance of network formation among prison inmates. Here, we compare two sets of inmates who are similar except in one aspect: one set experienced overlapping prison terms, while the other did not. This method parallels our earlier approach, where we exploited variations in peer groups over time within the same facility during a limited time frame. This setup allows us to compare the outcome of one pair—the focal inmate and his peer—with the outcome of a different pair, consisting 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. Our proxy for network formation is co-offending, defined as the probability that a given pair will be charged in the same criminal case in the future.

Specifically, we leverage the pair-level dataset and estimate the following equation:[33]

$$Y_{i(s)j(s')f} = \gamma_0 + \gamma_1 Overlap_{i(s)j(s')f} + \gamma_2 \widetilde{X}_{j(s')} + \alpha_i(s) + \nu_{i(s)j(s')f} \ , \qquad (2)$$

where $Y_{i(s)j(s')f}$ is a binary indicator measuring post-incarceration co-offending between a focal inmate i in spell s and co-inmate j in spell s' in facility f. $Overlap_{i(s)j(s')f}$ is a binary variable indicating at least one day of overlap between the two inmates. $\widetilde{X}_{j(s')}$ controls for peer characteristics. Standard errors are clustered at the facility level. We exclude peers who had common charges in the five years prior to incarceration to avoid factoring in pre-existing networks.

To validate the results from this analysis, we run a similar randomization test as in the first analysis. Specifically, we predict the probability of having a joint charge within five years of prison entry based on the age, sex, number of years of education, 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 $Overlap_{i(s)j(s')f}$ variable. Reassuringly, overlapping with a given co-inmate is uncorrelated with the predicted probability of post-incarceration co-offending, as demonstrated in Appendix Table A6.

Table 7 reports the γ_1 coefficients from our estimation of Equation 2. The results clearly indicate network effects of prison, as overlapping prison terms significantly increase the likelihood of co-offending within the next five years. The effect is robust to the inclusion of spell fixed effects, even when interacted with the type of crime committed by the peer. Although the likelihood that any given pair will co-offend in the future is inherently low, making the absolute values of these coefficients appear small, the relative impact is substantial. Specifically, experiencing an overlap in prison terms increases the likelihood of future co-offending by 38% in our most stringent specification, highlighting the significant influence of shared incarceration time on subsequent criminal collaborations.[34]

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[33]The construction of the pair-level dataset 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.

[34]As shown in Appendix Table A7, this result remains robust when using logistic regression analysis.

Table 7: Probability of having a common charge within five years of prison entry

	Co-offence within five years of prison entry			
Overlap	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

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

Heterogeneity analyses. To shed further light on the observed network formation in prison, we explore the heterogeneity of the co-offending effect. As observed in the effect of peers' criminal experience on recidivism, homophily may influence the formation of criminal networks within prison. Furthermore, if the prison environment strengthens criminal networks beyond what typically occurs outside its walls, we would expect also pairs who are likely to interact outside of prison (due to shared traits such as location) to exhibit increased rates of co-offending resulting from their overlapping periods of incarceration.

To explore these points, we segment peer groups according to shared characteristics between inmate pairs. Figure 6 reports the β_1 coefficients from the estimation of Equation 2, analyzing the effect of overlapping prison terms on the likelihood of co-offending for each categorized group. The findings confirm the role of homophily in shaping criminal connections, particularly among inmates who belong to the same age group or were incarcerated for the same type of crime. Together with the above-mentioned results that criminal experience mainly affected recidivism through 'branching out', this implies that branching out might be driven by skill transmission, while reinforcing effects might be driven by network formation. In terms of network formation in prison above and beyond what might occur on the outside, note that we still find a positive effect for inmates from the same municipality, even though they might naturally interact outside prison. This

underscores the critical role of prisons in fostering criminal networks.

