Donkey Business: Trade, Resource Exploitation, and Crime*

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Abstract

This paper examines the relationship between the institutionalization of a renewable resource market with poorly defined property rights and local crime rates. We focus on the regulation of the donkey hide trade in Brazil, driven by foreign demand for *ejiao*, a Traditional Chinese Medicine product. Using a quasi-experimental research design, we leverage the timing of regulatory measures alongside spatial variations in donkey populations across Brazilian municipalities to provide causal evidence that the slaughtering of free-roaming donkeys led to an increase in crime and violence. We further explore the role of market illegality, finding that the impact on crime was twice as large during periods when the trade was illegal in Brazil. Our results carry important policy implications for developing countries grappling with resource booms and weak property rights. These findings emphasize the need for effective regulation, robust monitoring, and enforcement mechanisms to mitigate the social costs associated with natural resource exploitation.

Keywords: Crime; Illegal Behavior; Natural Resources; Resource Exploitation; Renewable Resource Trade; Property Rights.
JEL Codes: F14; K42; L70; O13; O17; O19; Q27.

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1 Introduction

Natural resources account for over 20% of global goods exchange, and their sustainable use is becoming increasingly critical as countries around the world grapple with resource depletion and overexploitation (Ruta & Venables, 2012). In many renewable resource markets, unclear property rights and weak regulatory enforcement lead to overuse, a pressure often exacerbated by international trade (Copeland & Taylor, 2009). This dynamic raises concerns about the long-term sustainability of natural resource use, particularly in regions where regulation is insufficient or inconsistently enforced, leading to both economic and ecological consequences.

One timely and notable example of these pressures is the rising demand for *ejiao*, a Traditional Chinese Medicine product made from donkey hides, which has sparked a global trade that significantly impacts donkey populations and local economies, particularly in low- and middle-income countries (Lesté-Lasserre, 2019). Once a luxury item reserved for China's elite, *ejiao* has gained popularity among the broader middle class due to rising incomes, creating a shortage of donkeys within China (Sheikh & Lohre, 2023; Skippen et al., 2021; Waters, 2019). In this context, Brazil has emerged as a key supplier of donkey hides, especially after regulating this trade in 2017 and establishing export-oriented slaughterhouses. However, Brazil faces a pressing challenge: the absence of clear property rights for donkeys, many of which roam freely in semi-arid regions with high poverty levels. Once vital to local communities, modernization and economic changes have diminished the donkeys' value, leading to increased abandonment. The potential for quick profits through their sale to slaughterhouses has complicated ownership claims, leading to conflicts over these donkeys and raising concerns about violence and the sustainability of this trade.

We examine the relationship between contestable markets – particularly those with poorly defined or enforced property rights – and crime, focusing on the direct consequences of institutionalizing the donkey hide trade on crime and violence dynamics at the local level in Brazil. Three main features contribute to the escalation of crime around this market: (i) the emergence of dealers and intermediaries' agents that fuel the supply of free-roaming donkeys to slaughterhouses, (ii) the legal status of slaughtering activities, which were under dispute in the Brazilian judicial system and considered illegal in some periods, and (iii) the association of donkey hide trade with other criminal activities, such as parallel trafficking[1](Sheikh & Lohre, 2023; The Donkey Sanctuary, 2022). This research addresses

[1]For instance, Su et al. (2022) show that at least 13 groups of CITES-listed species are involved in the

the question: What impact does regulating a contestable market have on local crime rates? Our inquiry seeks to understand the socio-economic implications of market regulation, particularly the negative externalities associated with the donkey hide trade.

To explore this question, we first document the increase in donkey slaughters following the regulation of the market. Before the rise in Chinese demand, there were almost no recorded slaughters, but they surged to over 8,000 per month at their peak, according to official data. These numbers dropped sharply after Brazilian authorities imposed a ban, followed by a significant increase in the slaughter of "other equids", such as horses and mules, exclusively in the region where the donkey market was active. Donkey slaughters resumed as soon as the ban was lifted, and trade statistics show that the export boom of equids' raw skin and hides remained largely unaffected by regulatory changes. This pattern, along with extensive anecdotal evidence, suggests that slaughterhouses may have operated illegally during the national ban.

