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THE EFFECTS OF LIMITING ACCESS TO GAMBLING

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The effects of limiting access to gambling: Insights from the closures of Electronic Gambling Machines*

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Abstract

In industries where consumption generates negative externalities, governments can attempt to curb excess demand by restricting supply. However, this strategy may simply shift consumption to substitutes with similar negative consequences. We explore this issue in the Finnish gambling market using two quasi-experiments and a difference-in-differences framework to assess how reducing the supply of land-based gambling affects gambling volume. Our findings suggest that, overall, there is limited substitution between different types of gambling. However, among high-volume gamblers, we observe some substitution, though even for these individuals, total gambling volume declines.

JEL Codes: D12, I18, L83.

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1 Introduction

Governments often regulate or tax the consumption of products and services with negative externalities or other harmful effects. These policies are often not complete in their coverage and apply to only a subset of products or services that contribute to negative effects. If consumers can easily find close substitutes for regulated products or services, regulations may merely shift demand to unregulated alternatives, resulting in little overall reduction in the consumption of goods contributing to adverse outcomes.

We study the issue of substitution in the context of the Finnish gambling market. Although for many gambling is a relatively harmless form of recreation, a subset of gamblers experience severe harms, including financial stress, family and relationship disruptions, health issues, declining job performance, criminal activity, and even suicide (Gabellini et al., 2023; Marionneau and Nikkinen, 2022; Binde, 2016). Problem gambling also imposes significant costs to the society (Hautamäki et al., 2025), and behavioral biases—such as limited attention, innumeracy, and lapses in self-control—can lead individuals to gamble more than they initially intended (Lockwood et al., 2024). As a result, the gambling industry is subject to extensive regulation. In Finland, gambling is exclusively operated by a state-owned monopoly. Across the country, the state-owned gambling monopoly supplies land-based electronic gambling machines (EGMs), also known as slot machines, in bars and retail outlets. While some argue for reducing the number of land-based EGMs (Heiskanen et al., 2020), others caution that such a move could drive more gambling to online platforms (STM, 2024). In particular, this could be the case for players who suffer from gambling problems.

We estimate how changes in the access to land-based gambling affect gambling volume[1] using two distinct quasi-experiments and player-level data originating from the state-owned monopoly. Our first empirical setting is centered around the land-based EGM closures during the COVID-19 pandemic. In Finland during COVID-19, hospital districts determined whether EGMs were kept open or closed in their area. During

[1] 'Gambling volume' refers to the stakes paid by players, from which winnings paid out to players have not been deducted.

the second wave of COVID-19, in one hospital district, North Savo, the EGMs were kept open, while in all neighboring hospital districts the EGMs were closed. Analysis of Google mobility data indicates that variations in shopping activity between North Savo and neighbouring hospital districts were quite small, suggesting a similar impact of COVID-19 on consumer behaviour across these regions. In our empirical analysis, we compare land-based and digital gambling volumes in North Savo to those in Central Finland, the neighboring hospital district that kept land-based EGM gambling closed the longest.

A drawback in the first empirical setting is that we are unable to track the land-based gambling of individuals, but instead use data aggregated at the municipality level. In our second empirical setting, we leverage the mandatory identification requirement for most land-based and all digital gambling in Finland, effective since January 2021. We base our empirical strategy on the closures of decentralized EGMs between 2022 and 2023. Closures occur because outlets such as grocery stores or bars close their business and also because the government has steered Veikkaus to reduce the number of land-based EGMs. We construct the treatment group from gamblers who played at a sales location that closed its EGMs. The control group consists of EGM players who did not play in any of the locations that closed its EGMs.

In addition to estimating average treatment effects for the whole sample, we are also able to analyze heterogeneous effects across different player segments. In particular, we focus on how player behavior varies according to their pre-closure gambling volume levels. The motivation for this is that players with higher gambling volume are more likely to suffer from gambling problems (Markham et al., 2015; Zendle and Newall, 2024). This distinction matters because if gambling reductions mainly come from casual players, this may reflect lost consumer surplus rather than reduced harm. In contrast, targeting high-volume gamblers—who are more likely to experience gambling problems—is more likely to reduce the negative effects associated with gambling. This perspective aligns with the primary aim of gambling policies in Finland, which is to curb problem gambling (Valtioneuvosto, 2022). Our heterogeneity analysis enables us to evaluate the policy's effectiveness along this critical dimension.

We find that on average, the substitution between land-based gambling and digital gambling is limited. Based on our results, the closure of the EGMs in Central Finland during COVID-19 resulted in around 40% decrease in gambling volume, which translates to roughly 50-60 euros.[2] We find some substitution to other forms of land-based gambling, but we find no statistically significant effect on digital gambling volume. Interestingly, we do not find evidence of long-term effects. Following the closures, land-based EGM volume and total gambling volume in Central Finland rise to match the trend in North Savo.

In the second empirical setting, focused on studying the effects of individual EGM closures, we again find a decrease in total gambling volume. Total gambling volume decreases on average by 5.9%, which is driven by an average reduction of 15.5% in EGM gambling. This 15.5% decrease corresponds to just over one-third of the share associated with the closed machine in the treatment group. This suggest that around two thirds of the volume previously allocated to the closed machine was redirected to other EGMs. On average, we do not find any statistically significant substitution to other forms of gambling. However, when we divide the sample into quintiles based on preclosure gambling volume, we observe a statistically significant shift to other categories in the highest-spending group. Even for this group, we observe a statistically significant decrease in total gambling volume.

Overall, the results suggest that restricting access to land-based gambling can be an effective strategy for reducing gambling activity. Specifically, at the aggregate level, we find that substitution between different types of gambling is limited, whereas substitution within the same type of gambling is relatively substantial. Despite a overall reduction in gambling volume, our findings indicate that policymakers should consider the potential for high-volume gamblers to reallocate a portion of their activity from the form under regulatory scrutiny to alternative types of gambling. If the goal is to reduce the gambling of those with the highest volume, additional regulatory measures on other game types,

[2] This figure refers to gambling volume not on lost money.

such as gambling in digital channels, might be required.

A key limitation of our study is that our data only captures gambling activity within the state-owned monopoly. Although foreign gambling operators are prohibited from operating in Finland, Finnish residents can still access and gamble on foreign websites. Estimates suggest that approximately half of digital gambling takes place on these foreign sites, and survey data indicates that high-volume gamblers are particularly likely to use them (Karjalainen et al., 2023).[3] During the COVID-19 closures, we find no significant differences in Google search queries for terms like 'online casino' or 'casino' between the control and treatment groups, suggesting that overall substitution toward foreign gambling sites was limited. However, these results should be interpreted with caution, as search data does not necessarily accurately reflect actual gambling volumes.

Previous research has examined how regulating one sin good can lead to increased consumption of other goods with similar negative externalities.[4] Several recent studies have specifically analyzed how cannabis legalization influences alcohol consumption. Anderson et al. (2013), Dragone et al. (2019), and Wen et al. (2015) find that legalizing marijuana is associated with reduced alcohol consumption and related harms.[5] Similarly, the liberalization of alcohol laws or tax reductions has been shown to shift alcohol purchases across borders (Voas et al., 2002; Vingilis et al., 2006; Asplund et al., 2007; Stehr, 2007; Johansson et al., 2014; Ye and Kerr, 2016).

Substitution patterns between different types of gambling have been examined in previous research, with earlier studies focusing on various forms of land-based gambling (Marionneau and Nikkinen, 2017; Nedved and Ferreira Neto, 2024). Several papers have also examined the correlation between land-based gambling availability and gambling volume (Selin et al., 2024; Badji et al., 2020). The shift from physical to online gambling has received attention during the COVID-19 pandemic. Studies based on descriptive

[3]Foreign operators and sites in this context refers not only to foreign gambling companies but also to the Finnish company Paf, which has the exclusive right to offer gambling in the autonomous Åland, but does not have the right to offer gambling in mainland Finland. Companies that do not have the right to offer games in mainland Finland can also be referred to as 'offshore operators'.

[4]Substitution effects between regulated and unregulated products have also been studied in environmental contexts. For instance, Taylor (2019) documents that banning 40 million pounds of plastic carryout bags led to a 12 million pound increase in trash bag purchases.

[5]For a comprehensive review of cannabis liberalization, see Anderson and Rees (2023).

evidence have found limited evidence of substitution between these modalities. (Marionneau et al., 2024; Auer et al., 2023; Black et al., 2022).[6] Our study contributes to this literature by providing causal evidence on substitution between different types of gambling including both substitution between different types of land-based gambling and substitution between land-based gambling and digital gambling.

On the regulatory side, our study also relates to recent research examining the effects of sports gambling legalization in the U.S. Since the 2018 U.S. Supreme Court ruling, 38 states have legalized sports betting. Baker et al. (2024) find that after legalization, sports betting expands rapidly, with increasing participation and betting frequency over time, leading to reduced savings as risky bets crowd out positive expected value investments without displacing other gambling or consumption. Hollenbeck et al. (2024) find that consumers' financial health declines following sports gambling legalization, as evidenced by dropping average credit scores, and the effect is significantly stronger in states permitting online betting compared to those restricting it to in-person venues. We complement these recent papers by examining an opposite policy approach, focusing on measures that restrict access to gambling rather than those that expand it. Similarly to these papers, we find that changes in access to gambling can have substantial effects on gambling volume.

This article is structured as follows. Section 2 offers a brief overview of gambling in Finland, with particular emphasis on regional variation in the availability of EGMs, which serves as the primary basis for our empirical strategy. Section 3 describes the data used in our analysis. In Section 4, we outline our empirical framework, followed by the presentation of our results in Section 5. Section 6 concludes with some closing remarks.

[6] The effects of the pandemic more generally on gambling behavior have also been examined, with mixed findings. Anderson and Rees (2023) reports a slight increase in gambling in Sweden, while Auer and Griffiths (2022) finds no significant change. Conversely, Close et al. (2022) and Hing et al. (2024) observe a decline in gambling participation post-pandemic, with Hing et al. (2024) noting that the effect persisted two years after restrictions were lifted. Similarly, Black et al. (2022) documents a sustained decrease in gambling sessions five months after restrictions ended.

2 Institutional Setting

The Finnish gambling market operates under a state-controlled monopoly managed by Veikkaus Oy. Veikkaus controls the entirety of the physical gambling market in Mainland Finland and it also holds a legal monopoly in online gambling. In Finland, the objectives of the gambling policy include preventing and reducing the financial, social, and health-related harms caused by participation in gambling. The Ownership Steering Department of the Prime Minister's Office is responsible for the ownership steering of Veikkaus Oy, and its key task is to ensure the company operates in accordance with the specific duties defined for it in gambling legislation. The National Police Board oversees Veikkaus Oy's gaming operations from the perspective of ensuring player rights, preventing irregularities and crime, as well as preventing and reducing harms caused by gambling. (Valtioneuvosto, 2022) Although foreign operators are prohibited from establishing themselves in Finland, Finnish residents are not barred from gambling on foreign websites. Studies estimate that approximately half of digital gambling takes place on foreign sites (Karjalainen et al., 2023).

In 2023, Veikkaus' gross gaming revenue, the total amount lost on Veikkaus games, was 1032 million euros. To put this into perspective, on average Finnish adults lost approximately 230 euros on Veikkaus games. A considerable share of Finnish gambling expenditure, in 2023 11% of total gross gaming revenue of Veikkaus, is spent on physical EGMs. These EGMs are located in grocery stores, restaurants, bars, and other retail outlets. Retail outlets have a financial incentive to host EGMs, as Veikkaus shares a portion of the revenue with them. In recent years, there have been several notable changes in the accessibility of electronic gambling machines.

During the COVID-19 pandemic, Veikkaus adhered to government guidelines and made business decisions accordingly. Finland did not implement strict movement lock-downs, allowing most retail gambling outlets that sold lottery and betting products to remain open. However, in March 2020, Veikkaus closed all EGMs and gaming arcades to curb the virus's spread, reopening them in July 2020.[7] During the second wave in fall 2020, Finland implemented a three-stage regional action plan based on hospital district risk levels. From November 2020 to May 2021, EGMs and gaming arcades remained open in low-risk areas but were closed in higher-risk districts. North Savo Hospital District was the only region where EGMs stayed open throughout the second wave. Other districts experienced varying closure lengths. By the third wave in late 2021–early 2022, there were no widespread, long-term EGM closures, though gambling was affected by restrictions on food and beverage outlets.

Already prior to the COVID-19 pandemic, the Finnish government has guided Veikkaus to reduce the number of EGMs. The decision to reduce exposure to and availability of electronic gambling machines is part of a broader strategy to address gambling-related harms, particularly among individuals with gambling disorders. In October 2019, Veikkaus announced plans to significantly decrease the number of decentralized EGMs, reducing them from ca. 18,500 in 2019 to fewer than 9,100 by 2022 (Veikkaus 2019, 2022). These reductions have primarily targeted partner locations such as grocery stores, restaurants, and bars. Veikkaus retained discretion over which EGMs to remove. Prior research suggests that EGMs have been disproportionately concentrated in socio-economically disadvantaged areas (Raisamo et al., 2019), likely reflecting higher demand in these regions.

In addition to changes in geographical availability, there have also been other major changes in the Finnish gambling legislation. These changes have primarily focused on extending mandatory identification and introducing precommitment requirements across various gambling modalities, encompassing both digital and land-based platforms.

Digital gambling in Veikkaus.fi has required mandatory identification from inception, as it allows the enforcement of age restrictions and ensures compliance with legal standards. Subsequently, the mandatory identification requirement was progressively extended to land-based gambling between January 2021 and January 2024. Mandatory identification was instituted for decentralized EGMs—situated outside traditional casino environments—effective January 2021, and in January 2024 the requirement was extended

[7] Sports betting was also severely affected by event cancellations.

to scratch cards marking the culmination of efforts to ensure that all gambling products offered by Veikkaus operate under a uniform identification framework. In addition to identification requirements, a significant regulatory development occurred in September 2021, when Veikkaus mandated pre-commitment for EGM players, which requires players to set personal loss limits before engaging in gambling activities.

3 Data and descriptive statistics

3.1 Data

Our main dataset covers all Veikkaus gambling activity from January 2020 to December 2023. Each observation in the data corresponds to a specific player on a given day, with separate entries for different game types. Game types include lotteries, EGMs, sports betting, horse-race betting, table games and scratch cards. We can differentiate between online and physical gambling in each game type. Also in physical gambling the data separate between different gaming locations. For the locations, we observe their postcode and the type of outlet, i.e. whether the outlet is a grocery store, gas station, arcade hall, kiosk, or a bar. The key variables in the data are gambling volume, which equals the total wagers placed by the player, and total winnings.[8] In addition to these variables, the data also record players' age[9], gender, and home postcode.[10]

A key limitation of the data is that not all gambling is identified. For non-identified gambling, we are not able to track the players but for land-based gambling do observe the outlet at which the gambling took place. As explained in the previous section, the starting date for mandatory identification has varied for different gaming types. Identified gambling accounted for 58.1% in 2020, rising to 91.0% in 2023. The total number of identified players was ca. 2.15 million at the end of 2020 and increased to ca. 2.52 million by the end of 2023 (Veikkaus 2021, 2023). For physical EGMs, mandatory identification

[8]To protect client identities, large lottery winnings exceeding 100,000 euros have been censored in the data.

[9]The age variable in the dataset is truncated at 85.

[10]Demographic data is missing for a small share of players. For example, in 2022 gender was not available for less than 0.1% of players.

has been required since January 2021, and online gambling has required identification through the whole time period covered by our data.

The second dataset we utilize is the Paavo postal code area statistics from Statistics Finland, which provides demographic information at the postcode level such as the share of residents with a college degree, average income, and population density. We merge this information to the gambling data using the home postcode of the player.

3.2 Descriptive statistics

The number of outlets with active electronic gambling machines is a key factor driving our empirical strategy. We plot this in Figure 1.[11] While the number of EGMs varies across outlets, we do not have data on the exact number of machines hosted by each individual outlet. In the Figure, we distinguish between different types of outlets. Throughout the time period studied in this paper, the number of outlets with EGMs was highest in grocery stores. Bars ranked second, followed by other retail outlets, which include gas stations and kiosks. In addition, the figure displays the number of active Veikkaus game rooms, which are arcade halls operated by Veikkaus. In January 2020, the total number of outlets was 6,262. This falls to zero during the first wave of COVID-19 between March 2020 and July 2020. The number of outlets again starkly decreases during the second wave of COVID-19 from November 2020 to May 2021. However, this time the number of active EGM outlets does not fall to zero, because machines are kept open in North Savo. The second wave is marked in the Figure using red vertical lines. During the third wave, the number of EGM outlets was only affected in bars.