Figure 6: Heterogeneity: Effect of overlapping in prison
on the Pr(Cooffending within five years of prison entry)
by shared traits
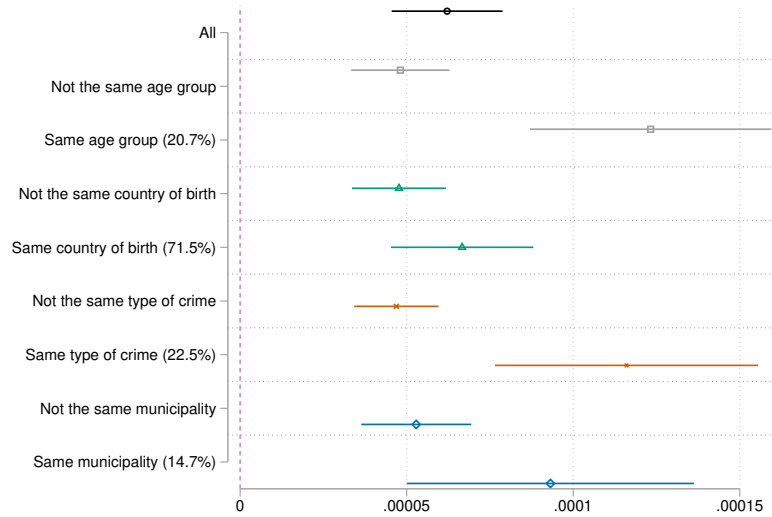
NOTE: This figure shows the effect of overlapping with a given co-inmate separately for whether that co-inmate shared a given characteristics with the focal inmate. We display standardized coefficients and 90% confidence intervals from the estimation of Equation 2. Same age group is defined as inmates being within +/- three years of the focal inmate's age. Crime type is classified across six broad categories (drug, property, economic, violent, traffic, and other crime). The share of each group in the sample is reported in parentheses.

To understand whether the characteristics of prison facilities also influence network formation, we estimate Equation 2 separately for each of the 56 prison facilities in our sample. We then compare, in Table 8, the characteristics of the facilities where the estimated network formation effect ranked in the top 10% of the overall distribution to the characteristics of the remaining facilities. Notably, prisons with more pronounced network formation effects are significantly more likely to be open and smaller in size (p-value = 0.108). This likely reflects that such environments facilitate greater inmate interactions, thereby bolstering our hypothesis that the observed effects stem from peer interactions. Furthermore, the network formation effect is stronger in prison facilities with a larger share of inmates incarcerated for drug crimes and where inmates were incarcerated for more severe crimes. Overall, our findings support the notion that specific prison characteristics, such as openness, size, and the severity of inmate crimes, play

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a critical role in fostering the development of criminal networks. These insights offer valuable information for prison design aimed at curbing the expansion of these networks.

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

	Top 10%	Rest of the distribution	(1) - (2)
Closed prison	0.200	0.588	-0.388*
			0.231
Prison size	17.816	60.160	-42.344
			25.910
Share of violent crimes	0.253	0.240	0.013
			0.037
Share of property crimes	0.185	0.199	-0.014
			0.045
Share of economic crimes	0.097	0.087	0.010
			0.021
Share of drug crimes	0.342	0.237	0.105**
			0.045
Share of other crimes	0.073	0.103	-0.029**
			0.013
Share of traffic crimes	0.049	0.135	-0.086
			0.062
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 presents summary statistics comparing prisons where the effect of overlapping on co-offending is large to those where the effect of overlapping is smaller. Prison size is measured as the average stock of inmates over the 2000-2010 period.

5 Summary and Concluding Remarks

The secretive nature of the criminal sector, coupled with the lack of formal structures, underscores the importance of understanding peer interactions in this domain. To this end, this paper provides a more complete understanding of how peer effects among prison inmates shape post-incarceration recidivism. We first corroborate and expand upon earlier evidence by documenting that peers' criminal experience increases recidivism at both the intensive and the extensive margin. We further document that this influence is significantly more pronounced among first-time offenders and those incarcerated for minor offenses, such as traffic violations, highlighting the need for targeted interventions for

these groups.

Our findings offer several additional new insights. First, we highlight the role of top criminals and show that part of the peer effects in criminal experience is driven by these pivotal figures. While the narrative of the 'kingpin' influencing collective behavior within prisons has often been speculated, our research provides concrete evidence supporting this theory. Second, addressing the underlying mechanisms of the observed prison peer effects, our unique data allow us to confirm the hypotheses of earlier studies by documenting criminal network formation among prison co-inmates.

Our analysis also underscores the importance of homophily in the formation of these peer effects. The effects are particularly pronounced among inmates who share similar backgrounds—such as age, nationality, or municipality—suggesting that shared characteristics facilitate stronger bonds and more influential interactions. This observation highlights the potential for interventions tailored to specific inmate demographics.