Leveraging the timing of national regulation of the donkey market, combined with variations in the historical presence of donkeys across Brazilian municipalities, we use a difference-in-differences research design to estimate the causal impact of the donkey market on violence. Our results show a positive effect of the donkey market on crime rates, measured by homicides, in Brazilian municipalities. Regions with higher donkey populations before the regulation experienced relatively higher crime rates after the institutionalization of the market. To put this in perspective, a one-standard-deviation increase in donkeys per thousand inhabitants corresponds to a quarterly increase of approximately 1.31 homicides per 100,000 inhabitants in Northeast municipalities. Moreover, we find that this effect is stronger for municipalities closer to a slaughterhouse, and that there are null effects for other climate-resilient livestock, strengthening the causal interpretation of our results. These findings are consistent across various samples, time periods, alternative treatment variables, and remain robust when controlling for different crime dynamics in municipalities with varying initial characteristics.

Finally, we study the role of the illegality of the market in criminal dynamics. Using judicial decisions that imposed a national ban on slaughtering, which was later lifted, we apply a triple-difference strategy and find that illegality plays a major role in driving the observed effects. Our estimates indicate that the effect on crime was twice as large during the illegal period. These results, however, do not diminish the role of open access and lack of property rights over the animals in driving violence, as the effects remain positive and

densely connected donkey skin product network, facilitated through online wildlife trade.

both economically and statistically significant during the period of legal slaughter. In light of this, we conclude that both resource booms and illegality in such contestable markets play a critical role in explaining the effects on crime and violence.

Our findings make at least three contributions to the existing literature. First, we contribute to the broad literature on trade in natural resources and economic development (Ruta & Venables, 2012). Specifically, we add to the literature on the consequences of (wildlife) renewable resource overuse (Brander & Taylor, 1998; Copeland & Taylor, 2009; Taylor, 2011) by demonstrating an unintended welfare loss associated with a pervasive feature of such markets – open access to the resources. Previous studies document externalities associated with wildlife depletion. For instance, Feir et al. (2024) show that the near extinction of the North American bison[2] had long-lasting effects on populations that relied on them, while Frank and Sudarshan (2024) argue that the collapse of vultures in India had important consequences for human health. We show that the institutionalization of a new wildlife market, combined with open access and resource overuse, may lead to increased crime in resource-abundant regions.

Second, we provide empirical evidence on the impact of regulatory interventions in a natural-resource market on local crime rates, shedding light on an underexplored aspect of contestable market operations. Prior studies have uncovered correlations between regulatory interventions in illegal drug markets and subsequent spikes in violence (Angrist & Kugler, 2008; Castillo et al., 2020; Dell, 2015; Dube et al., 2016; Mejia & Restrepo, 2011). Another strand of the literature suggests that illegal markets often foster competition, leading to violence among competitors and within organizations (Adda et al., 2014; Dragone et al., 2019; Owens, 2014; Reuter, 2009). In the case of natural resources, Chimeli and Soares (2017) and Pereira and Pucci (2024) find that violence is associated with the illegal status of logging and mining in the Brazilian Amazon, respectively. We find a positive effect on crime following the institutionalization of the donkey market. While prohibition and illegal activity intensify this effect, it remains significant even during periods of legal market operations. This suggests that crime can result from markets with poorly defined property rights, even when these markets are not strictly illegal.

Finally, we uncover a previously underexplored consequence of China's rise in global trade, particularly in its effects on developing countries most impacted by the exploitative depletion of natural resources. While previous research has focused on the impact of Chinese import competition on variables such as manufacturing employment (Autor et

[2]For a detailed discussion on this process, see the seminal contribution in Taylor (2011).

al., 2013; Pierce & Schott, 2016) and workers' earnings (Autor et al., 2014; Dix-Carneiro et al., 2023), there is less work examining the demand-side effects of China's economic ascendancy, especially on natural-resource-based markets. Concerning the *ejiao* market and donkey hide trade, other studies show detrimental effects on rural livelihoods in African countries where donkeys are important assets (Carder et al., 2019; Goodrum et al., 2022; Maggs et al., 2023). Our findings, however, reveal an important resource-boom effect: international demand has made previously worthless animals valuable. Combined with open access, excessive hunting, and weak enforcement in Brazil, crime emerges as an unintended consequence of this boom and the operation of the market.