In February 2022, there were 4,801 outlets with EGMs.[12] By December 2023, this number had decreased to 4,287. This decline was driven by a combination of factors, including businesses closing or choosing to remove EGMs from their premises. Additionally, some of the reduction resulted from Veikkaus deactivating machines. In the figure vertical black lines indicate the time period studied in the second empirical setting of this

[11] There is one Casino and one horse race track in Finland hosting EGMs of Veikkaus and we omit these from the Figure.

[12] The number of active EGMs is lower in January 2022 compared to February since some EGMs located in bars were closed. The figures cited in the text omit the Casino and horse track hosting Veikkaus EGM.

paper. During the time period from April 2022 to July 2023 the number of EGM outlets decreased by 410.

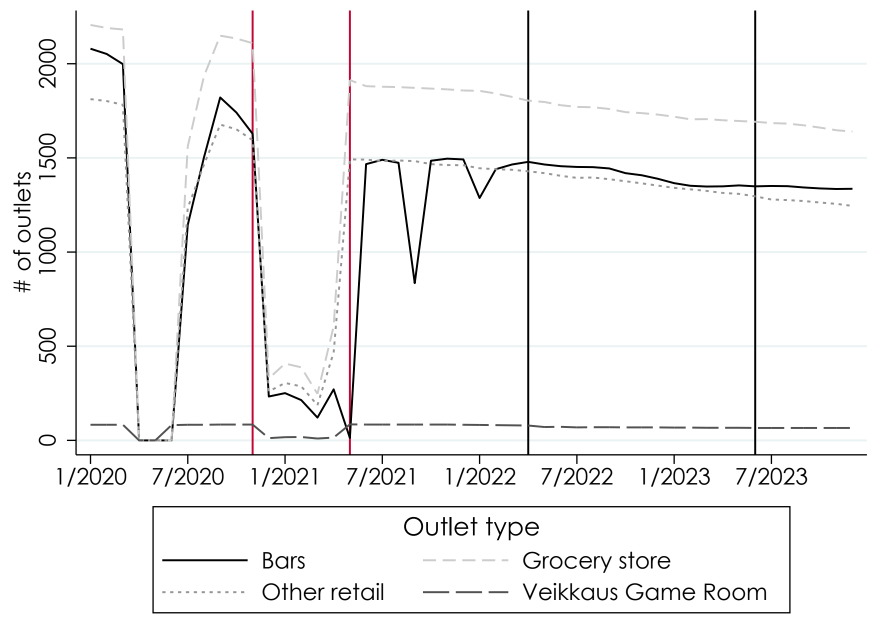

Figure 1: Number of outlets with EGMs

In this Figure we plot the number of outlets hosting EGMs from the beginning of January 2020 to December 2023. An outlet is classified as active if it has positive turnover. During the first outbreak of COVID-19 we also classify as inactive a few outlets that reported turnover of less than 1000 euros. The categories of outlets originate from the data by Veikkaus. Other retail includes other shops and sales points, transport stations, kiosks, department stores, and gas stations.

Figure 2 illustrates Veikkaus' gross gaming revenue during our sample period. For context, we have also included data from 2019, the year preceding our study and the onset of the COVID-19 pandemic. In 2019, total gross gaming revenue amounted to 1,691 million euros, with land-based gambling and EGMs accounting for 68% and 40% of the total, respectively. In 2020, gross gaming revenue dropped sharply to 1,260 million euros with EGMs contributing 384 million euros less than in 2019, while digital gambling saw a modest increase of 9 million euros. Land-based gambling, excluding EGMs and including lottery tickets, scratch cards, and sports bets purchased at physical outlets, declined by 55 million euros between 2019 and 2020. This decrease was significantly smaller than the decline in EGM gambling. In the following years after 2020, the total gross gaming revenue of Veikkaus did not recover to 2019 levels but continued to decline slightly, reaching 1,032 million euros in 2023.

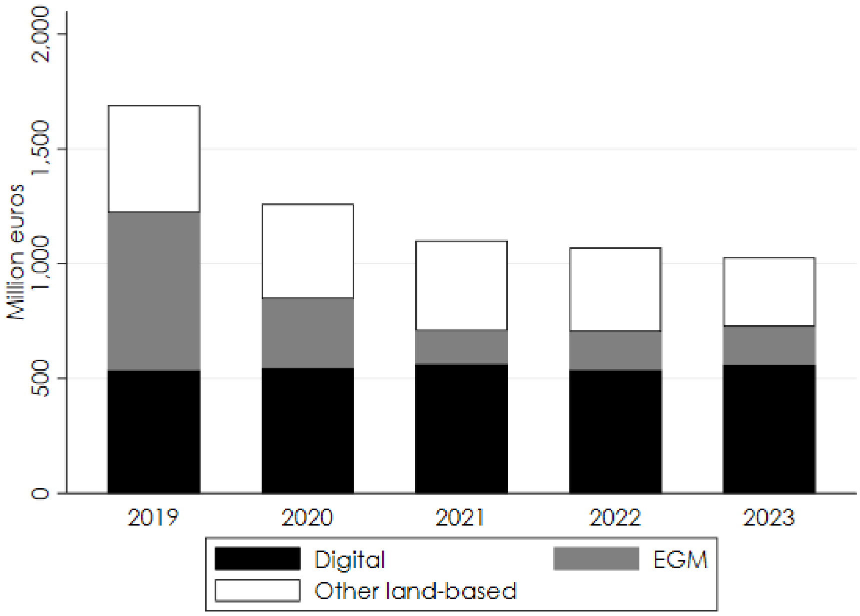

Figure 2: Development of gross gaming revenue

This figure shows the development of Veikkaus' gross gaming revenue, based on data from the company's financial statements.

Spending by Finns on foreign gambling operators is not tracked in any official statistics. However, estimates from the consulting firm H2 Gambling Capital suggest that offshore gambling amounted to just under 300 million euros in 2019 and slightly exceeded 300 million euros in 2020. All offshore gambling is conducted digitally. According to H2, offshore gambling rose to approximately 400 million euros in both 2021 and 2022. This corresponds to an estimated market share of around 30-40% of the total gambling market, and approximately 50% of the digital gambling segment. A survey conducted by the Finnish Institute for Health and Welfare yields a similar estimate for the market share of offshore operators in Finland.[13] Overall, even when accounting for the increase in offshore gambling, the amount of money lost on gambling decreased considerably between 2019 and 2023. In 2019 total gross gaming revenue was close to two billion euros while in the last years of our sample period it has decreased to around 1.5 billion euros.

The developments described above suggest that COVID-19 and the reduction in the number of EGMs have led to a significant decline in land-based gambling, with only

[13]For a more comprehensive analysis of money spent by Finns on foreign operators, see Karjalainen et al. (2023).

limited substitution to other types of gambling. However, these aggregate trends should be interpreted with caution. As discussed in Section 2, Veikkaus has introduced measures such as mandatory identification and pre-commitment (loss limits), which are likely to influence gambling volume. Additionally, other broader trends may have contributed to the decline in gambling, independent of changes in availability. In the next section, we outline our approach to estimating the causal effects of changes in EGM availability.

4 Empirical strategy

This study aims to estimate the impact of changes in the availability of land-based gambling on individual gambling behavior. To this end, we employ two complementary empirical strategies. First, we exploit regional variation in the availability of EGMs resulting from COVID-19-related closures, applying a standard difference-in-differences design. Second, we use a stacked difference-in-differences framework to analyze the staggered, decentralized closure of EGMs between January 2022 and December 2023. In this section, we outline both empirical approaches. We begin by describing the sources of variation and the key identification assumptions associated with each empirical approach. Next, we detail the construction of treatment and control groups and present summary statistics by group. Finally, we describe our estimation procedure and empirical specification.

4.1 COVID-19 closures

During the second wave of the pandemic in Finland, North Savo was the only hospital district that kept EGMs open, while all other districts closed them for varying lengths. This policy divergence generates substantial variation in EGM availability across regions. In a difference-in-differences setting, we compare gambling volume in North Savo to Central Finland before, during and, after the closures. Central Finland is the neighboring hospital district with the longest closure. Later we call Central Finland, where the EGMs were closed, as the treatment group, and North Savo, where the EGMs remained open, as the control group. The pre-period covers August to October 2020, during which EGMs were operational in both hospital districts. The post-period spans December 2020 to April 2021, when the machines were closed in Central Finland. November 2020 and May 2021 have been excluded from most specifications, as the closures began in Central Finland in mid-November and ended in early May. We also present results from a staggered design, where we compare North Savo with all neighboring hospital districts. The key identifying assumption in our analysis is that without the COVID-19 related closures gambling volume in the treatment group would have evolved similarly to that in the control group.

A potential concern in our empirical setting is that North Savo followed a different policy due to stark differences in the severity of the COVID-19 pandemic in the region and that differences in the severity of COVID-19 pandemic could also have an effect on gambling. In Appendix A.1, we present evidence from Google mobility data that differences in mobility across the two hospital districts were only small. In the same Appendix, we also present data on the number of infections in the regions.

At the start of the second wave EGM gambling did not yet require identification. Due to this, we have to aggregate the data at the municipal level. For land-based gambling, we allocate volumes based on the location of the outlet. This assumes that all gambling at a given location is done by players living in the same municipality. This is likely to be roughly correct, since previous studies have found that most land-based gambling in Finland takes place very close to the home address (Selin et al., 2024). For digital gambling, where identification was already mandatory prior to the COVID-19 pandemic, we can allocate gambling volumes based on the player's home postcode. For both digital and land-based gambling we collapse the daily data at the monthly level.

In Table 1, we present some descriptive statistics on the control and treatment municipalities before and after closures. The total number of municipalities in North Savo is 21 and in Central Finland 18. Gambling volume is measured by dividing the total volume by the number of adults in the municipality. Due to confidentiality reasons, we present gambling volumes indexed up to one month prior to municipal closures. That is, for each municipality, gambling volume is divided by the average volume recorded in its corresponding hospital district one month prior to the closures. The figures reveal that, as expected, EGM gambling during the closures falls to zero in the treatment group. We also see a decrease in EGM gambling in the control group and a slight increase in digital gambling for both the treatment and control groups. Overall gambling volume falls more sharply in the treatment municipalities. For confidentiality reasons, the index allows no comparison of the level of gambling volume in the treatment and control municipalities. However, for year 2022 the average gross gaming revenue figures are publicly available because Veikkaus allowed a Finnish newspaper to publish the figures. In North Savo average gross gaming revenue was 305 euros and in Central Finland 271 euros.

The table also presents key municipality characteristics, such as the size of the adult population and average household earnings. Municipalities in the control group are slightly larger and have higher average incomes than those in the treatment group. The proportion of highly educated individuals is significantly below the national average in both groups.[14] Meanwhile, the share of males and the average age are similar across treatment and control municipalities.

[14]The largest cities in North Savo and Central Finland have a much higher share of highly educated residents. As a result, a population-weighted average would be considerably higher than the unweighted average shown in the table.

Table 1: Descriptive statistics by clinic type

Gambling volume (indexed)	Treat. - Bef.	Treat. - Aft.	Cont. - Bef.	Cont. - Aft.
Total	92.91	57.33	95.04	90.12
Digital	87.17	98.81	89.43	103.26
Land-based excl. EGM	96.89	95.03	94.82	91.54
EGM	98.46	0.00	102.74	71.75
Municipality characteristics				
Adult population	10,938	11,064	9,591	9,620
Average age	49	49	47	47
Highly educated share	0.12	0.12	0.14	0.14
Male share	0.51	0.51	0.51	0.51
Average income	21,618	21,618	22,095	22,095
# of municipalities	18	18	21	21

Before treatment refers to August and October 2020, while after treatment correspond to December 2020 and May 2021. The municipality characteristics data for the pre-treatment period is sourced from the 2020 vintage of Paavo database and post-treatment of 2021 vintage of the same database. We define higher education as having completed either a lower or higher level university degree. The shares are calculated from the adult population. Gambling volume is indexed as the non-weighted hospital district average in October 2020. All numbers in the table are not weighted by population.

We estimate the average treatment effects using the following two-way fixed effects model:

$$\log(Y_{it}) = \theta_i + \gamma_i + \beta D_{it} + \epsilon_{it} \tag{1}$$

, where $\log(Y_{it})$ corresponds to the logarithm of the outcome variable for municipality i at month t, θ_i correspond to time fixed effects and γ_i to municipality fixed effects. D_{it} equals one for the treatment municipalities after the closures and is otherwise zero. ϵ_{it} is the error term. The parameter of interest is β, which recovers the effect of the closure on the outcome.

We use three outcome variables: digital gambling volume, land-based gambling volume and total gambling volume. We opted to use gambling volume as the outcome variable instead of gross gaming revenue for two key reasons. First, gross gaming revenue, even at the municipal level, can be heavily influenced by large winnings, introducing variability unrelated to gambling demand. Second, gambling volume more accurately reflects the actual demand for gambling. Moreover, over the long run, gambling volume and gross gaming revenue are strongly correlated, as winnings in games like EGMs and lotteries are determined by chance. To get a sense of the relative magnitudes of gambling volume and gross gaming revenue, in 2021, Veikkaus' total volume was approximately 6.9 billion euros, while its gross gaming revenue amounted to 1.1 billion euros (Veikkaus, 2021).

In our main specification, we cluster standard errors at the municipal level and weight municipalities based on their adult population. We also present results from a specification with no clustering and weighting. In addition to the main analysis, we also examine whether the closures had long-term effects on gambling. In this specification, the pre-period is the same as in the main specification, but the post-period starts June 2021 and ends in May 2022.

4.2 Individual closures

Our second empirical setting examines the individual closures of EGMs across Finland, driven both by business closures of hosting outlets and government efforts to reduce the number of EGMs. These closures result in variation among players, as some played on the closed machines while others did not. We determine the closing month of each outlet by analyzing individual gambling data alongside sales location records. Our treatment group includes players who played a now-closed machine within the three months preceding its closure. The control group comprises all players who did not engage with any closed machines during the event window. The key identifying assumption is that without the closures, the gambling volume in the treatment group would have evolved similarly to in the control group.

Because closures occur at different times, our difference-in-differences setting is staggered. Recent studies have shown that in staggered settings a two-way fixed effects model may result in biased estimates (see e.g. Goodman-Bacon (2021) and Baker et al. (2022)). We use the stacked difference-in-differences model to estimate the treatment effect (see e.g. Wing et al. (2024), Cengiz et al. (2019), and Butters et al. (2022)). For each of the closure times ("sub-experiments"), we create a separate data set. These individual subsets are appended or "stacked" across all events to create our estimation dataset. Each sub-experiment includes a three-month pre-treatment period and a six-month post-treatment period, thus each event window, including the month the machine is closed, is made from 10 months of data. In most of our analyses, we exclude the closing month, leaving us with 9 months of data.

We use data from January 2022 to December 2023. To ensure that we have enough data prior and after the closure, we study closures occurring between April 2022 and June 2023, thus having 15 sub-experiments (e.g., sub-experiment 15 has June 2023 as time 0, January 2023 as time -3 and December 2023 as time +6). The start date was selected to ensure the study is not affected by COVID-19-related closures, while the end date was chosen to guarantee that our data includes a full six-month period following each closure. A total of 500 decentralized EGM outlets were closed during this time window. After excluding 14 closures of game rooms, spaces dedicated for gambling, we end up studying 486 closures.[15]

Individuals are assigned to the treatment group of each sub-experiment if the combined share of their gambling volume in outlets that close during the treatment month is at least 15%.[16] The control group consists of individuals who did not gamble at any closed outlet during the event window.[17] To ensure the sample reflects active gamblers, for each event, we calculate each individual's total gambling expenditure over the pe-

[15]Between April 2022 and July 2023, the number of EGMs decreased by 410. As noted in the main text, 500 outlets closed during this period. Additionally, 92 new outlets hosting EGMs were opened, and few outlets that were open in April 2022 were temporarily closed by July 2023 (and vice versa), contributing to the overall change.

[16]In Appendix B, we also present results using alternative thresholds.