Moreover, consistent with the social nature of peer effects, we find that peer effects are stronger in open and smaller prison facilities. The peer effects on recidivism and co-offending also vary with the demographic composition of the inmate population, indicating that interventions to mitigate negative peer influences should be prioritized in open facilities and tailored to specific demographic and crime profiles of inmate populations.

In conclusion, our findings provide valuable insights with broader policy implications for prison management strategies. By shedding light on the role of pivotal inmates, network formation, and the heterogeneous nature of prison peer effects, our findings inform policymakers on designing more effective interventions to prevent the spread of criminal behaviors and effectively manage inmate populations. This could involve strategic inmate placement to avoid high-risk combinations of inmate groups, as well as enhanced structuring and monitoring of inmate activities. Such changes in prison inmate composition hold the potential to significantly reduce crime rates with all their related broader societal implications. Implementing such changes, however, requires a careful balancing act, considering other impacts on inmates' welfare and future outcomes.

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A Appendix: Additional Tables and Figures

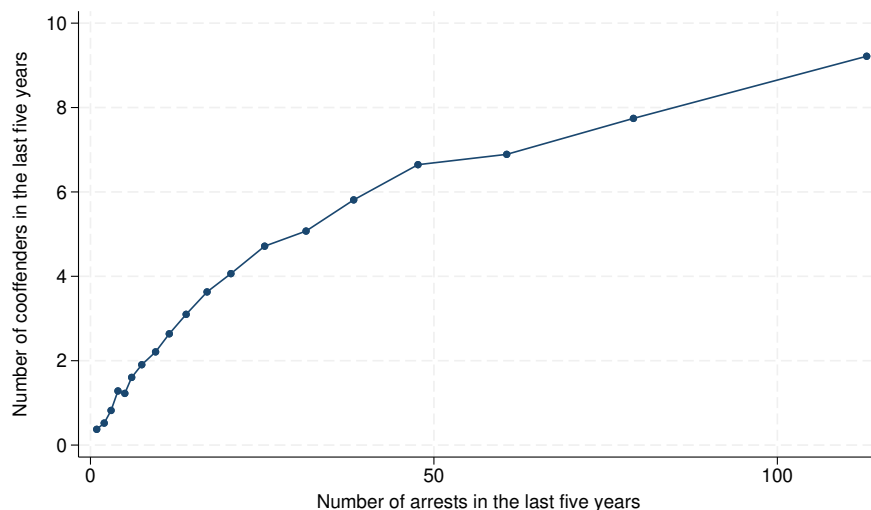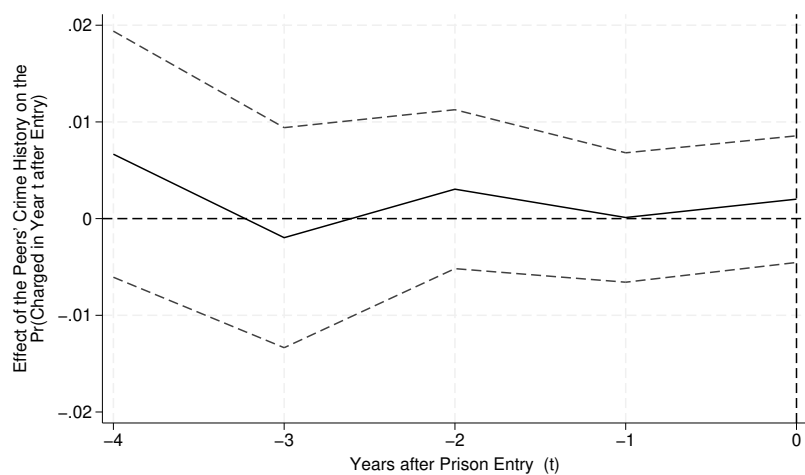Figure A1: Network size as a function of criminal experience

Figure A2: The correlation between peers' criminal experience and the focal inmate's probability of having a criminal charge in the five years prior to incarceration