These findings carry significant policy implications, underscoring persistent externalities in the trade-resource depletion relationship. This pattern of unintended welfare consequences from overexploitation recalls the historical decline of the North American buffalo over a century ago (Feir et al., 2024; Taylor, 2011) and aligns with research linking commodity price shocks to crime (Dube & Vargas, 2013; Komarek, 2018). Similar resource booms are emerging across many developing economies, notably in the donkey hide trade. As governments face challenges in implementing and enforcing effective regulations, our results suggest that global coordination may be essential to mitigating these social costs.

The remainder of this paper is organized as follows: Section 2 provides background information on the *ejiao* market, detailing the rise of the donkey hide market in Brazil and its regulatory framework. Section 3 describes the data used in our empirical analysis and outlines our empirical strategy. In Section 4, we present the main results and robustness checks. Section 5 offers a falsification exercise, while Section 6 explores the validity of our proposed mechanism. Finally, Section 7 concludes with a discussion of the implications and policy relevance of our findings.

2 Background

2.1 *Ejiao* and donkeys' hide trade

Donkey products have long been revered in Traditional Chinese Medicine for their purported medicinal and beautifying properties. Central to this is *ejiao*, a gelatin made from donkey hides, believed to offer health benefits like blood enrichment, immune enhancement, and cancer prevention. Despite its long-standing tradition and perceived efficacy, empirical evidence supporting these claims is lacking (Li et al., 2017; Wang et al., 2012).

Originally reserved for the elite in Chinese society, *ejiao* has witnessed a notable shift in its consumer base, predominantly due to a substantial increase in average income in China. As a result, the product now primarily targets the burgeoning middle class, leading to a significant surge in demand in recent years (Köhle, 2018; Lesté-Lasserre, 2019). This escalating demand has overwhelmed the domestic supply of donkeys in China (Sheikh & Lohre, 2023; Skippen et al., 2021; Waters, 2019). Data from the Food and Agricultural Organization of the United Nations (FAO) indicate a drastic decline in the Chinese donkey population from approximately 11 million in 1994 to less than 2.7 million in 2018. To sustain the *ejiao* market in China alone, an estimated 5-6 million donkeys annually are required (The Donkey Sanctuary, 2022), a figure far surpassing China's current population.

Consequently, suppliers have turned to sourcing donkey hides from developing countries, particularly in South America and Africa, where the donkey hide trade has flourished.[3] Donkeys are slaughtered in these regions, and their skins are exported to Chinese factories for *ejiao* production. This global trade has put immense pressure on donkey populations, sparking concerns over sustainability, animal welfare, and the livelihoods of communities reliant on these animals (Bennett & Pfuderer, 2020; Goodrum et al., 2022; Waters, 2019).

The protracted gestation period of donkeys, lasting up to 14 months, presents a significant obstacle to sustainable production, particularly amid the surge in demand. This slow reproductive rate, coupled with the exploitative nature of the trade, heightens the risk to donkey populations, particularly in developing regions. Beyond animal welfare concerns, the trade's impact extends to the communities that rely on donkeys for agriculture and transportation. Maggs et al. (2023) highlights the vital economic and social roles donkeys play in West African households, where their loss can severely disrupt livelihoods.

In addition to its direct effects, the donkey hide trade is often intertwined with broader wildlife trafficking. Hides are often smuggled alongside other banned wildlife products, a practice known as parallel trafficking (Sheikh & Lohre, 2023; The Donkey Sanctuary, 2022). Scientists have also raised concerns about this trade facilitating the spread of zoonotic and other infectious diseases, further complicating the array of issues posed by the donkey hide industry (Goodrum et al., 2022; Skippen et al., 2021).