[17]To ensure comparability between the treatment and control groups, we exclude players from treatment group who gamble at outlets that closed in months other than $t = 0$.

riod spanning the three months immediately preceding the event month plus the event month itself, and exclude anyone whose cumulative spending on EGMs in that window falls below 50 euros. A potential concern with our empirical strategy, particularly the selection of the control group, is that although players in the control group did not use the closed machine, their gambling behavior may still have been affected by its closure. The mere presence of EGMs could serve as a form of marketing that influences behavior. To mitigate the concern that some of the players in the control group were influenced by the closures, despite not playing in these outlets, we form an alternative control group of players experiencing no closures within a radius of 10 kilometers from their home postcode.

In Table 2, we show some descriptive statistics on the treatment and our main control group. The total number of players in the treatment group is 14,830 and in the control group 324,439. A player can belong to the control and treatment group in several sub-experiments. In particular, this is common for the control group where 6% of players belong to the control group in only one sub-experiment. The average share of gambling volume in outlets that close ("closed share") is 45%. Gambling volume in the table is indexed to the pre-treatment sample average. Since both the treatment and control groups are indexed using the same sample average, the index enables a direct comparison of gambling volume levels between the two groups. Gambling volume is lower in the treatment group already prior to the closure. In our difference-in-differences specification, permanent differences in outcome are essentially canceled out. After the closure, gambling volume considerably decreases in the treatment group. Gambling volume slightly decreases also in the control group. This reflects the overall declining trend in gambling volume depicted in Figure 2. The average age and the male-to-female ratio are very similar across the control and treatment group. We also present the average income and the proportion of highly educated individuals in the home postcode.[18] Also, these are very similar across the control and treatment groups.

[18] We define higher education as having completed either a lower-level university degree or a higher-level university degree. The shares are calculated from the adult population.

Variable	Treatment - Before	Treatment - After	Control - Before	Control - After
Gambling volume (indexed[a])				
Total volume	92.88	84.96	99.32	96.81
EGM volume	89.52	71.40	99.21	93.87
Other gambling volume	96.05	97.78	99.43	99.58
Customer characteristics				
Age (years)	42.04	42.89	42.44	43.07
Sex (0=female, 1=male)	0.79	0.79	0.78	0.78
Closed share	0.45	0.45	0.00	0.00
Number of unique customers	14,830	14,830	324,439	324,439
Postcode-level characteristics				
Average income (EUR/year)	25,583	26,046	25,322	25,718
Highly educated share	0.23	0.23	0.22	0.22
Number of observations	44,757	89,514	7,382,727	14,765,454

[a] Indexed monthly average. 1 month prior to closures = 100. The month of closure is omitted from the table.

Table 2: Descriptive statistics for treatment and control group

Similar to our first empirical setting, our outcome variable is gambling volume. Substantial share of the observations in our estimation data report zero gambling volume, indicating that the player did not gamble at all that month. A common approach in such settings in the prior literature would be to impose a small addition to the observed values to deal with the zeros and then take a logarithm of the transformed outcome variable (e.g., $log\ (Y_{ict} + 1)$). However, as shown in Chen and Roth (2023) this approach can result in biased estimates. We follow the advice in Chen and Roth (2023) and estimate our difference-in-differences model using Poisson Pseudo-Maximum Likelihood (PPML). In the Poisson specification, the parallel trends assumption applies to percentage changes, meaning that, in the absence of treatment, the outcome's percentage change would have followed the same trajectory as in the control group.

More concretely, our main estimation equation has the following form:

$$\mathbb{E}[Y_{ict} \mid X] = \exp(\theta_{tc} + \gamma_{ic} + \psi D_{ict}) \tag{2}$$

, where Y_{ict} is the outcome variable for individual i at time t of sub-experiment c. D_{ict}

is equal to $\text{Treat}_{ic} \times \text{Post}_{ct}$, and is equal to 1 if individual i in sub-experiment c is treated at time t and 0 otherwise. θ_{tc} are sub-experiment-time fixed effects and γ_{ic} are individual-sub-experiment fixed effects. ϵ_{ict} is the error term for individual i at time t of sub-experiment c. The sub-experiment specific fixed effects ensure that we always compare the treatment and control group within the sub-experiment. We also present results from a model that facilitates comparison across different sub-experiments by replacing sub-experiment-specific fixed effects with an indicator variable for the treatment group and post-period in the estimation equation. Additionally, we present results from a model specification that includes sub-experiment-specific fixed effects, as well as age and sex fixed effects. This ensures that the comparison between the control and treatment groups is made among players of the same age and sex. In all our specifications standard errors are clustered at the player level to account for within-individual correlation.

We again analyze three different outcome variables.. We estimate the effects separately for EGM gambling, gambling excluding EGMs, and total gambling. Unlike in the first empirical setting, where all EGMs in the region were closed, this approach allows us to estimate the impact of closures on EGM gambling, as the treatment group still has access to alternative EGMs. In this empirical setting, we have decided not to separate between digital gambling and other land-based gambling, which are both included in the "other" category.[19] Because other land-based gambling in terms of volume is considerably smaller than digital gambling, the "other" category mostly represents changes in digital gambling. As before, the amount of gambling in our models is measured in gambling volume rather than losses.

A concern raised in the literature regarding the stacked difference-in-differences model is that it does not identify the target aggregate or any other average causal effect because it applies different implicit weights to treatment and control trends. In the Appendix we provide results using the weighting proposed in Wing et al. (2024). One concern related to our control group is that some players in the control group are potentially exposed to

[19]In the COVID-19 specification, we treated land-based gambling as a separate category from digital gambling, as we were able to allocate digital activity based on players' postcodes, whereas physical gambling was assigned to municipalities using the postcode of the physical outlet.

closures of the EGMs in their neighborhood. We address this concern in the Appendix by providing results from a specification where we exclude all players from the control group experiencing any closure of EGMs within a 10-kilometer radius of their home address.

Given that this setting allows us to track the same individuals over time, we can examine the heterogeneous effects of the machine outlet closures. Specifically, we investigate how the treatment effects vary between heavy and casual gamblers. This distinction is particularly important, as gambling policies often aim to reduce problematic gambling behavior; thus, understanding how reduced exposure to EGMs affects different types of players is essential for evaluating policy effectiveness.

In previous literature, gambling expenditure has been shown to be an important predictor of gambling problems (Nedved and Ferreira Neto, 2024; Markham et al., 2015). Gambling in Finland is highly concentrated among heavy users. While we do not report euro-denominated figures due to confidentiality concerns, survey data from the Finnish Institute for Health and Welfare illustrate this concentration: among individuals who gambled at least once in the previous year, average annual spending in the lowest quintile was approximately 11 euros, compared to 2480 euros in the highest quintile. The median values were 11 euros and 845 euros, respectively.[20]

To estimate the heterogeneous effects of the policy, we assign people into quintiles[21] based on their gambling volume in EGMs in the three months prior to the closures. Our estimation equation is a slight modification of Equation 2:

$$\mathbb{E}[Y_{ict} \mid X] = \exp\left(\theta_{tcg} + \gamma_{icg} + \sum_{g=1}^{5} \psi_g D_{icg}\right) \tag{3}$$

Where g denotes the gambling-volume-group and with θ_{tcg} as sub-experiment-time-group fixed effects and γ_{icg} as individual-sub-experiment-group fixed effects. The coeffi-

[20]The lowest quintile also includes players who reported gambling with zero euros, even though we limited the analysis to respondents who stated they had gambled at least once in the previous year. This can be at least partly explained by the fact that in the survey from which we calculated the annual gambling expenditure, respondents could report their gambling amount for the previous week, month, or year. The annual figures were calculated based on the reported weekly/monthly gambling and for some respondents gambling in the previous week/month may have been zero, even if the individual had gambled at some point during the year.

[21]Formally, we use the quintiles of these pre-treatment volumes to form the 5 categories

cients ψ_g capture differences in treatment effects across the five volume groups.

5 Results

5.1 COVID-19 closures

Figure 3 displays the population-weighted average gambling volume in the treatment and control hospital districts, both before and during the EGM closures.[22] Gambling volume in the Figure is indexed to the hospital district weighted average in November 2020. Before the closures, volume develops roughly similarly in the control and treatment municipalities. After the closures, as expected, EGM gambling decreases to zero in the treatment group. We also see a decline in EGM gambling in the control group. This could potentially correspond to the mandatory notification being required in EGM gambling from January 2021 onwards. After the closures, EGM gambling volume in treatment municipalities quickly increases to the same level as in the control municipalities.[23] Based on the figure other land-based gambling and digital gambling volume develop very similarly in the treatment and control municipalities throughout the period covered by the figure, while in the total volume there is a clear and visible decrease in volume in the treatment group.

[22] We use the 2021 Paavo population data as weights.

[23] The significant decline in EGM gambling volume in both the control and treatment groups in September 2021 may be attributed to the introduction of the mandatory precommitment policy that month.

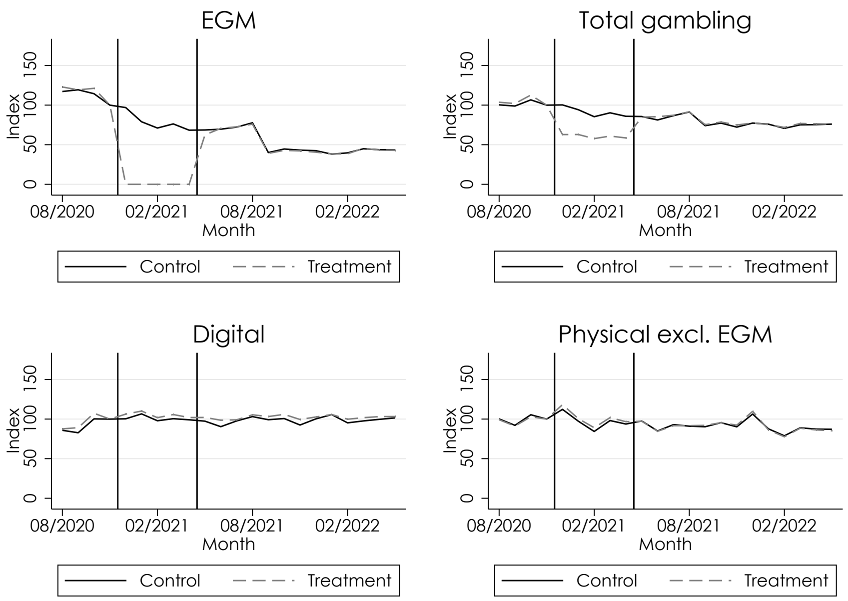

Figure 3: Development

This figure shows the evolution of gambling volume in treatment and control group municipalities. The vertical lines mark the timing of EGM closures in the treatment group.

Next, we present estimates from our main specification. In the first column, the outcome variable is the volume on digital gambling. The point estimate is small in magnitude and is not statistically significantly different from zero. In the second column, the outcome variable is land-based gambling excluding EGMs. There based on the results, the closures led to a 6% increase in volume.[24] In the final column the outcome variable is total gambling volume including EGMs. Based on the results, the closures resulted in a substantial 36% decrease in total gambling volume. This translates to a roughly 50-60 euro decrease in monthly gambling volume.[25]

[24] To translate the point estimates to percentage changes we use the following transformation: $e^{0.061} - 1 = 0.063$

[25] For confidentiality reasons, we do not disclose monetary figures in this paper; instead, we present the results as percentages. The euro-nominated estimate is calculated as follows. In 2021, total spending on Veikkaus games amounted to 6.9 billion euros. On average, the total volume of gambling by each adult was approximately 1,500 euros per year or around 130 euros per month. 36% of 130 euros is 47 euros. According to 2022 data, gambling volume in both North Savo and Central Finland was slightly above the national average.

Table 3: The effect of closures on gambling

	Log(Digital)	Log(Land-based excl. EGM)	Log(Total)
β	-0.009	0.061***	-0.447***
	(0.017)	(0.016)	(0.050)
Observations	312	312	312

Notes: The estimated β coefficient captures the average treatment effect on the treated (ATT). Dependent variable is the logarithm of gambling volume in municipality. Land-based gambling volume excludes EGM gambling. Standard errors clustered at the municipality level. November 2020 is excluded from the sample. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Next, in Figure 4, we present results from a corresponding event-study specification, where instead of D_{it}, we include interactions between time periods (both before and during the closure) and a treatment group dummy in the estimation equation. Similarly to our main specification, we omit November 2020 from the estimation equation because the closures occurred in the middle of the month. In the figure, the time period zero corresponds to December 2020. Prior to the closure, the point estimates for all gambling types are close to zero indicating that prior to closure the trends in volume were somewhat similar in the control and treatment group. For total volume, one of the point-estimates is statistically significantly different from zero already before the closures. However, it is around 10 times smaller in magnitude than the estimates during closures.

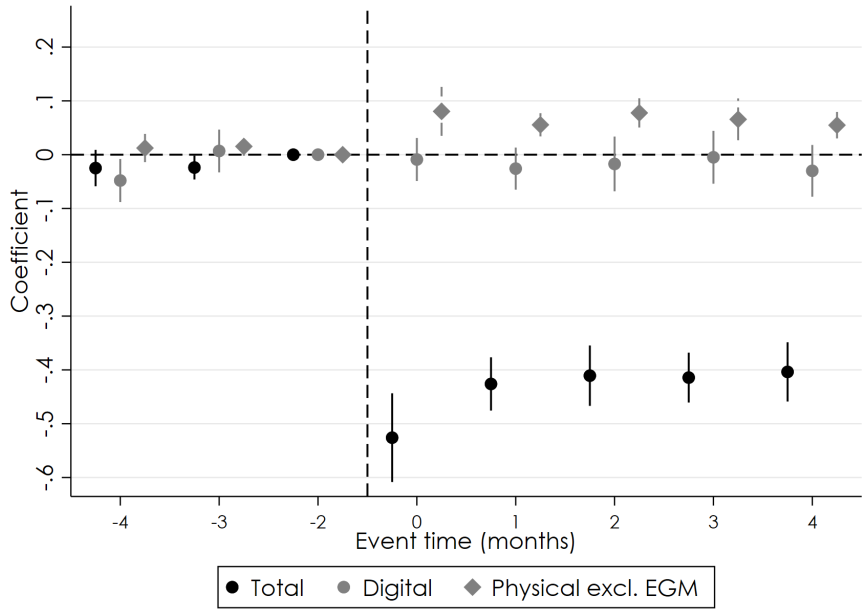

Figure 4: Event-study estimates for COVID-19 closures

This figure presents point estimates from the event-study specification described in the text. The black line represents point estimates and 95% confidence intervals using total gambling volume as the outcome. The dashed gray line shows the estimates and confidence intervals for land-based gambling excluding EGMs, while the solid gray line depicts the results for digital gambling volume.

Based on the event-study results, there appear to be modest deviations in gambling trends between the treatment and control groups. To account for potential violations in parallel trends, we adopt the robust inference framework proposed by Rambachan and Roth (2023), which is designed for difference-in-differences and event-study settings. Their method constructs confidence intervals for treatment effects by leveraging information from the estimated pre-treatment trends in the pre-treatment period. Specifically, we follow their approach of bounding potential post-treatment deviations from parallel trends. This involves assuming that any such violations in the post-treatment period do not exceed a constant $\bar{M}$ times the maximum deviation observed in the pre-treatment period. In our analysis, we set $\bar{M} = 2$, allowing post-treatment violations to be up to twice as large as the largest pre-treatment deviation. We choose this relative-bound approach over smoothness restrictions due to the limited number of pre-treatment periods in our data. The resulting estimates are reported in Appendix A.5. Even under this conservative assumption, the estimated effect on total gambling volume remains highly statistically significant, with the 95% confidence interval ranging from approximately -0.4

to -0.6. This suggests that our main findings are robust to substantial violations of the parallel trends assumption. As anticipated, the estimated effect on digital gambling volume remains statistically insignificant when allowing for deviations in parallel trends. For other forms of land-based gambling (excluding EGMs), the point estimate is statistically significant when the bound is set at $\bar{M} = 1.5$, but loses significance when the bound is increased to $\bar{M} = 2$.