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

Figure A3: Extensive margin: Effect of peers' criminal experience on probability of future charges
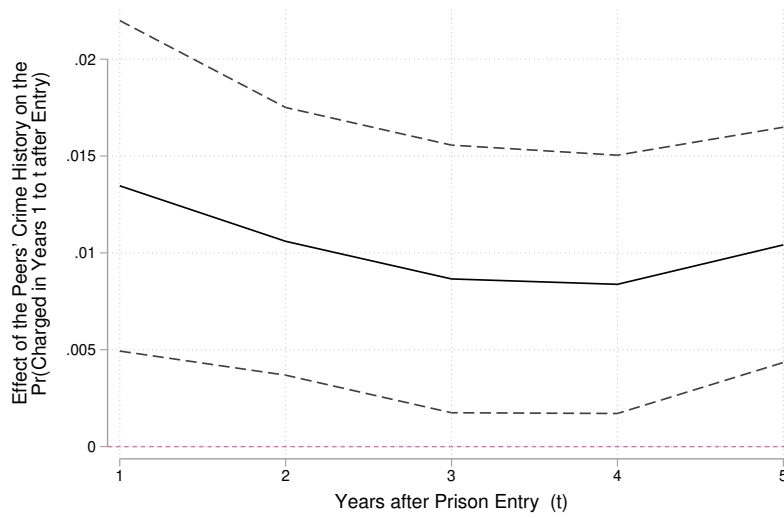
NOTE: Sample of prison spells that started between 2000 and 2010. 90% confidence intervals. Standardized independent variable.

Figure A4: Intensive margin: Effect of peers' criminal experience on number of future charges

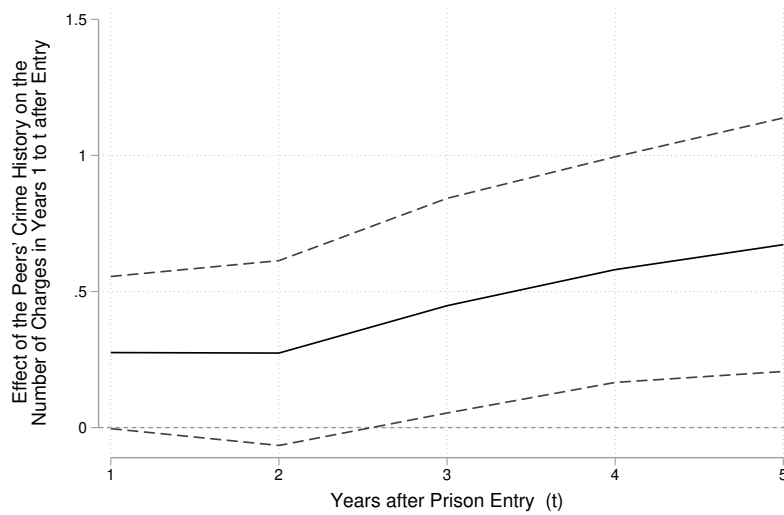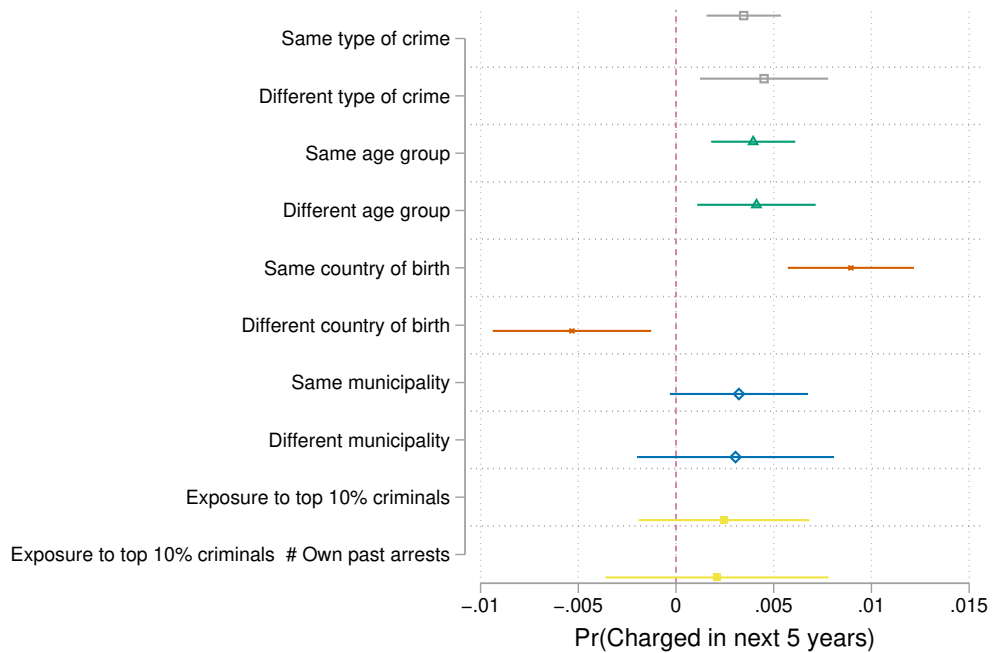*NOTE:* Sample of prison spells that started between 2000 and 2010. 90% confidence intervals. Standardized independent variable.