In response to growing concerns over the economic and social impacts of the trade,

[3]Panel (a) of Figure A.1 illustrates the global distribution of donkey populations, while panel (b) provides examples of products derived from donkey hides. Also, see detailed coverage of the recent trend in Nature, The Economist, and The New York Times.

several governments – such as Burkina Faso, Ghana, Nigeria, and Senegal – implemented export restrictions on donkey products. However, these unilateral efforts were often undermined by illegal animal transport and hide smuggling across borders (Voice of America, 2022). Most recently, the African Union introduced a continent-wide ban on the donkey skin trade, which has been praised by animal welfare advocates for its potential to protect both donkey populations and the livelihoods of communities dependent on them.[4]

2.2 The donkey market in Brazil

The historical significance of donkeys in Brazil dates back to the 16th century when Portuguese colonizers introduced them to the Brazilian Northeast. Alongside other equid species, donkeys played a vital role in the region's development due to their resilience and adaptability to local environmental conditions. They became indispensable for various tasks such as packing, drafting, and transportation, particularly in the semi-arid regions of the Northeast (Carneiro et al., 2018; Salles et al., 2013).

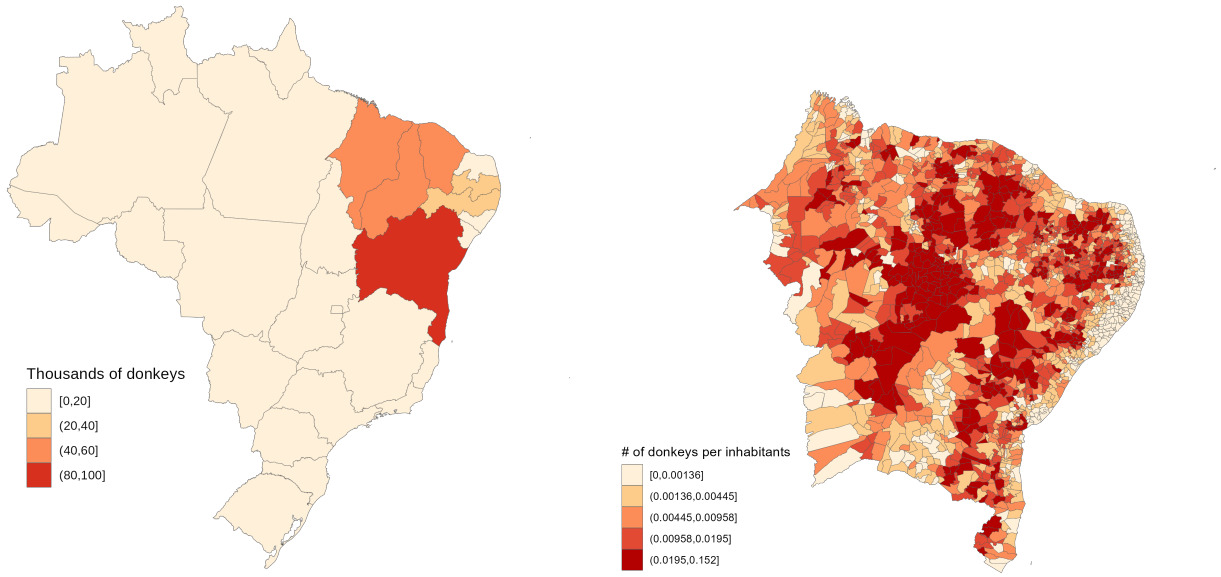
This historical prominence has led to a highly concentrated distribution of donkey populations, with approximately 90% of all donkeys in Brazil located in the Northeast.[5] Panel (a) of Figure 1 shows the number of donkeys across Brazilian states, emphasizing the Northeast's concentration. Panel (b) shows the number of donkeys per inhabitant and zooms in on municipalities in the Northeast, particularly highlighting the cluster in the more arid regions.

Notwithstanding, unlike many other developing countries, Brazil's Northeast has experienced a significant decline in the utility of donkeys as working animals over the past two decades. This decline is largely due to improvements in agricultural technology, greater access to credit, and rising living standards. As a by-product of regional development, the advent of motorized vehicles has further contributed to a decline in the utilization of donkeys, leading to instances of abandonment and uncontrolled breeding. This shift is underscored by anecdotal evidence, such as former President Luiz Inácio "Lula" da Silva's famous remark, months after leaving government with 87% of approval, that "the thing that makes us most proud is that folks are exchanging our beloved donkey for a motorcycle" (O Globo, 2011). As a result, free-roaming and feral donkey populations have

[4]For more details, see coverage from BBC, The New York Times, Reuters, and The Atlantic.

[5]Figures A.2 and A.3 illustrate the spatial distribution of donkeys in Brazilian municipalities in 2017, highlighting this regional concentration.