To further assess the robustness of our results, we have used alternative specifications. If instead of clustered standard errors we use robust standard errors, the estimated standard errors are slightly smaller. If instead of only Central Finland we include all the neighboring hospital districts to the treatment group the point-estimates are very similar: no effect on digital gambling volume, 5% increase on other land-based gambling and 32% decrease in total gambling volume. The results from these analyses are presented in Appendix A.6. In addition to the robustness checks, we conducted an additional analysis, in which we focus on the long-term effects of the closures. In this specification the post-period consist of the year after the closures ended in May 2021. If some gambling resulted from habit persistence (Marionneau and Järvinen-Tassopoulos, 2022), then a forced break in the habit could continue to influence gambling behavior even after the closures ended. Based on our results, the closures had no statistically significant effect on gambling after the closures ended. These results are available in A.3.

One potential caveat in our results is that, since our data only covers gambling with the state monopoly, we are unable to observe any potential substitution toward foreign operators. This is a valid concern, given that estimates suggest roughly half of online gambling in Finland involves foreign operators (Karjalainen et al., 2023). To assess whether such substitution occurred, we collected data on the number of Google search queries, such as online casino, casino and gambling operators Paf and Unibet, by Finnish regions.[26] If a substantial number of players in the treatment group had shifted to foreign operators, we would likely observe an increase in these search queries within the region

[26]The hospital districts North Savo and Central Finland contain the same municipalities as the regions North Savo and Central Finland with the exception of Jämsä in Central Finland and Joroinen in North Savo, which belonged to the Pirkanmaa and South Savo hospital districts, respectively.

compared to the control group. The results of this analysis are presented in Appendix A.2. We find no significant differences in how the number of search queries evolved during the closures between the treatment and control groups. This suggests that substitution toward foreign gambling sites was limited. However, this result should be interpreted with caution. Changes in search behavior do not perfectly reflect gambling volume, especially given that gambling spending is known to be highly concentrated, with a small proportion of players accounting for a large share of total spending. However, Houghton et al. (2023) have compared gambling-related Google searches with actual gambling data in the United Kingdom during the COVID-19 pandemic and found a strong correlation between them.

5.2 Individual closures

Next, we report the results from the analysis focusing on the effects of closures of individual EGMs. Again, we start presenting the results by plotting in Figure 5 the trends in gambling volume over time for both the treatment and control groups. The Figure reveals a sharp and immediate decline in EGM gambling volume within the treatment group following the closures. The control group also shows a more gradual yet noticeable decrease in volume over the same period. This resembles the overall decreasing trend of EGM gambling. In total gambling, there is also a clear decrease in activity for the treatment group. In contrast in the other category the control and treatment groups seem to evolve quite similarly both before and after the closure.

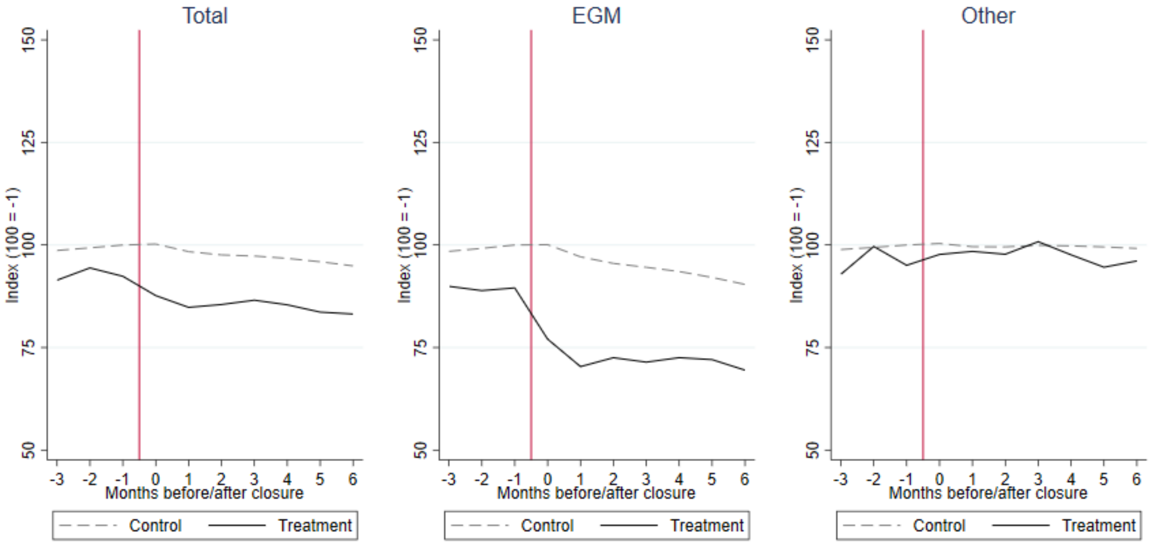

Figure 5: Average gambling consumption over stacked events window

This figure shows the evolution of gambling volume in treatment and control group. Gambling volume in the control and treatment group is indexed to pre-treatment sample average. The vertical lines mark the timing of the closure.

To formally assess and quantify changes in gambling volume observed in Figure 5, we estimate the parameters outlined in equation 2. Table 4 presents results from the three specifications outlined in Section 4.2: the model in the first column includes an indicator variable for the treatment group and post-period[27], the second column includes the full sub-experiment specific fixed effects and the model in the third column, in addition, includes age and sex fixed effects. Panel A shows the results for total gambling, Panel B for EGM gambling and panel C for other gambling excluding EGMs.

Across all specifications, the results show a statistically significant reduction in total gambling volume. In the first specification, the decrease is 6.1%[28], while in the second and third specifications, it is 6.01%. As expected, this overall decline is driven by a reduction in EGM gambling volume, which is estimated to decrease by 15% to 15.7%, depending on the specification. On average, the closed share accounted for 45% of the total EGM gambling activity within the treatment group. Consequently, around two thirds of volume previously allocated to the closed machine appears to have been substituted to

[27]The point estimate from this specification is equivalent to the simple difference in percentage point changes between the treatment and control groups from the pre- to post-period.

[28]The estimated coefficient of -0.063 corresponds to a 6.1% decrease, calculated using $e^{-0.063} - 1$

other EGMs. For other forms of gambling, the point estimate is positive but statistically insignificant, suggesting that, on average, the closure of EGMs did not have a meaningful impact on other land-based or digital gambling. Overall, the findings indicate that EGM closures led to a substantial decline in EGM volume, with minimal effects on other gambling activities.

The reduction in gambling volume could, in principle, result from players either placing smaller stakes after the closure or reducing the frequency of their play. To investigate this, we also estimate the effects using the number of days gambled per month as the outcome variable, as detailed in the Appendix. The point estimates from this analysis closely mirror those reported in Table 4. Across all types of gambling, depending on the specification, we find a 4% to 5% decrease in the number of days gambled. For EGMs, the reduction is more pronounced, ranging from 13% to 14%, while for other types of gambling, the results show no statistically significant change. These findings suggest that the observed decline in gambling volume is primarily driven by fewer gambling occasions rather than by smaller stakes.

Table 4: Regression Results: Total, EGM, and Other gambling consumption

Panel A: Total Volume			
ψ	-0.063***	-0.062***	-0.062***
	(0.013)	(0.013)	(0.013)
Observations	22,282,452	22,246,362	21,078,604
Panel B: EGM Volume			
ψ	-0.171***	-0.170***	-0.163***
	(0.016)	(0.016)	(0.016)
Observations	22,282,452	22,085,316	20,944,117
Panel C: Other Gambling Volume			
ψ	0.016	0.017	0.012
	(0.020)	(0.020)	(0.020)
Observations	22,282,452	19,269,252	18,640,786
individual - sub-experiment FE	No	Yes	Yes
sub-experiment - time FE	No	Yes	Yes
age and sex FE	No	No	Yes

Notes: The estimated ψ coefficient captures the average treatment effect on the treated (ATT). Dependent variables: Panel A, total gambling volume in all games. Panel B, EGM gambling. Panel C, gambling in games other than land-based EGM. Standard errors in parentheses, clustered at the individual level. The month the EGM was closed ($t = 0$) is excluded from the sample. The varying number of observations in the first, second and third column is explained by both missing observations for age and sex and the Poisson pseudo-likelihood regression with multiple levels of fixed effects dropping zero observations that are perfectly predicted by fixed effects. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To assess whether the treatment and control groups exhibited parallel trends prior to the closures, and to examine the dynamic effects of the intervention over time, we estimate an event-study specification. This approach incorporates interactions between time indicators (relative to the closure) and a treatment group indicator, while controlling for individual-by-subexperiment and time-by-subexperiment fixed effects. The results are displayed in Figure 6. Importantly, the coefficients for the pre-treatment periods are small in magnitude and not statistically different from zero, suggesting that treatment and control groups followed similar trends prior to the closures. Following the closures, we observe a pronounced decline in the point estimates for both EGM volume and total gambling volume, with these effects remaining stable throughout the post-closure period. For gambling volume excluding EGMs, the estimated effects are statistically insignificant in six out of the seven post-closure periods.

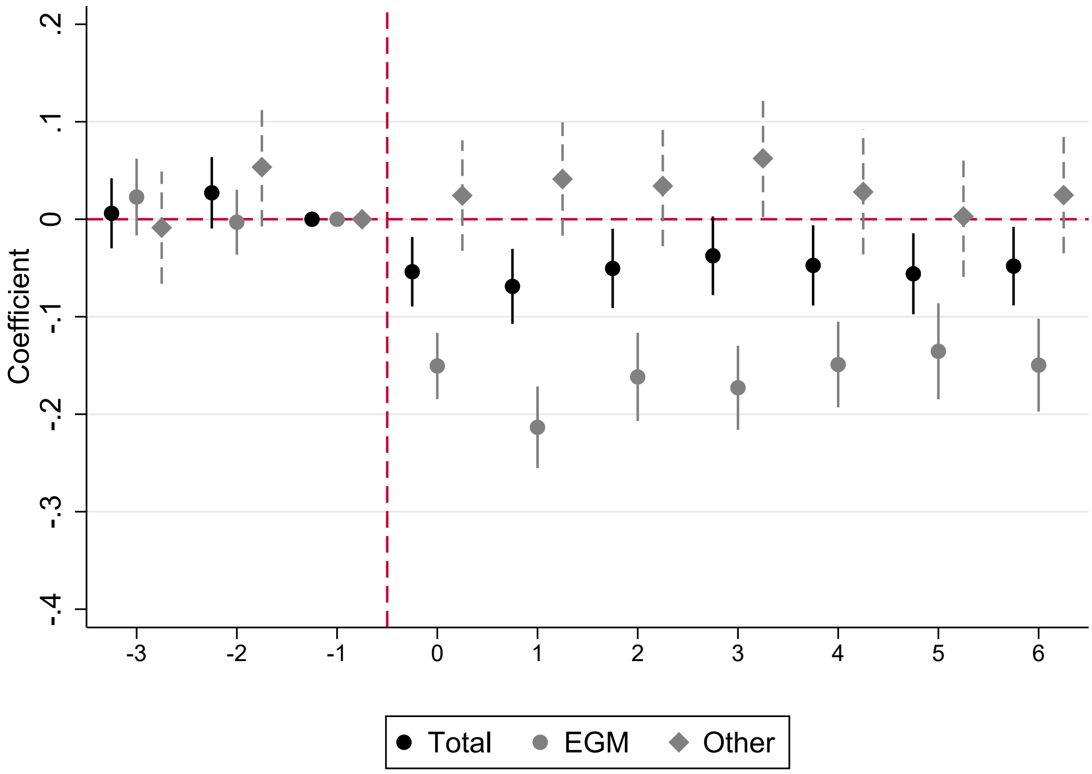

Figure 6: Event study

This figure presents point estimates from the event-study specification described in the text. The black line represents point estimates and 95% confidence intervals using total gambling volume as the outcome. The dashed gray line shows the estimates and confidence intervals for gambling excluding EGMs, while the solid gray line depicts the results for EGMs.

To assess the robustness of our findings, we conduct several additional analyses. As outlined in Section 4.2, we re-estimate our main results using the weighting method proposed by Wing et al. (2024). These alternative estimates, presented in Appendix B.1, closely align with our primary results, further supporting the reliability and validity of our conclusions. To strengthen the credibility of our identification strategy, we also implement a robustness check that restricts the control group to individuals who were never within 10 km of an outlet closure from January 2021 to December 2023. [29] This restriction helps address potential concerns about spillover or anticipatory effects among the control group, which could bias the estimates if untreated individuals were indirectly exposed to nearby closures. The results from this restricted sample, also reported in Appendix B.2, remain consistent with our main specification: we find a significant 8% reduction in total gambling volume, primarily driven by declines in EGM gambling, with no evidence of significant substitution to other gambling activities. Finally, we assess the sensitivity of our results to the definition of the treatment group. A player is classified as treated if they have spent at least 15% of their gambling on the closed machine. In Appendix B.3, we present results using alternative thresholds of 20% and 25%. The point estimates for total gambling volume are slightly larger in absolute terms under these alternative definitions and more pronounced for EGM gambling volume where the reduction increases monotonically with the closed share threshold, while the estimates for gambling volume excluding EGM remain statistically indistinguishable from zero.

Next, we examine the heterogeneous effects of the policies on individuals with varying levels of gambling volume. The results, presented in Figure 7, indicate that EGM access restrictions lead to a general decline in gambling volume across all volume groups. However, the magnitude of this reduction is inversely related to pre-treatment volume levels: individuals with higher baseline gambling volumes experience a smaller relative decline compared to those with lower initial spending.

For the group with the lowest EGM volume, the relative decrease in EGM gambling is around 58% while for the group with the highest volume it is 13%. The corresponding decrease in total gambling volume is 14% for the group with lowest EGM volume and 6% for the group with the highest. Also, the point estimates for gambling volume excluding EGMs differ between groups. For the two groups with the highest volume we find positive estimates, statistically significant (at $p < 0.05$ level) for the highest group, while for the groups with lowest volume the point-estimate is negative and statistically insignificant. For the highest volume group the point-estimate indicates an 8% increase in volume.

[29] Distances are calculated using postcode-level geolocation data. Only individuals whose minimum distance to any closed outlet consistently exceeded the threshold during the study period are included.

Overall, the findings indicate that reduced availability of land-based gambling resulted in decreased gambling volume across all groups, with the most substantial impact observed among individuals with the lowest pre-closure volume. This pattern is explained by higher-volume players substituting their gambling activity with both other EGMs and other forms of gambling. Although the estimated effects are largest in percentage terms for players with the lowest gambling volume, it is important to remember that the point estimates are expressed as percentage changes. As discussed in Section 4.2, the gambling volume in the highest group is more than 100 times greater than in the lowest group. This implies that, in absolute monetary terms, the impact is actually greater for the highest-volume group, despite their smaller percentage effects.

We also examined the effects of the closure on the number of gambling days across different groups, reporting those results in Appendix B.5. Among the group with the lowest gambling volume, we observe a substantial decline, over one-third, in the frequency of EGM gambling. In contrast, the effects are smaller for groups with higher gambling volumes, with the smallest estimated reduction, around 10%, observed for the highest-volume group. For all types of gambling, the point estimates reveal a similar pattern: a negative relationship (in absolute terms) between gambling volume and the estimated effect size. For gambling types other than EGMs, the estimated effects on gambling frequency are statistically insignificant across all groups. These results suggest that the increase in volume shown in Figure 7 for the "other" gambling category among players with the highest gambling volume is driven not by more frequent play, but by higher daily spending conditional on playing.