Figure A5: Effect of the number of days of overlap with top criminals 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. Days of overlap with a top criminal is computed separately based on whether the top criminal share or does not share a given characteristic with the focal inmate. We define same age group as the inmate being aged within +/- three years of the focal inmate's age. Regressions include controls and fixed effects specified in Equation 1. Crime type is classified across six broad categories (drug, property, economic, violent, traffic, and other crime).

Table A1: Extensive margin: Effect of peers' criminal experience on probability of future charges - Logit model

Panel A: Pr(Charged within one year of prison entry)	
Peers' weighted average criminal experience	0.04202*
	(0.02281)
Outcome mean	0.4475
Panel B: Pr(Charged within five years of prison entry)	
Peers' weighted average criminal experience	0.04726**
	(0.02328)
Facility-by-Type-of-crime-by-Year FE	Yes
Outcome mean	0.7022
Observations	138361

This table reports the coefficients and standard errors from a logistic regression of the focal inmate's probability of re-offending on peers' weighted average criminal history (i.e. peers' number of arrests in the last five years weighted by the number of days each peer overlapped with the focal inmate in prison). The outcome variable is a binary indicator for having been charged with a criminal offense within one (Panel A) or five (Panel B) years after incarceration. Controls include age, gender, marital status, number of years of education, severity of the crime, spell length of the focal inmate. Based on a sample of prison spells that started between 2000 and 2010.

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

Table A2: Descriptive statistics on criminals belonging
to the top 10% of the suspected crimes distribution

	Top 10% (1)	Rest of the distribution (2)	(2) - (1) (3)
Age	30.367	32.534	2.167***
			0.093
Female	0.056	0.078	0.022***
			0.002
Married	0.027	0.096	0.069***
			0.002
Foreign-born	0.042	0.106	0.065***
			0.003
Years of education	9.153	10.154	1.001***
			0.030
Charges in the 5 years preceding incarceration	77.738	13.162	-64.576***
Incarcerated for...			
...violent crime	0.080	0.227	0.147***
			0.003
...property crime	0.603	0.155	-0.448***
			0.003
...economic crime	0.068	0.090	0.022***
			0.002
...drug crime	0.156	0.196	0.041***
			0.003
...other crime	0.071	0.113	0.041***
			0.003
...traffic crime	0.022	0.220	0.197***
			0.003
Observations	15084	125875	140959

This table shows (1) the average characteristics of inmates belonging to the top 10% of the distribution with regards to criminal experience (i.e. number of arrests in the five years preceding prison entry), (2) the average characteristics of inmates belonging to the rest of the distribution, and (3) the difference between the two groups.
*p<0.05, ** p<0.01, *** p<0.001. Standard errors clustered at the facility level in parentheses.*

Table A3: Effect of exposure to "top criminals" on probability of being charged within five years of prison entry - Logit model

	Pr(Charged within five years of prison entry)
Number of days with a top 10% criminal	0.0276**
	(0.0125)
Number of days with a top 1% criminal	0.0209***
	(0.0075)
Controls	Yes
Facility-by-Type-of-crime-by-Year FE	Yes
Outcome mean	0.7023
Observations	138189

This table reports the coefficients and standard errors from a logistic regression of the focal inmate's probability of re-offending on number of days of exposure to top criminals. The outcome variable is a binary indicator for having been charged with a criminal offense within five years after incarceration. Controls include age, gender, marital status, number of years of education, severity of the crime, spell length of the focal inmate and peers' weighted average criminal experience. Based on a sample of prison spells that started between 2000 and 2010.
* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

Table A4: Standardized effect of peers' criminal experience on recidivism for different samples of focal inmates

	Baseline	Only first-time incarcerated	Only traffic offenders
Panel A: Pr(Charged within one year of prison entry			
Peers' weighted average criminal experience	0.01369***	0.02087***	0.01480**
	(0.00490)	(0.00558)	(0.00605)
Outcome mean	0.4464	0.2776	0.2307
Panel A: Pr(Charged within five years of prison entry			
Peers' weighted average criminal experience	0.01033***	0.01854***	0.01412**
	(0.00324)	(0.00635)	(0.00657)
Outcome mean	0.7074	0.5298	0.4940
Controls	Yes	Yes	Yes
Facility-by-Type-of-crime-by-Year FE	Yes	Yes	Yes
Observations	141018	52343	28021