Figure 1: Spatial distribution of donkeys in Brazil



(a) Number of donkeys (b) Donkeys per capita - Northeast municipalities

Source: Data on donkey population is from the 2017 Census of Agriculture. Population data is from IBGE.

proliferated in the semi-arid regions of Brazil, contributing to challenges for local governments, particularly an increase in traffic accidents caused by these animals (Carneiro et al., 2018; G1 - Globo, 2017b; Gameiro et al., 2022; Salles et al., 2013).

The existing population of donkeys, now freely roaming the arid regions of Northeast Brazil, has not escaped notice amidst the burgeoning market for donkey hide. In late 2015, then-Minister of Agriculture, Kátia Abreu, shared a noteworthy anecdote on Twitter.[6] She recounted that "at the entrepreneurs' seminar, an investor caught our attention with an interest that seemed like a joke to us, but it wasn't. He wants to export donkeys to China." The Minister also expressed astonishment at the magnitude of the investor's demand: "Unbelievable, but their demand is 1 million donkeys per year[...]" (Valor Econômico, 2015).

In 2016, public officials began using the presence of donkeys on roads as a key justification for legalizing donkey slaughter in Bahia for meat and hide export (Gameiro et al.,

[6]The original tweet from then-Minister of Agriculture, Kátia Abreu, is accessible via this link.

2021, 2022). Local government discourse framed this trade as a humane solution to the long-standing issue of roaming animals (Diário Oficial da Bahia, 2016). Subsequently, in 2017, the federal government established the legal framework for animal slaughter and transportation, marking the complete regulation of the activity in the country – under *Decreto 9.013, March 2017*. With local government support, three slaughterhouses linked to Chinese entrepreneurs were established in Bahia state between mid-2017 and 2018.[7]

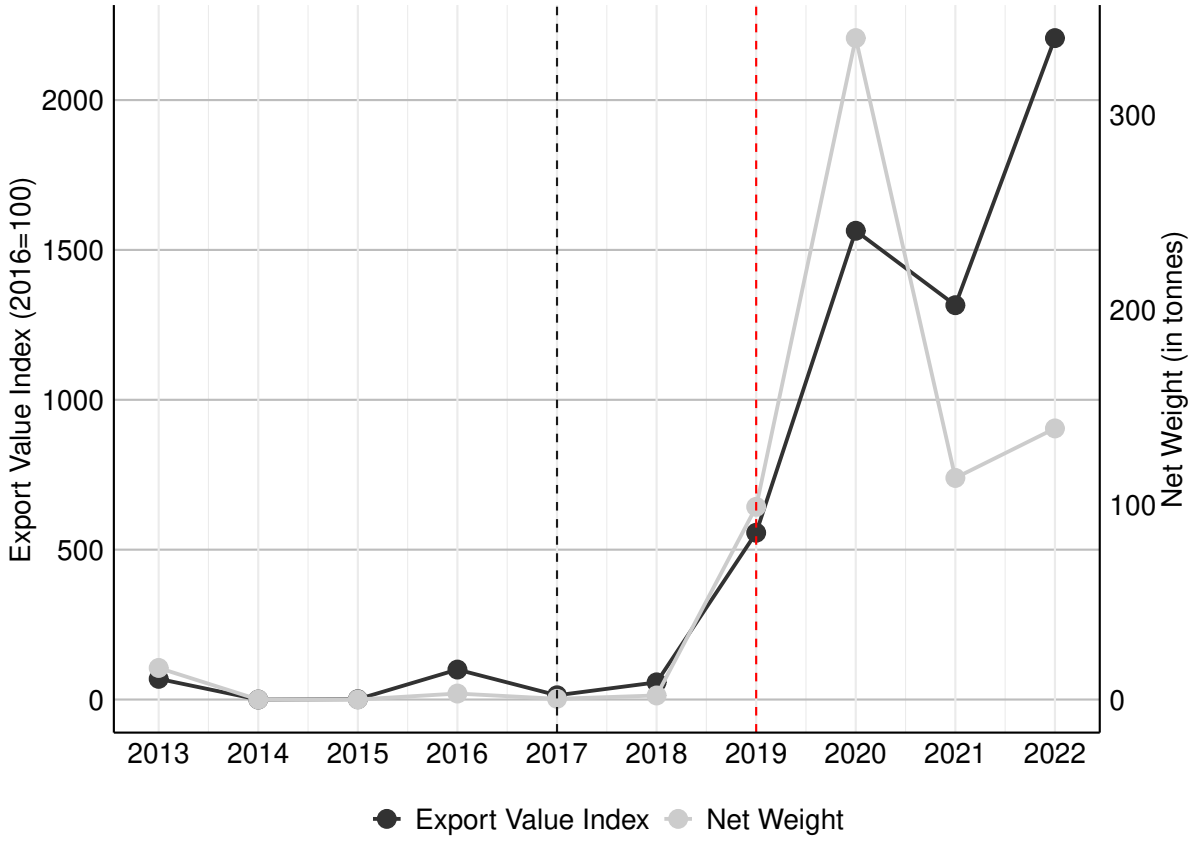
As a result, exports of donkey products in Brazil saw considerable growth. Figure 2 illustrates the rise in both value and net weight of raw skins and hides from donkeys and other equids, likely materials used in *ejiao* production. Exports surged from around 3 tonnes in 2016 to approximately 340 tonnes by 2020, with an even steeper rise in export value. Concurrently, the number of slaughtered donkeys soared by 4,788% during the same period (Gameiro et al., 2021, 2022). Figure 3 shows the trajectory of slaughtered donkeys and other equids (horses and mules) in Brazil from 2013 to 2021. The reduction in Brazil's donkey population over recent decades is notable. According to estimates from FAO Stat, the number of donkeys decreased by approximately 43% between 1996 (1.370 million) and 2022 (782 thousand). This decline underscores the impact of market forces and regulatory decisions on donkey demographics in Brazil.