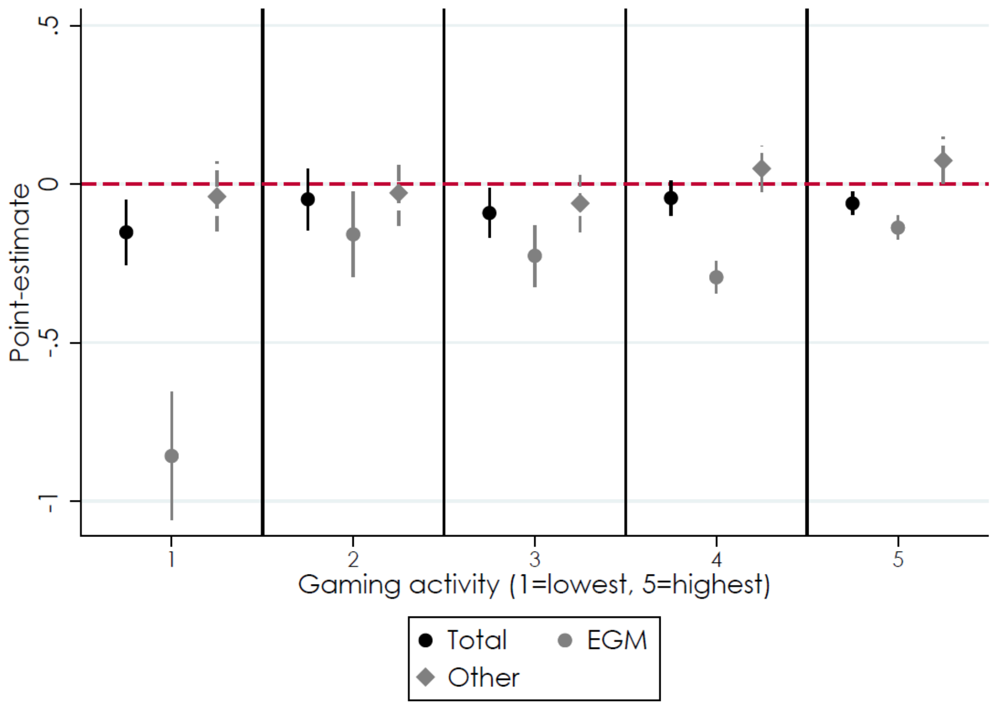

Figure 7: Heterogeneous response: gambling intensity

This figure presents point estimates from a heterogeneity analysis, where the effects of the closures are estimated separately across quintiles based on EGM gambling volume. On the horizontal axis, 1 corresponds to the lowest quintile and 5 to the highest. The black line shows point estimates and 95% confidence intervals for total gambling volume, the gray line for EGM gambling, and the dashed gray line for gambling excluding EGMs. The month the EGM was closed ($t = 0$) is excluded from the sample.

Appendix B.4. presents results from additional heterogeneity analyses of the baseline results. As expected, there is a clear relationship between the estimated decline in EGM gambling and the share of gambling volume previously allocated to the closed machine. The effect is strongest among players for whom the closed machine represented a larger portion of their EGM gambling activity, and weakest among those for whom it accounted for the smallest share. In a second heterogeneity analysis, we examine the effects across age groups. While we do observe some variation in responses by age, no consistent pattern emerges from these results.

6 Conclusion

In this paper, we studied how changes in the availability of land-based gambling affected gambling volume in Finland. Utilizing two quasi-experimental settings, we find that, reduction in the availability of EGMs did not result in large substitution towards other types of games and resulted in a decrease in total gambling volume. The closure of EGMs during the COVID-19 pandemic led to a substantial reduction in gambling volume used for land-based games, with no significant increase in digital gambling. Similarly, our analysis of individual EGM closures post-2021 reveals that overall gambling volume decreases following closures, with only the highest-spending individuals shifting some of their activity to other channels. Even for these individuals, total gambling volume declines, suggesting that limiting access to land-based gambling can reduce gambling activity.

These findings have significant policy implications. The results indicate that limiting access to land-based gambling can effectively reduce overall gambling volume. However, policymakers should recognize that high-volume gamblers may shift some of their activity to games, such as digital gambling, unaffected by the policy. If the goal is to substantially reduce gambling among this group, additional regulatory measures, such as restrictions on advertising, deposit limits, and strengthened self-exclusion mechanisms, may be necessary.

Although not directly examined in this paper, an important factor to consider when evaluating the costs and benefits of access restrictions is the potential loss in consumer welfare resulting from reduced gambling by casual players who do not generate negative externalities. Ideally, policy measures would effectively target problem gamblers while minimizing unintended impacts on casual users. Our findings, however, indicate that reducing the number of EGMs fails to meet this criterion, as it disproportionately affects low-volume gamblers. One possible benefit of reduced gambling among casual users is the potential to prevent the development of future gambling problems. Nonetheless, to determine whether such restrictions yield a net welfare gain or loss, further research is necessary—particularly studies that quantify both the consumer surplus derived from casual gambling and the social costs associated with problem gambling.

A key limitation of our study is that our data is confined to gambling activity within the state-owned monopoly, excluding gambling on foreign digital platforms. We track

Google search queries during the COVID-19 related EGM closures in the affected and non-affected municipalities and find no divergence in search terms such as online casino, indicating that the EGM closures potentially had little effect on gambling activity on foreign sites. However, search queries are a crude measure of gambling activity and future research should aim to incorporate data from foreign gambling operators to provide a more comprehensive understanding of consumer behavior and substitution patterns. An interesting avenue for future research is to examine the effectiveness of other regulatory measures introduced in Finland. Although the sharp decline in Veikkaus' revenues in recent years offers descriptive evidence that mandatory identification and pre-commitment requirements may have contributed to reduced gambling volume, a more rigorous study is needed to establish the causal effects of these policies.

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Appendix A. Additional results for the analysis of the effects of COVID-19 related closures

A.1 Mobility data and number of cases for treatment and control hospital districts

In Figure 8, we present Google mobility data for North Savo and Central Finland, focusing on the Grocery and Pharmacy category, as most EGMs are located in grocery stores. Google Community Mobility Reports data provide information on how people's movement patterns changed over time in response to the COVID-19 pandemic. The reports track movement trends across different categories of places, such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas. The data show how visits and time spent at these locations have increased or decreased compared to a baseline period before the pandemic. The data is presented as percentage changes relative to the baseline. The baseline value is the median day's data from a five-week period spanning from January 5 2020 to February 6 2020. Comparisons are always made to the value of the same day of the week. For example, the value for Monday, February 17 2020, is compared to the median Monday of the baseline period. (Google, 2025a)

Before the EGM closures began at the end of November, mobility levels in North Savo and Central Finland were nearly identical. During the closure period, mobility in North Savo was slightly higher, though the differences remained small.

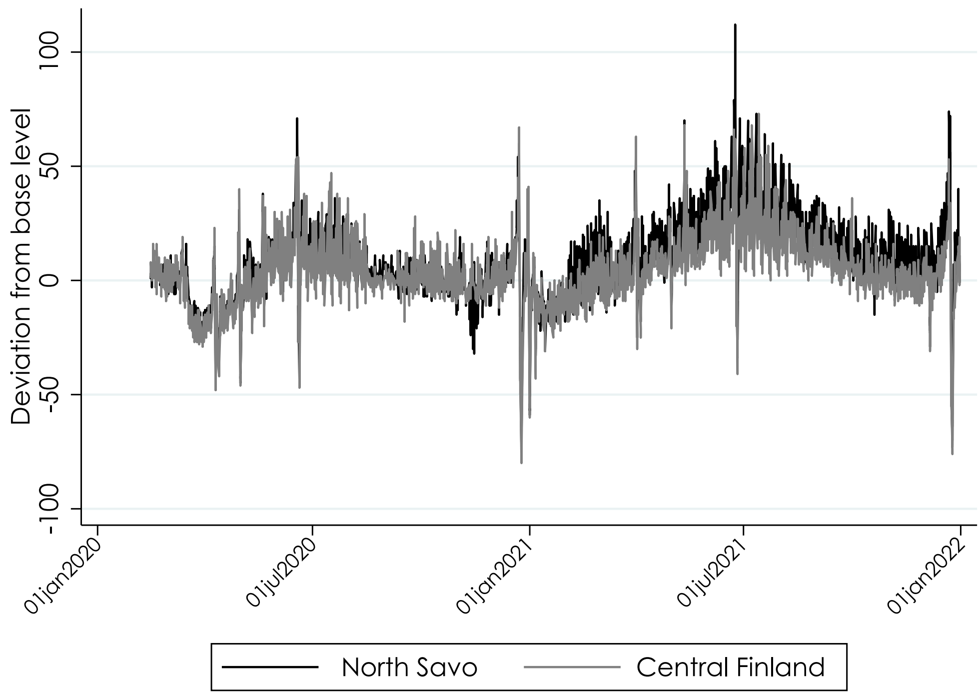

Figure 8: Mobility data

This figure displays mobility data for municipalities in the control group (North Savo) and the treatment group (Central Finland), sourced from Google.

In Figure 9 we plot the number of coronavirus infection cases in North Savo and Central Finland. Prior to the closures, the number of cases is higher in Central Finland. However, even in Central Finland Covid incidence remained at relatively low level in 2020. Also during the closures the number of cases continued to remain higher in Central Finland compared to North Savo.

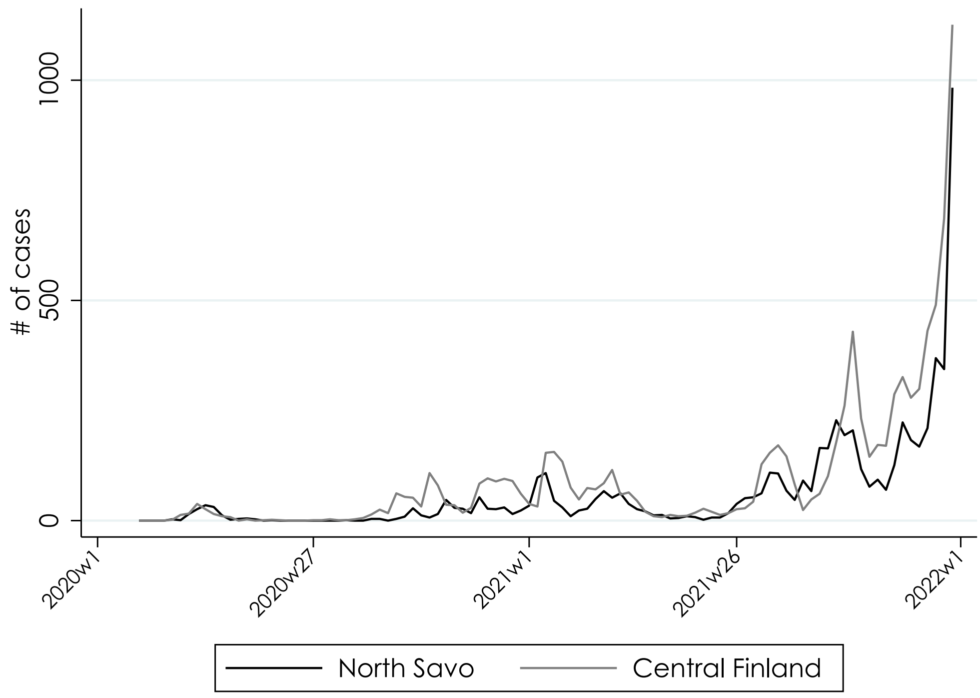

Figure 9: Number of coronavirus infection cases

This figure displays the number of confirmed coronavirus infection cases in the control group (North Savo) and the treatment group (Central Finland), sourced from The Finnish Institute for Health and Welfare (Finnish Institute for Health and Welfare, 2025).

A.2 Google search queries

A key limitation of our data is that it only includes gambling activity within the national monopoly. However, in the case of online gambling, approximately half of the total volume is directed to foreign operators (Karjalainen et al., 2023). To explore potential substitution towards offshore gambling during the COVID-19-related closures of Electronic Gambling Machines (EGMs), we examined Google search trends in both treatment and control municipalities. If players in the treatment areas increasingly turned to foreign gambling sites due to EGM closures, we would expect a corresponding rise in related search queries.

To investigate this, we tracked search interest for several gambling-related topics (”Nettikasino” [online casino in Finnish], ”Kasino,” and ”Casino”) as well as for two major offshore operators popular in Finland—Paf and Unibet—over the period from July 2020 to May 2021. Figure 10 displays the search interest over time, allowing for a visual comparison between the two regions. We use Google Trends data, which reports a relative index (ranging from 0 to 100) representing search interest for each topic as a proportion of total search activity within the chosen timeframe and geography. While Google Trends does not provide absolute search volumes, it enables meaningful comparisons of public interest across regions and time periods (Google, 2025b).

Despite some fluctuations, we do not observe systematic differences in search trends between North Savo (treatment group) and Central Finland (control group). In the pre-closure period, the average calculated from the indices was 54 for North Savo and 54 for Central Finland. During the closure period, the averages remained closely aligned with the average index being 65 in North Savo and 66 in Central Finland, suggesting that the closures did not lead to a noticeable increase in interest towards offshore gambling operators in the treatment areas.[30] For reference, we also include search interest in Veikkaus, the national monopoly. Our previous findings indicate that digital gambling activity evolved similarly in both groups during the study period. Consistently, Google search interest in Veikkaus remained stable and comparable across the two regions, further supporting the absence of significant substitution behavior towards foreign operators.

Although we cannot be certain that search queries perfectly reflect actual gambling activity, prior research supports their usefulness. For instance, Houghton et al. (2023) found a strong correlation between gambling-related Google searches and actual gambling behavior in the UK during the COVID-19 pandemic.

[30] The average was first calculated by determining the weekly average of the five search topics. Subsequently, the averages for the pre-closure period and closure period were calculated from these average weekly indices. In addition to the average of the indices, we also calculated a weighted average for each region. The calculation of the weighted average utilized comparative data on the prevalence of search topics obtained from Google Trends, which was used to determine weekly weighting factors for the different indices. The weighting factor was formed by dividing the weekly index of a search topic by the sum of the weekly indices of all five search topics. The original weekly indices for each search topic were multiplied by the weighting factor, and these indices were then summed together. The averages for the pre-closure period and closure period were calculated from these weighted weekly averages. The weighted average for the pre-closure period was 56 in North Savo and 57 in Central Finland, and for the closure period, it was 67 in North Savo and 68 in Central Finland.

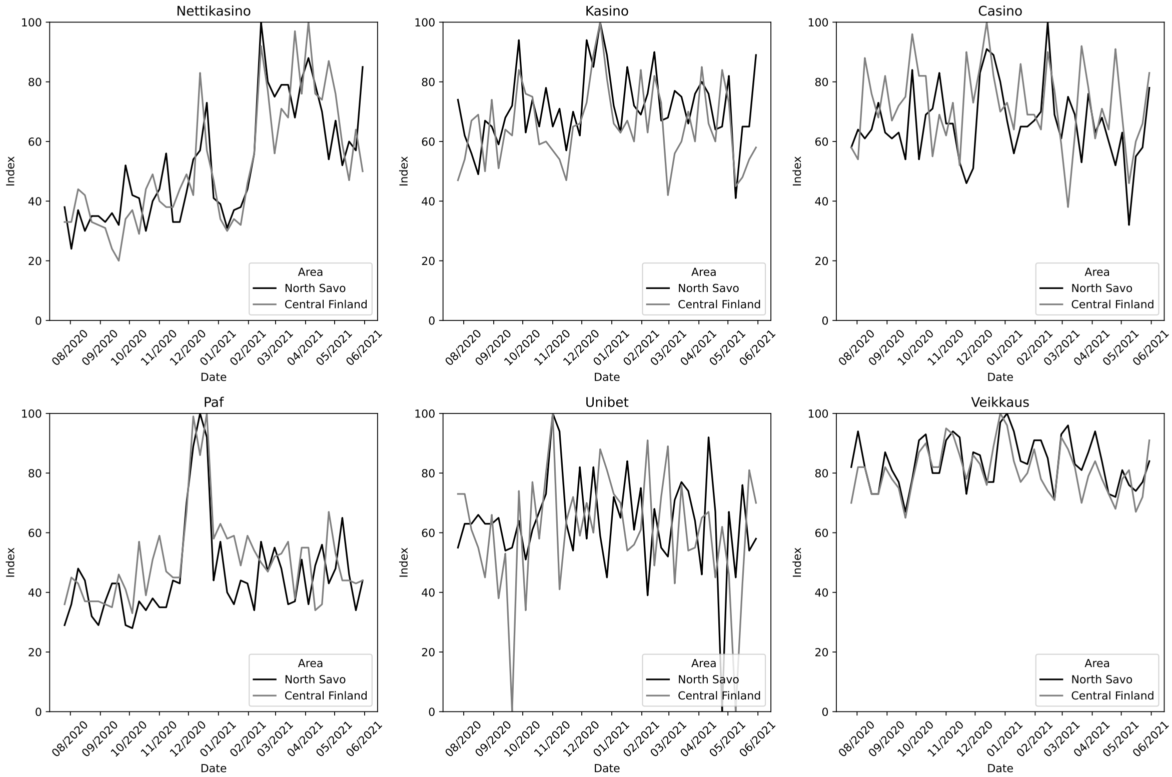

Figure 10: Google search queries

This figure shows Google search query data from municipalities in the control group (North Savo) and the treatment group (Central Finland), focusing on terms potentially related to gambling with foreign operators. The specific search topics are indicated in the titles of each subplot. Details on how Google constructs the indices are provided in the main text.