This table reports the coefficients and standard errors from the regression of the focal inmate's probability of re-offending on peers' weighted average criminal history (i.e. peers' number of arrests in the last five years weighted by the number of days each peer overlapped with the focal inmate in prison), for different samples of focal inmates. Column 1 reproduces our main findings for the overall population of focal inmates (Table 3, column 4), while columns 2 and 3 restricts the sample to only first-time incarcerated focal inmates (i.e. inmates who appear in the prison data for the first time since data starts in 1992) and focal inmates incarcerated for traffic offenses, respectively. The outcome variable is a binary indicator for having been charged with a criminal offense within one (Panel A) or five (Panel B) years after incarceration. Controls include age, gender, number of years of education, 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, number of years of education, proportion of females, distribution of type of crime and proportion of married co-inmates. Based on a sample of prison spells that started between 2000 and 2010.
* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered at the prison level in parentheses.

Table A5: Effect of Peers' criminal experience on Recidivism - Reinforcing vs. Branching out Effect

	Violent Crimes	Property Crimes	Economic Crimes	Drug Crimes	Other Crimes	Traffic Offense
Panel A: Probability of being charged in the same type of crime						
			In year 1 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.00502	0.01454	-0.00020	0.01435	-0.00720	0.00032
	(0.00467)	(0.01224)	(0.01133)	(0.01257)	(0.01126)	(0.00526)
Outcome mean	0.1061	0.5013	0.1261	0.3193	0.2845	0.1058
			In years 1 to 5 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.00945	0.00488	0.03307**	0.01348	-0.01238	-0.00251
	(0.00896)	(0.00830)	(0.01355)	(0.01378)	(0.01063)	(0.00766)
Panel B: Probability of being charged in a different type of crime						
			In year 1 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.02869***	-0.00036	0.01379	0.01111	0.00953	0.01906***
	(0.00915)	(0.01090)	(0.01799)	(0.01090)	(0.01171)	(0.00567)
Outcome mean	0.3493	0.6660	0.2682	0.3682	0.4163	0.1749
			In years 1 to 5 after prison entry			
Weighted average of peers' suspected crimes in the last 5y	0.01891**	-0.00217	0.01880	-0.01644	-0.00508	0.01733*
	(0.00837)	(0.00706)	(0.01836)	(0.01194)	(0.01131)	(0.00992)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Facility-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Outcome mean	0.3037	0.7488	0.2749	0.6283	0.5551	0.3008
Observations	29729	28602	12388	27038	15240	28021

* p<0.05, ** p<0.01, *** p<0.001. Standard errors clustered at the facility level in parentheses. Each column exhibits the results from a regression on a different sample. The column title indicates the specific sample. Panel A reports results on the probability of reoffending in the same type of crime as the one the inmate has been incarcerated for, i.e. a reinforcing effect. Panel B reports results on the probability of reoffending in a different type of crime than the one the inmate has been incarcerated for, i.e. a branching out effect.

Table A6: Randomization test: Overlapping in prison is uncorrelated with predicted likelihood of future co-offending

	Predicted Pr(Common charge)			
	Within 1 year		Within 5 years	
Overlap	0.000000	0.000000	0.000000	0.000000
	(0.000000)	(0.000000)	(0.000000)	(0.000000)
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
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 or five years and a dummy equal to one if there is any overlap in the same facility. All columns include peer's month of entry fixed effects. The probability is predicted using the same fixed effects and the age, sex, number of years of education, marital status and crime's severity of the peer. We exclude co-inmate pairs who had a common charge in the five years preceding the focal inmate's incarceration.

Table A7: Probability of having a common charge within five years of prison entry - Logit model

	Co-offence within five years of prison entry
Overlap	0.354586***
	(0.050743)
Spell FE	Yes
Peer's type of crime FE	Yes
Outcome mean	0.003623
Observations	1665308

*p<0.05, ** p<0.01, *** p<0.001. Standard errors clustered at the prison spell level in parentheses.*

This table reports the coefficients from a logistic regression of an indicator variable for having a common charge within 5 years after incarceration on overlapping in the same prison facility at the same time. The regression is run at the pair level. Sample of prison spells that started between 2000 and 2010.