With no established commercial production chain for donkeys in Brazil, sourcing them typically involves capturing animals from rural communities or directly from roads for slaughter (Gameiro et al., 2022). This has led to the rise of a network of dealers and intermediaries who pay for the capture of donkeys, which are then sold to one of the few slaughterhouses (BBC-Brasil, 2021; UOL, 2023). Anecdotal evidence suggests that donkeys are collected from various points in the Northeast region, often caught and sold by impoverished farmers for rewards ranging from 20 to 50 Brazilian reais (roughly US$4 to $10), while their hides can fetch over US$4,000 in China (BBC-Brasil, 2021). The widespread absence of property rights over these animals, coupled with the potential for quick profits in poor areas through their sale to slaughterhouses, may contribute to rising criminal activities. Our analysis explores whether areas with high donkey populations before market institutionalization experienced a subsequent increase in crime, as disputes over ill-defined property rights often escalate into violence.

Importantly, following repeated incidents of animal mistreatment reported by the press and denounced by animal protection NGOs and local communities, temporary bans were

[7] Panel (c) of Figure A.1 shows free-roaming donkeys on a state road in Ceará, while panel (d) provides an example of a Chinese donkey slaughterhouse in Amargosa, Bahia.

Figure 2: Exports of donkeys in Brazil

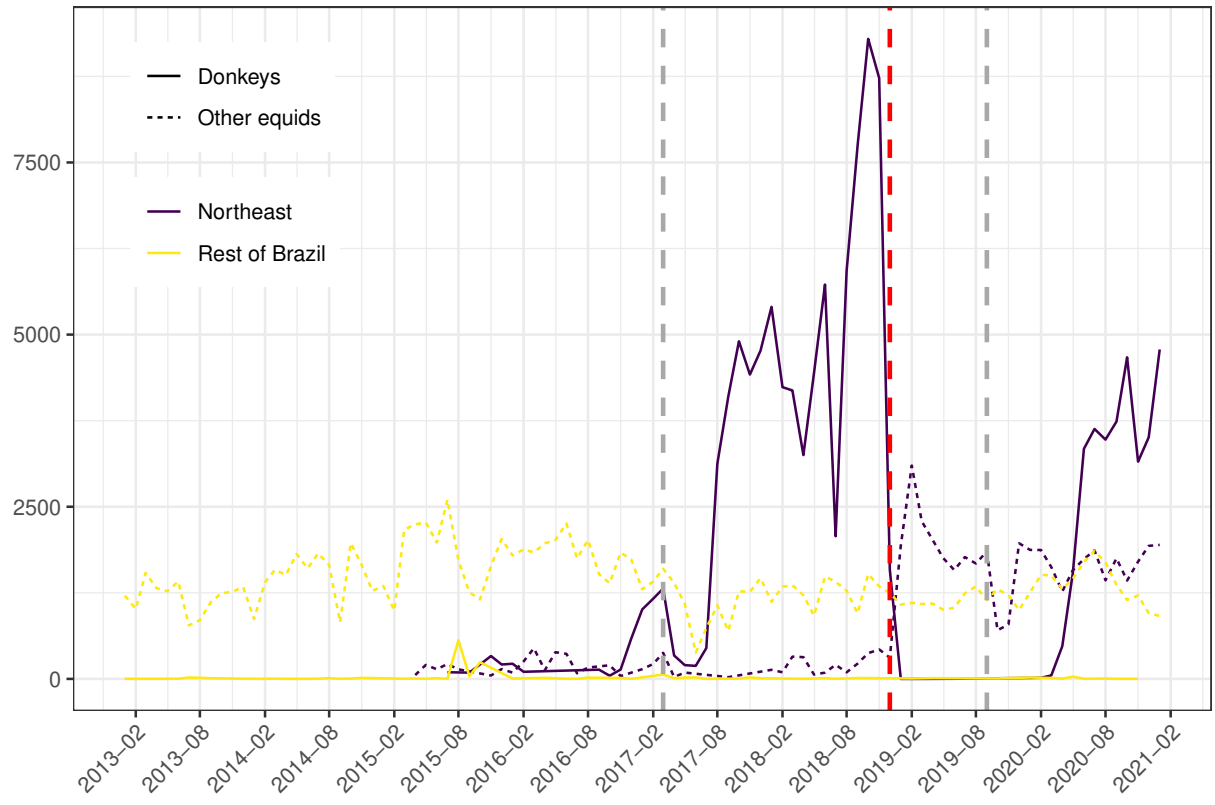


Notes: Data on exports of raw skins and hides from donkeys and other equids are sourced from SISCOMEX, affiliated with Brazil's Ministry of Industry, Foreign Trade, and Services. The black dashed line represents the year of regulation of the donkey market, while the red dashed line marks the timing of the prohibition.