A.3 Long-term effects

In this section, we present results from a specification in which the post-treatment period is the time after the closures. As explained in the main text, if gambling activity is driven by habit persistence, then the COVID-19 closures could have long-term effects on gambling. Marionneau and Järvinen-Tassopoulos (2022) examine this using an online survey and finds evidence that some respondents stated to have reduced EGM gambling even after the closures ended. In our specification, the post-treatment period starts from June 2021 and extends to May 2022.

The results are presented in Table 5. In the first column, the outcome variable is digital gambling volume. The point estimate is small in magnitude and statistically insignificant. Similarly we find null effects on other land-based gambling and total gambling. In the final column, the outcome variable is EGM gambling volume. The point estimate suggests a decrease of approximately 6% in EGM gambling within the treatment group, even after the closures ended. However, this estimate is imprecise and not statistically significant. Overall, we do not find strong evidence that the closures had long-term effects on gambling volume.

Table 5: The effect of closures on gambling

	Log(Digital)	Log(Land-based excl. EGM)	Log(Total)	Log(EGM)
β	-0.019	0.014	-0.025	-0.062
	(0.029)	(0.011)	(0.058)	(0.063)
Observations	585	585	585	585

Notes: The estimated β coefficient captures the average treatment effect on the treated (ATT). Dependent variable is the logarithm of gambling volume in municipality. Land-based gambling volume excludes EGM gambling. Standard errors clustered at the municipality level. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.4 Stacked analysis

In our main specification, we compare gambling volume in North Savo, which decided to keep the EGMs open during the second wave of COVID-19, to that in Central Finland, a neighboring hospital district that had the longest closures during the same period. In this section, we present results from an alternative specification in which, in addition to Central Finland, we include all other neighboring hospital districts in the control group. The closures in the neighboring hospital districts varied from 7 weeks to 5 months.

The starting and end dates of closures vary between hospital districts. We employ a stacked difference-in-differences design where for each hospital district we center the dates so that time zero indicates the month the closures started. Then after constructing separate data sets for each control and treatment group pair, we combine the data into one main data set used for estimation. The hospital districts remain in the treatment group as long as the EGMs remain closed and when the closures end, we remove the observations from the data. Due to the way the data is constructed, the composition of the treatment group changes over time.

Once the estimation data set is constructed, the difference-in-differences analysis is conducted similarly to the main specification using a two-way fixed effects model. Similarly to the main specification, we again weight observations based on adult population and cluster standard errors at the municipal level.

In Figure 3 we plot the development of gambling volume in the control group consisting of municipalities in North Savo and the treatment group consisting of municipalities in neighboring hospital districts. The development is closely aligned to those presented in Figure 3. Digital and physical gambling volume, excluding EGM, is relatively stable in the treatment and control group before and during closures. During closures, EGM gambling volume drops to zero in the treatment group, and total volume also shows a clear and noticeable decline.

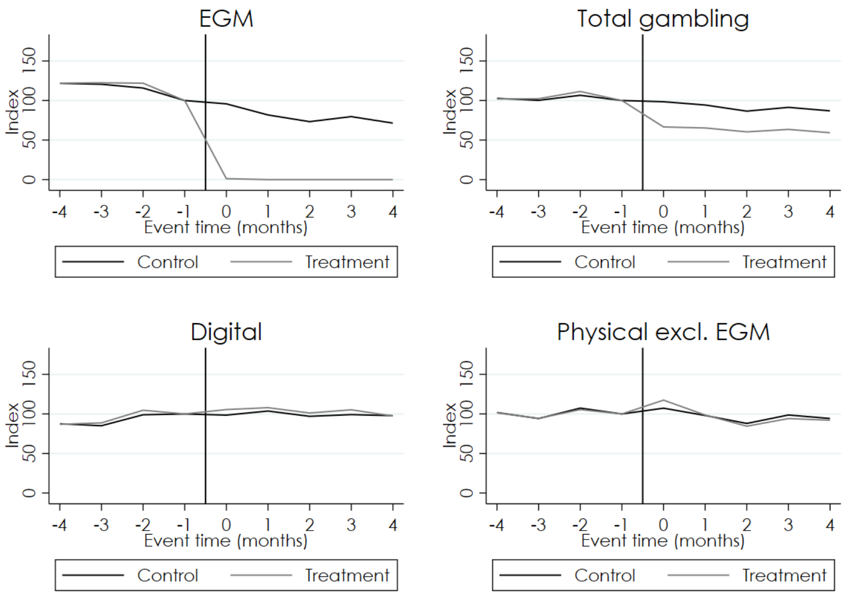

Figure 11: Development of volume in control and treatment group in stacked design

This figure illustrates the evolution of gambling volume in treatment and control group municipalities. For each municipality, gambling volume is indexed to its level one month prior to the closures, and a weighted average is calculated across municipalities. The control group comprises North Savo, while the treatment group includes all neighboring hospital districts that experienced closures of varying durations. Hospital districts remain in the treatment group for as long as the closures persist, resulting in a changing composition of the treatment group during the post-treatment period ($t > -1$).

The results from the two-way fixed effects regression are presented in Table 6. In the first column, the outcome variable is digital gambling volume. The point-estimate is close to zero and statistically insignificant, confirming that there was no substitution from EGM gambling to digital gambling during closures. In the second column, the outcome variable is land-based gambling excluding EGMs. Also in this specification, we find evidence of substitution with volume increasing by 5%. This is one percentage point less than in our main specification. In the final column, the outcome variable is total volume. Here we find a 32% decrease in total gambling volume, which is slightly less than in our main specification. Overall, the results from this alternative specification closely align with our main results: there is little substitution from EGMs to online gambling, and total gambling volume decreased considerably during the closures.

Table 6: The effect of closures on gambling

	Log(Digital)	Log(Land-based excl. EGM)	Log(Total)
β	0.011	0.049***	-0.389***
	(0.016)	(0.012)	(0.033)
Observations	1036	1036	1036

Notes: The estimated β coefficient captures the average treatment effect on the treated (ATT). Dependent variable is the logarithm of gambling volume in municipality. Land-based gambling volume excludes EGM gambling. Standard errors clustered at the municipality level. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.5 Allowing violations in the parallel trends assumption

As discussed in the main text, our event-study estimates suggest modestly diverging gambling trends between treatment and control municipalities. This raises concerns about whether these groups would have followed similar trajectories in the absence of treatment. To address potential violations of the parallel trends assumption, we apply the robust inference framework proposed by Rambachan and Roth (2023), developed for difference-in-differences and event-study designs. Their method constructs confidence intervals for treatment effects by leveraging pre-treatment trend estimates. We specifically follow their approach of bounding potential post-treatment deviations from parallel trends, assuming that such violations do not exceed a constant $\bar{M}$ times the maximum pre-treatment deviation. In our analysis, we set $\bar{M} = 2$, allowing post-treatment violations to be up to twice as large as the largest observed pre-treatment deviation. We adopt this relative-bound method rather than smoothness restrictions, given the limited number of pre-treatment periods in our data. This appendix presents the results from this robustness analysis.

First, we evaluate the results using total gambling volume as the outcome variable. Figure 12 displays the 95% confidence intervals under varying values of $\bar{M}$, ranging from 0.5 to 2. The estimated effect remains highly statistically significant even at $\bar{M} = 2$, with the confidence interval spanning approximately 0.4 to 0.6.

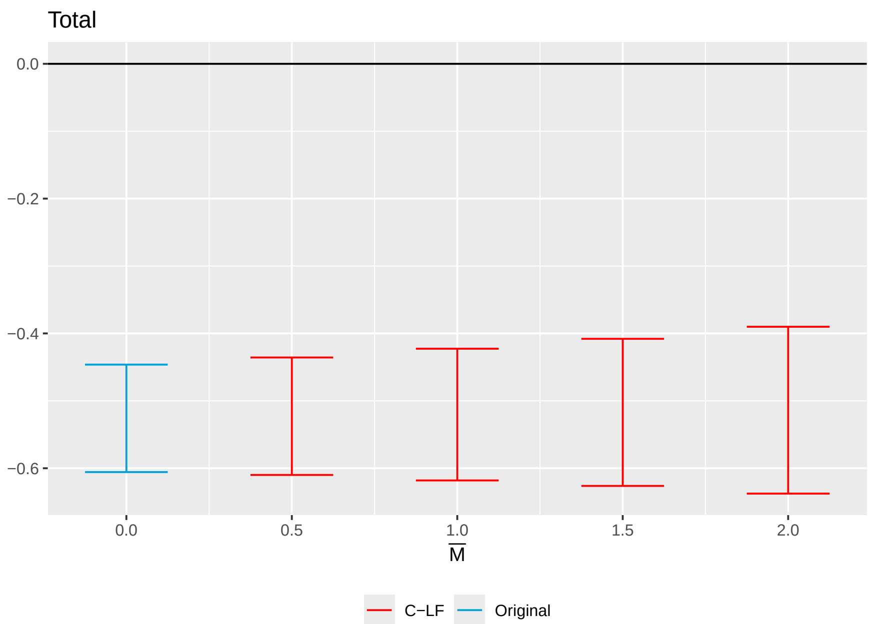

Figure 12: Sensitivity analysis of parallel trends assumption for total volume

This figure presents results using total gambling volume as the outcome, based on the robust inference framework proposed by Rambachan and Roth (2023), which accounts for deviations from parallel trends estimated in the pre-treatment period. The parameter $\bar{M}$ indicates the magnitude of allowed trend deviations. The blue lines show the original 95% confidence intervals, while the red lines display the confidence intervals under the robust inference framework.

Next, Figure 13 presents the results using digital gambling volume as the outcome variable, with $\bar{M}$ again ranging from 0.5 to 2. As the main estimate was already statistically insignificant, the results remain statistically indistinguishable from zero when allowing for deviations from parallel trends, as expected.

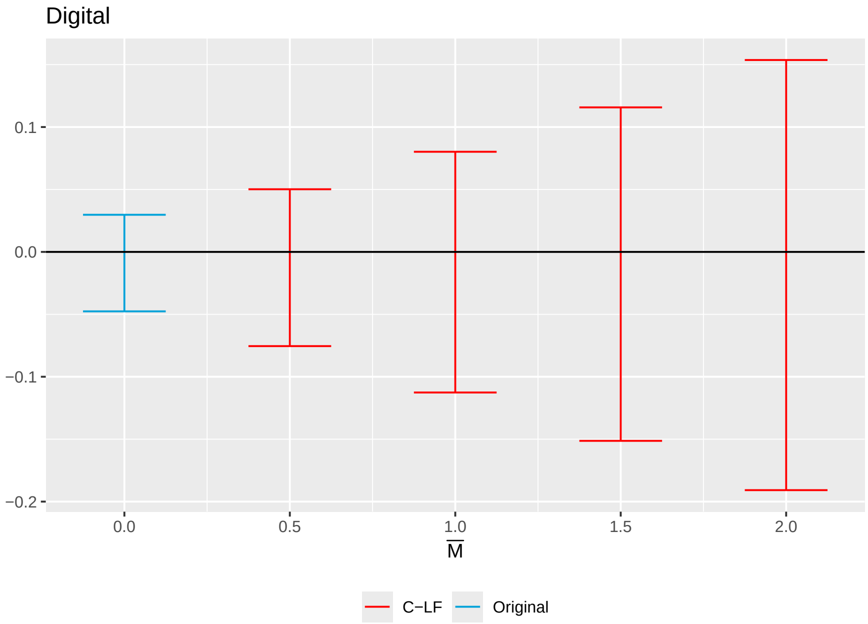

Figure 13: Sensitivity analysis of parallel trends assumption for digital volume

This figure presents results using digital gambling volume as the outcome, based on the robust inference framework proposed by Rambachan and Roth (2023), which accounts for deviations from parallel trends estimated in the pre-treatment period. The parameter $\bar{M}$ indicates the magnitude of allowed trend deviations. The blue lines show the original 95% confidence intervals, while the red lines display the confidence intervals under the robust inference framework.

Finally, Figure 14 shows the results using volume on land-based gambling excluding EGMs as the outcome variable. The estimated effect remains statistically significant when allowing for modest deviations from parallel trends, but becomes statistically insignificant when post-treatment violations are permitted to be up to twice as large as those observed in the pre-treatment period (i.e., $\bar{M} = 2$).

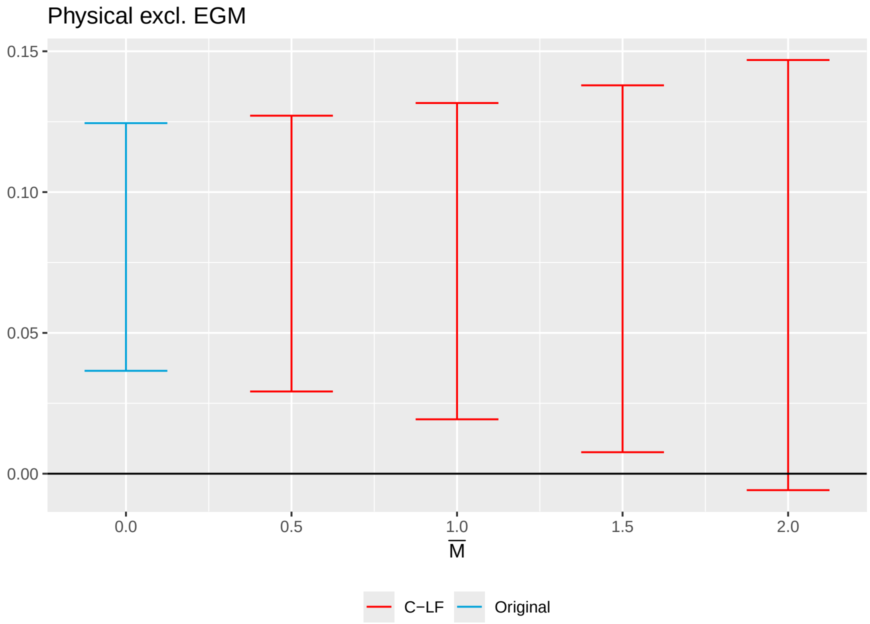

Figure 14: Sensitivity analysis of parallel trends assumption for other physical volume

This figure presents results using land-based gambling volume excluding EGMs as the outcome, based on the robust inference framework proposed by Rambachan and Roth (2023), which accounts for deviations from parallel trends estimated in the pre-treatment period. The parameter $\bar{M}$ indicates the magnitude of allowed trend deviations. The blue lines show the original 95% confidence intervals, while the red lines display the confidence intervals under the robust inference framework.

A.6 Additional results for main specification

In this section, we present the results of several robustness checks. The number of clusters, 39, is relatively small in our main specification. In the first robustness check, instead of using clustered standard errors, we use robust standard errors. The standard errors are considerably smaller when we use no clustering. The results of this analysis are available upon request.

In our main specification, we weight observations based on the adult population of the municipality. Following the advice of Solon et al. (2015) we also present results using no weights. The results of this analysis are presented in Table 7. The point estimates for digital gambling and total gambling volume are very similar in magnitude to our main specification. For total volume, the results are slightly less precise but do, however, remain highly statistically significant. For other land-based gambling volumes, excluding EGMs, the results of the unweighted specification differ from our main analysis. While the main specification showed a statistically significant increase in gambling volume, the unweighted specification found no such increase.

Table 7: The effect of closures on gambling

	Log(Digital)	Log(Land-based excl. EGM)	Log(Total)
β	-0.008	0.009	-0.407***
	(0.036)	(0.022)	(0.061)
Observations	312	312	312

Notes: The estimated β coefficient captures the average treatment effect on the treated (ATT). Dependent variable is the logarithm of gambling volume in the municipality. Land-based gambling volume excludes EGM gambling. Standard errors clustered at the municipality level. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix B. Additional results for the analysis of the effects of individual closures

B.1 Analysis using corrective weights

Wing et al. (2024) show that the coefficients from a basic stacked event study regression do not recover the average treatment effects across sub-experiments. Even when the standard difference-in-differences (DID) assumptions hold within each sub-experiment, these stacked regressions can yield biased estimates due to differential weighting of treatment and control trends across sub-experiments. Wing et al. (2024) demonstrate that the average treatment effect can instead be consistently estimated by fitting a saturated DID regression using weighted least squares.

In this Appendix section, we present results using the weights proposed by Wing et al. (2024). The code to compute the weights was retrieved in January 2025 from the repository at `https://github.com/hollina/stacked-did-weights`. The results, shown in Table 8, are very similar to those from our main specification, suggesting that our findings are robust to this alternative approach. It is worth noting that our specification differs from the one discussed in Wing et al. (2024), as we estimate the DID model using a Poisson regression. Interestingly, we find that when we instead use a linear DID model with the level of gambling volume as the outcome, the differences between the standard weighting and the weighting proposed by Wing et al. (2024) become more pronounced.

Table 8: Regression Results: Total, EGM, and Other Gambling Consumption

Panel A: Total Volume			
ψ	-0.063***	-0.062***	-0.062***
	(0.013)	(0.013)	(0.013)
Observations	22,282,452	22,246,362	21,078,604
Panel B: EGM Volume			
ψ	-0.170***	-0.170***	-0.162***
	(0.016)	(0.016)	(0.016)
Observations	22,282,452	22,085,316	20,944,117
Panel C: Other Gambling Volume			
ψ	0.016	0.017	0.011
	(0.020)	(0.020)	(0.020)
Observations	22,282,452	19,269,252	18,640,786
individual - sub-experiment FE	No	Yes	Yes
sub-experiment - time FE	No	Yes	Yes
age and sex FE	No	No	Yes

Notes: The estimated ψ coefficient captures the average treatment effect on the treated (ATT). Dependent variables: Panel A, total gambling volume in all games. Panel B, EGM gambling. Panel C, gambling in games other than land-based EGM. Standard errors in parentheses, clustered at the individual level. The varying number of observations in the first, second and third column is explained by both missing observations for age and sex and the Poisson pseudo-likelihood regression with multiple levels of fixed effects dropping zero observations that are perfectly predicted by fixed effects. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.2 Alternative control group

A potential concern with our empirical strategy is that players in the control group may also be indirectly affected by nearby closures. Even if they did not play the specific machines that were removed, the overall reduction in local gambling availability decreases their exposure to gambling opportunities in their neighborhood. To alleviate the concern that such spillover effects are driving our results, we restrict the control group to players who experience no closures during the whole sample period within a 10-kilometer radius of their home address. We calculate distances from the centroid of the home postcode of the player to the centroid of the postcode of the outlet hosting EGMs. After this restriction, the number of unique players in the control group decreases from 324,439 to 40,003.

The main results using this alternative control group are reported in Table 9. The estimated effects on EGM gambling volume (Panel B) are very similar to those obtained with our main specification in the first two models, and slightly larger in the third model, which includes age and sex fixed effects. For gambling volume excluding EGMs (Panel C), the estimates remain statistically insignificant across all specifications, with point estimates marginally closer to zero. For total gambling volume, the estimated effects are consistently slightly higher than those using the main control group. Overall, these findings replicate our primary results: a significant reduction in EGM and total gambling volume, with no evidence of substitution toward other forms of gambling.

Table 9: Regression Results: Total, EGM, and Other Gambling Consumption

Panel A: Total Volume			
ψ	-0.080***	-0.079***	-0.077***
	(0.014)	(0.014)	(0.013)
Observations	3,110,355	3,106,557	2,965,028
Panel B: EGM Volume			
ψ	-0.184***	-0.184***	-0.173***
	(0.017)	(0.017)	(0.016)
Observations	3,110,355	3,088,746	2,950,087
Panel C: Other Gambling Volume			
ψ	-0.001	-0.001	-0.006
	(0.021)	(0.021)	(0.020)
Observations	3,110,355	2,728,395	2,652,222
individual - sub-experiment FE	No	Yes	Yes
sub-experiment - time FE	No	Yes	Yes
age and sex FE	No	No	Yes

Notes: The estimated ψ coefficient captures the average treatment effect on the treated (ATT). Control group is restricted to players that live in a postcode at least 10 KM away from a postcode where outlets closed between Jan 2021–Dec 2023. Dependent variables: Panel A, total gambling volume in all games. Panel B, EGM gambling. Panel C, gambling in games other than land-based EGM. Standard errors in parentheses, clustered at the individual level. The varying number of observations in the first, second and third column is explained by both missing observations for age and sex and the Poisson pseudo-likelihood regression with multiple levels of fixed effects dropping zero observations that are perfectly predicted by fixed effects. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Next in Figure 15, we present the event-study point-estimates using this alternative control group. For all outcomes, the estimates are statistically insignificantly different in the pre-closure period. After the closure, the estimates for total and EGM gambling become statistically significant, while for gambling excluding EGMs they remain insignificant.

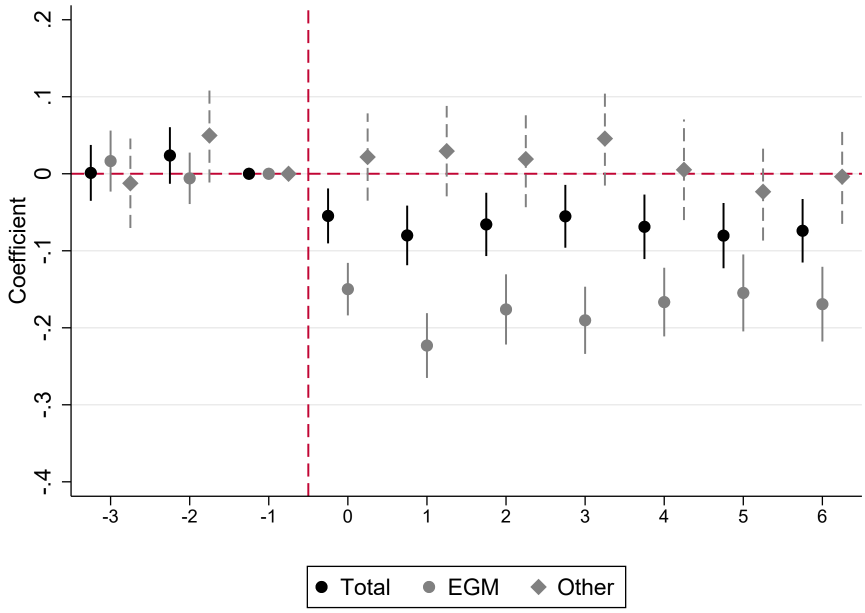

Figure 15: Event study, controlling for potential spillovers to the control group

This figure presents point estimates from the event-study specification described in the text. The black line represents point estimates and 95% confidence intervals using total gambling volume as the outcome. The dashed gray line shows the estimates and confidence intervals for gambling excluding EGMs, while the solid gray line depicts the results for EGMs.

Figure 16 presents the results of our heterogeneity analysis, where we divide the sample based on pre-closure EGM gambling volume and estimate treatment effects separately for each group. The pattern of point estimates for EGM gambling closely mirrors those from our main specification: the largest effects (in absolute terms) are observed in groups with the lowest initial gambling volume, while the smallest effects are found in the highest-volume groups. A similar pattern emerges for total gambling volume. For gambling excluding EGM, the point estimates follow a comparable trend, with the largest effects observed in the highest-volume groups. However, unlike in our main analysis, these estimates for the high-volume groups are not statistically significant.

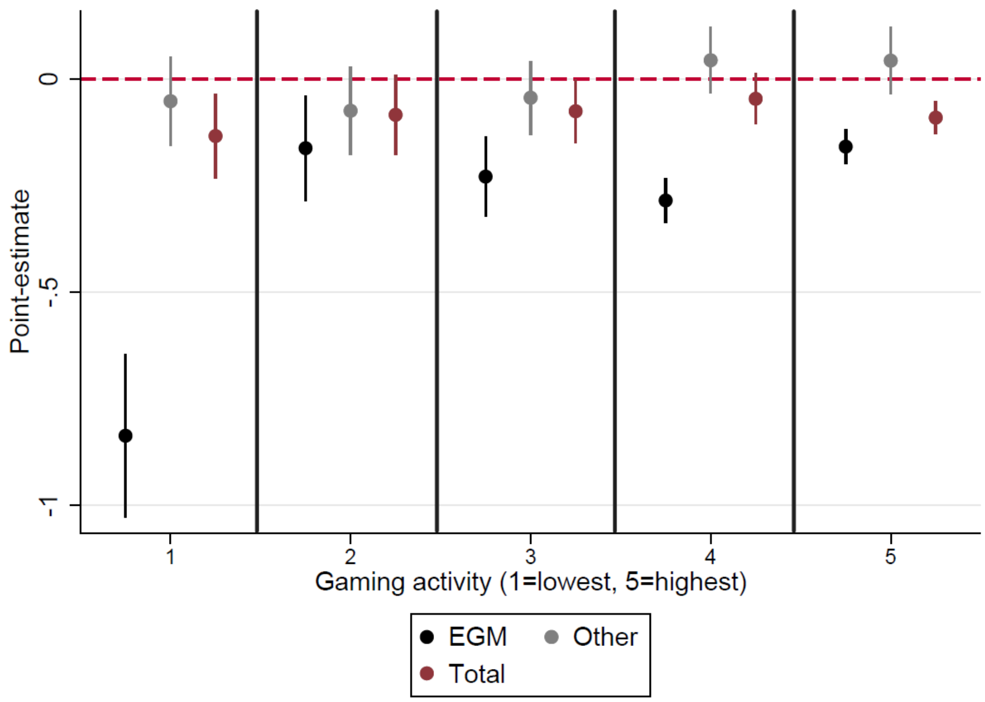

Figure 16: Heterogeneous response: gambling intensity, controlling for potential spillovers to the control group

This figure presents point estimates from a heterogeneity analysis, where the effects of the closures are estimated separately across quintiles based on EGM gambling volume. On the horizontal axis, 1 corresponds to the lowest quintile and 5 to the highest. The red line shows point estimates and 95% confidence intervals for total gambling volume, the gray line for gambling excluding EGMs, and the black line for EGM gambling specifically.

B.3 Different threshold for selection into treatment

To assess the robustness of our findings to alternative definitions of treatment intensity, we re-estimate the model from Table 4, including individual and time fixed effects, using alternative thresholds for the minimum share of EGM gambling volume in closed outlets. Specifically, we compare results using 20% and 25% thresholds to the 15% cutoff employed in the main specification. The results are presented in Figure 17. For total gambling volume, the point estimates using the 20% threshold show a slightly larger reduction than the baseline. The increase in reduction is more noticeable at the 25% threshold. This pattern is primarily driven by EGM gambling, where the reduction increases monotonically with the closed share threshold. The estimated effects on other types of gambling are positive but close to zero and statistically insignificant across specifications.

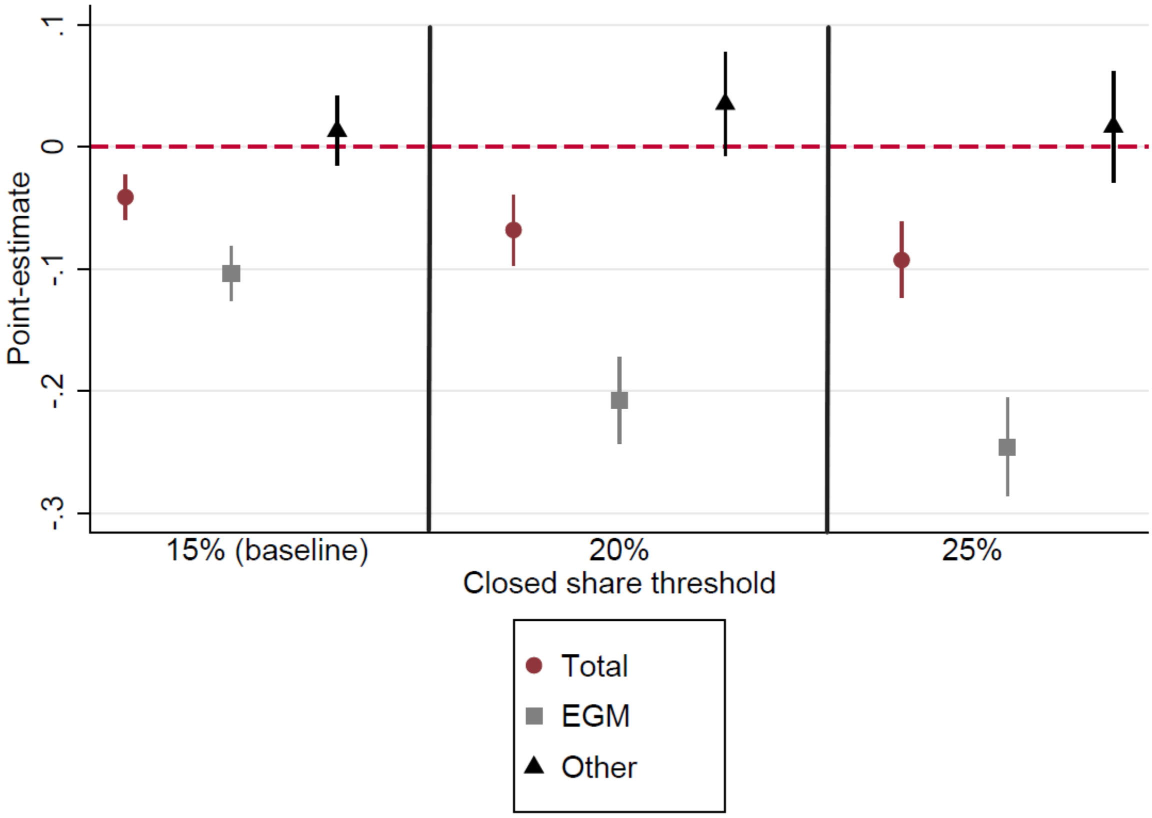

Figure 17: Sensitivity of results to closed share

This figure presents point estimates using individual and time fixed effects. Baseline results are those of column 2 of Table 4. The left panel shows results for Total gambling, middle panel results for EGM gambling and right panel results for other gambling. The red line shows point estimates and 95% confidence intervals for the baseline specification of 15% closed share, the gray line for 20% closed share, and the black line for 25% closed share specifically.

B.4 Additional heterogeneity analysis

In Section 5.2, we presented results on how EGM closures affected players with varying levels of gambling volume prior to the closure. In this appendix section, we extend the heterogeneity analysis by examining additional dimensions. Following the specification outlined at the end of Section 4.2, we now split the sample based on alternative factors, rather than dividing it into five groups by gambling volume.

The importance of a closed outlet, measured by the share of an individual's pre-intervention gambling volume at outlets that fully shut down their EGMs, may significantly influence the impact of the closures. Individuals who were more reliant on these outlets are likely to experience greater disruption, potentially leading to larger reductions in gambling volume or increased substitution toward other forms of gambling, compared to those less affected. We quantify outlet importance as the share of each individual's total gambling volume at treated outlets during the pre-intervention period ($t = -1, 2, 3$). Based on this measure, individuals are grouped into quintiles. For all the players in the control group, the closed share variable is zero by definition. In this heterogeneity analysis, instead of individual-sub-experiment-group specific fixed effects, we use individual-sub-experiment fixed effects essentially comparing all the players in the treatment group to all players in the control group within the same sub-experiment.

Figure 19 presents the results for each quintile. As expected, the smallest effects are observed in the two groups for whom the closed machines accounted for the lowest share of pre-closure gambling volume. The largest point estimate appears in the group with the highest volume share. For other forms of gambling, the point estimates are statistically insignificant across all groups, with the exception of the middle quintile.

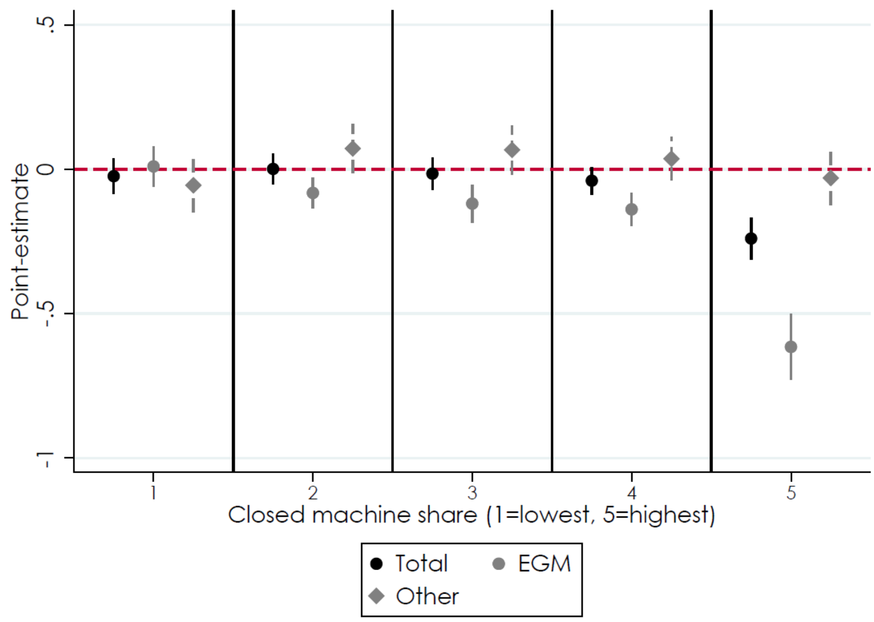

Figure 18: Heterogeneous response: importance of closed outlets

This figure presents point estimates from a heterogeneity analysis, where the impact of the closures on gambling volume is estimated separately across quintiles based on the share of EGM spending attributable to the closed machines. The horizontal axis ranks municipalities from the lowest (1) to the highest (5) quintile. The red line shows point estimates and 95% confidence intervals for total gambling volume, the gray line represents gambling excluding EGMs, and the black line corresponds specifically to EGM gambling.