imposed on donkey slaughter in Brazil (Gameiro et al., 2021; Skippen et al., 2021). The first major ban was instituted by the end of 2018 but was lifted in the second half of 2019 due to extreme pressure from business groups and local politicians. They argued that the interruption of slaughter had caused serious damage to the public economy as the activity generated jobs and income.[8] However, despite the ban, evidence suggests the practice persisted. Notably, following the ban on donkey slaughter, the number of "other equids" – horses and mules – slaughtered in the Northeast increased significantly,

[8]For instance, the then-mayor of Amargosa, home to the region's largest slaughterhouse, claimed that the facility was the city's second-largest private employer (BBC-Brasil, 2021).

Figure 3: Slaughters of donkeys in Brazil



Notes: Data on slaughters of donkeys and other equids is from *Serviço de Inspeção Federal* (SIF), associated with the Brazilian Ministry of Agriculture, Livestock and Food Supply. The grey dashed lines represent the months of the market's regulation and continuation, while the red dashed line indicates the timing of the prohibition.

deviating from historical trends, as shown in Figure 3. This pattern supports the abundant anecdotal evidence that illegal slaughters have surfaced in the Northeast region after the ban imposed by the federal government (BBC-Brasil, 2021; G1 - Globo, 2017a; Gameiro et al., 2021; UOL, 2023). Interestingly, even after the ban was lifted, the slaughter of "other equids" continued alongside donkeys in the Northeast, reaching levels near the peak before the prohibition. This suggests a persistent pattern of semi-licit activity, likely sustained by fixed costs already incurred and the risk of renewed prohibitions driven by public pressure.

The potential for quick profits in impoverished areas, coupled with the persistence of illegal operations and the absence of clear property rights, presents significant policy

challenges. Our analysis underscores the need for a thorough evaluation of both the benefits and external costs of this activity in Brazil. These findings also offer valuable insights for developing nations grappling with the surge in demand for donkey hides, as they confront the exploitative nature of the market and the difficulties of enforcing unilateral bans on the trade.