Age is a demographic factor that may influence how individuals respond to outlet closures. Younger gamblers, often more comfortable with technology, may readily shift to online gambling platforms or other outlets when physical access is restricted. Older individuals, however, may have stronger attachments to specific gambling outlets, potentially leading to a larger reduction in volume if their preferred outlets close. On the other hand, older gamblers can also be more willing to substitute EGMs if they have formed a habit over the years.

We categorize individuals into five equally distributed age groups based on their age prior to the treatment $t = -1$. Figure 19 presents the results for each age group. Interestingly, among the youngest group, we observe a reduction in both EGM gambling and other forms of gambling. One possible explanation is that outlets hosting EGMs may serve as a form of marketing for the younger population; thus, their closure reduces exposure to games hosted by Veikkaus. This interpretation is supported by population survey data, which indicate that younger individuals are the most likely to gamble with foreign operators (Karjalainen et al., 2023). For the remaining age groups, no clear pattern emerges. The impact on EGM gambling is highest among the middle-aged group and lowest among the oldest. For other forms of gambling, the point estimates are close to zero and statistically insignificant.

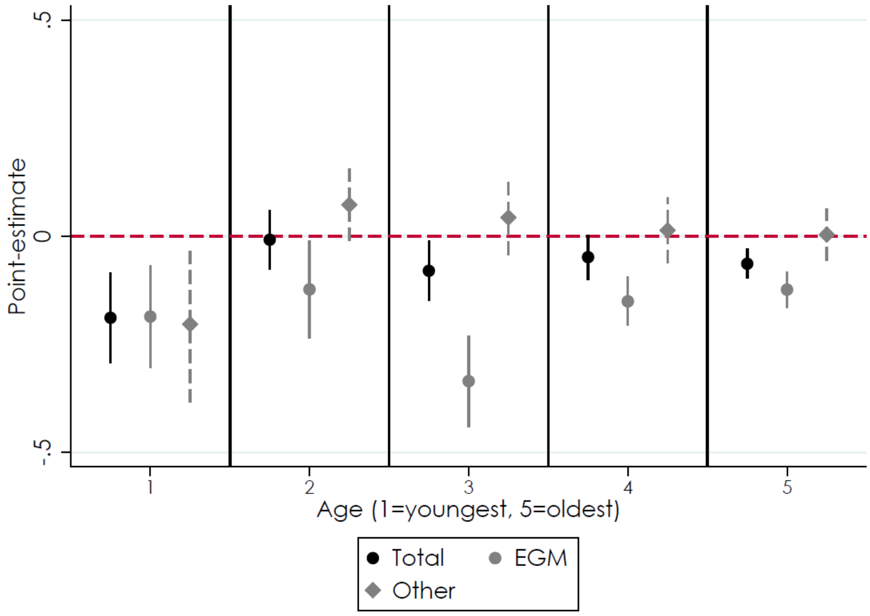

Figure 19: Heterogeneous response: age

This figure shows point estimates from a heterogeneity analysis in which the impact of the closures on gambling volume is estimated separately across quintiles based on player age. The horizontal axis ranks players from the youngest (1) to the oldest (5) average age quintile. The red line depicts point estimates and 95% confidence intervals for total gambling volume, the gray line for gambling excluding EGMs, and the black line for EGM gambling specifically.

B.5 Alternative outcome variables

We also conduct an analysis using the number of gambling days as the outcome variable, rather than gambling volume. As discussed in the main text, this approach allows us to distinguish whether the results based on gambling volume are driven by increased play frequency or by higher spending conditional on playing. For this analysis, we use the same estimation equation and specifications discussed in Section 4.2.

Before presenting the point estimates in Figure 20, we first plot the evolution of the number of days played per month for both the treatment and control groups, before and after the closures. For confidentiality reasons, the data is indexed to the sample mean one month prior to the closure. Across all three categories, both groups show a slight upward trend in the number of days played leading up to the closure. Following the closure, however, there is a clear and noticeable decline in the number of days gambled on any type of game, as well as in the number of days players engaged with EGMs. This provides an initial indication that the closures led to a reduction in gambling days within the treatment group.

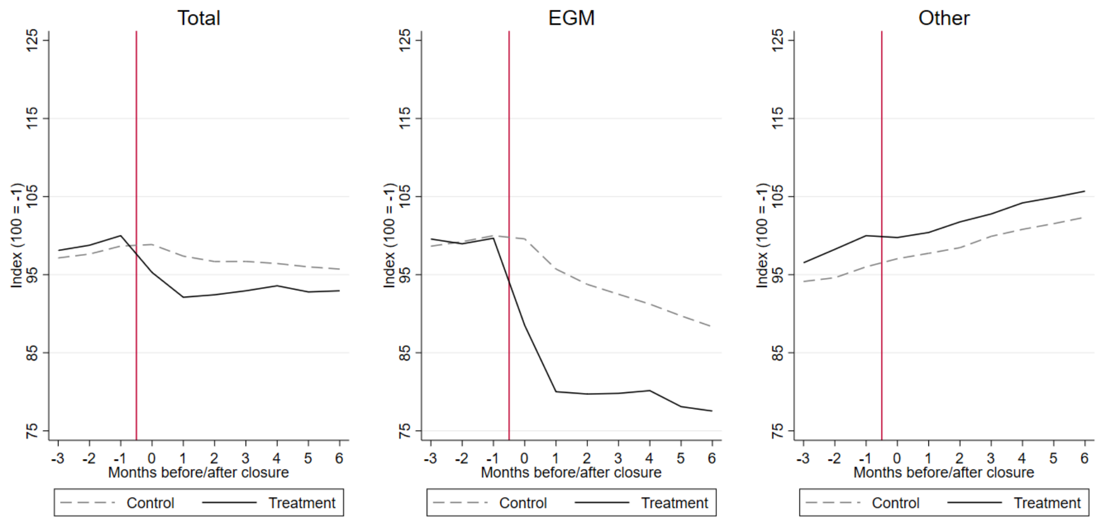

Figure 20: Average number of days played per month over stacked event window

This figure shows the evolution of the number of days gambled in the treatment and control groups. Values are indexed to the pre-treatment sample average for each group. The vertical line indicates the timing of the closure.

In Table 10 we report the full results. Similar to Table 4 the first column includes an indicator variable for the treatment group and post-period, the second column includes the full sub-experiment specific fixed effects, and the model in the third column, in addition, includes age and sex fixed effects. Panel A shows the results for total gambling, Panel B for EGM gambling, and panel C for other gambling excluding EGMs. Across all types of gambling, depending on the specification, we find a 3% to 5% decrease in the number of days gambled. For EGMs, the reduction is greater, ranging from 12% to 15%, while for other types of gambling, we find no statistically significant change in the number of days played.

Table 10: Regression Results: Number of days playing in total, days playing EGM, and days playing other gambling

Panel A: Total Gambling Days			
ψ	-0.050***	-0.049***	-0.044***
	(0.004)	(0.004)	(0.004)
Observations	22,282,452	22,246,362	21,078,604
Panel B: EGM Gambling Days			
ψ	-0.147***	-0.148***	-0.139***
	(0.007)	(0.007)	(0.006)
Observations	22,282,452	22,085,316	20,944,117
Panel C: Other Gambling Days			
ψ	-0.005	-0.005	-0.004
	(0.005)	(0.005)	(0.005)
Observations	22,282,452	19,272,636	18,643,850
individual - sub-experiment FE	No	Yes	Yes
sub-experiment - time FE	No	Yes	Yes
age and sex FE	No	No	Yes

Notes: The estimated ψ coefficient captures the average treatment effect on the treated (ATT). Dependent variables: Panel A, total days gambling. Panel B, days gambling in EGM. Panel C, days gambling in games other than land-based EGM. Standard errors in parentheses, clustered at the individual level. The varying number of observations in the first, second and third column is explained by both missing observations for age and sex and the Poisson pseudo-likelihood regression with multiple levels of fixed effects dropping zero observations that are perfectly predicted by fixed effects. Significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We also estimate the event-study model using the number of days played as the outcome variable. Consistent with the results based on gambling volume, the point estimates prior to the closure are relatively close to zero. Following the closure, we observe a marked increase in both the magnitude and statistical significance of the point estimates for all gambling types combined, and for EGM gambling specifically. In contrast, the estimates for other types of gambling remain close to zero throughout.

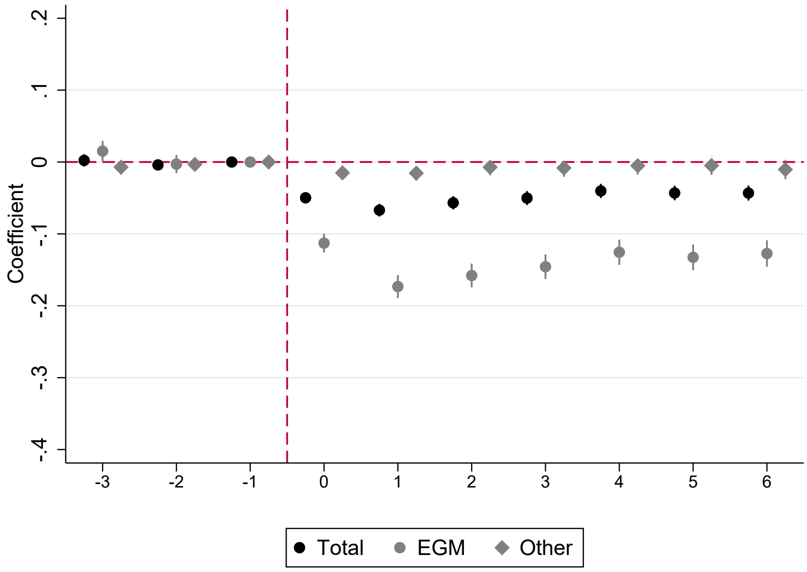

Figure 21: Event study

This figure presents point estimates from the event-study specification using number of days gambled as outcome. The black line represents point estimates and 95% confidence intervals using total gambling volume as the outcome. The dashed gray line shows the estimates and confidence intervals for gambling excluding EGMs, while the solid gray line depicts the results for EGMs.

Similarly to gambling volume, we have also estimated the effects separately for players with different levels of gambling volume prior to the closure. The results are shown in Figure 22. Among individuals with the lowest gambling volumes, we observe a substantial decline—over one-third—in the frequency of EGM gambling. In comparison, the reductions are smaller among groups with higher gambling volumes, with the highest-volume group exhibiting the smallest estimated decrease, approximately 10%. A similar pattern emerges when considering all types of gambling: the point estimates indicate a negative association (in absolute terms) between gambling volume and the size of the estimated effect. For non-EGM gambling, however, the estimated impacts on gambling frequency are statistically insignificant across all groups.

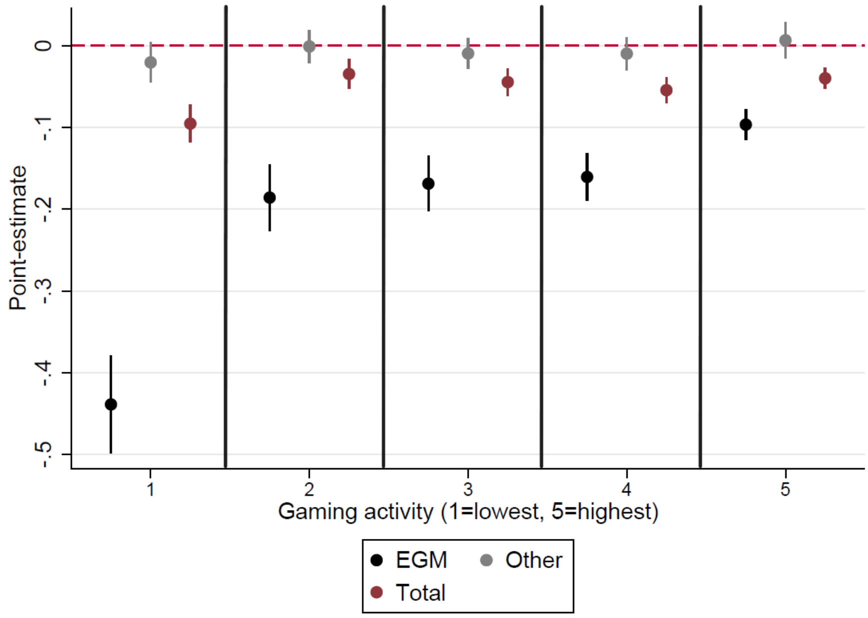

Figure 22: Heterogeneous response: gambling intensity

This figure presents point estimates from a heterogeneity analysis, where the effects of the closures on the number of days played are estimated separately across quintiles based on EGM gambling volume. On the horizontal axis, 1 corresponds to the lowest quintile and 5 to the highest. The black line shows point estimates and 95% confidence intervals for total gambling volume, the gray line for EGM gambling, and the dashed gray line for gambling excluding EGMs.

To see whether some players stop gambling altogether, we construct a monthly participation indicator equal to one if a player gambled at least once during the month and zero otherwise, and then plot the average of this indicator over time for the treatment and control groups. As shown in Figure 23, the treatment group's participation rate is higher than the control group's before the outlet closures and falls sharply immediately after, whereas the control group's participation rate declines more gradually. Compared with the days-played event-study in Figure 21, the drop in participation for the control group is actually steeper, while the pattern for the treatment group remains very similar. There is no noticeable change in participation in other gambling.

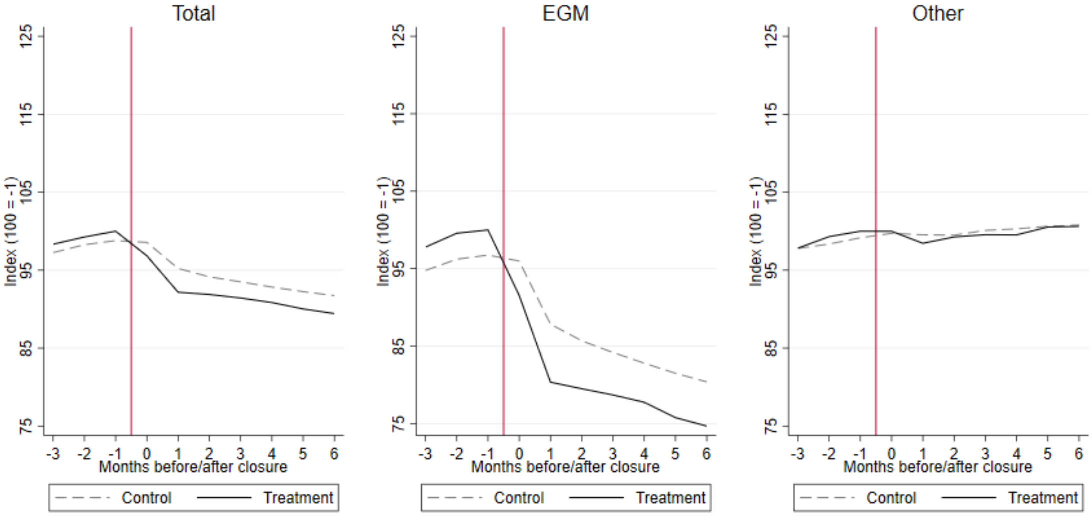

Figure 23: Monthly participation over stacked event window

This figure shows the evolution of the probability of gambling in the treatment and control groups. Values are indexed to the pre-treatment sample average for each group. The vertical line indicates the timing of the closure.