3 Data Description and Empirical Strategy

3.1 Data

Donkeys' presence

We rely on data regarding the presence of donkeys per municipality in Brazil obtained from the Census of Agriculture, conducted every ten years by the Brazilian National Statistical Institute (*Instituto Brasileiro de Geografia e Estatística* - IBGE). These agricultural census records are compiled through direct interviews with agricultural establishment managers and are accessible online through IBGE, aggregated at the municipality level. Our primary focus is on the 2017 wave, collected in the months before the donkey market's regulation, with the 1995 wave used for robustness checks. Combining this information with population data from IBGE allows us to construct our primary measure of continuous treatment in our empirical approach: the number of donkeys per 1,000 inhabitants. Figure 1 illustrates the spatial distribution of donkeys across Brazil and the donkey population density in the Northeast region. We also gather information on other types of livestock from the Census of Agriculture to conduct placebo exercises.

Crime data

Our outcome variable, serving as an indicator of the incidence of crime, is the homicide rate per 100,000 inhabitants. We use mortality records from DATASUS, an administrative dataset from the Ministry of Health, available at the municipality level. We use quarterly data from 2013 to 2021. Population data from IBGE are then employed to compute mortality rates per 100,000 inhabitants. Throughout our empirical investigation, we concentrate on homicide rates per place of occurrence. However, results are consistent when using rates by place of residence.[9]

[9] Results using the homicide rate per place of residence as the dependent variable in our main specifications are provided in the Online Appendix.

It is important to note that homicide rates typically exhibit higher reporting accuracy compared to other types of crime and violence in developing countries (Soares, 2004), and the unified system of public health maintained by the Brazilian government ensures a certain level of consistency in definitions across regions. This approach is commonly employed in the literature examining the relationship between economic shocks and crime in Brazil (Chimeli & Soares, 2017; Dix-Carneiro et al., 2018; Soares & Souza, 2023). Data on other forms of crime in Brazil are typically collected by state-level police forces. Unfortunately, states in the Northeast region of the country lack systematic data collection at the municipality level for these variables over time, precluding their use in our analysis.

Other variables

Our analysis also incorporates additional municipality-level data from the population census (IBGE) and mortality records (DATASUS). Specifically, we use control variables such as GDP per capita and the share of agriculture in GDP, both sourced from IBGE. Furthermore, we include mortality rates from suicide and transit accidents per 100,000 inhabitants, obtained from DATASUS. These variables help account for differences in urbanization and development across municipalities, allowing us to control for other potential influences on local crime rates.[10]

3.2 Empirical Strategy

We employ a difference-in-difference (DiD) research design, capitalizing on the natural variability in donkey density per capita and the timing of policy shifts. Our identification strategy hinges on the unique timing of the intervention, enabling us to discern divergent responses across regions to the regulation of the activity. Building upon the institutional context described in Section 2, we use the regulation changes outlined in March 2017 as the treatment time. Notably, all treated units experience policy changes simultaneously, mitigating potential drawbacks associated with conventional DiD estimators, as elucidated in recent literature (De Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2021; Roth et al., 2023).

We begin estimating the following difference-in-difference model:

$$\text{Homicides}_{i,t} = \alpha + \beta\left(\text{Slaughter}_t \times \text{Donkeys}_i\right) + \theta_i + \mu_{s,t} + \gamma_t X_i + \varepsilon_{i,t} \tag{1}$$

[10] Table A.1 describes the summary statistics for the relevant variables used in our analysis.

where $\text{Homicides}_{i,t}$ indicates the homicide rate per 100,000 inhabitants for municipality i in quarter t, Slaughter_t is a dummy variable equal to 1 for the quarters after March 2017 – when the slaughtering activity was made legal and started –, Donkeys_i is our exposure variable indicating the relevance of donkeys in terms of number of animals per 1,000 inhabitants in municipality i. Additionally, θ_i is a municipality fixed effect and $\mu_{s,t}$ represents state-quarter specific dummies. We include the state-quarter fixed effects on the estimation to deal with simultaneous changes beyond the regulation of the donkey market that could confound our estimates. Notably, the market's regulation may induce economic repercussions that indirectly influence violence incidences, such as enhanced income opportunities or altered agricultural patterns. By including these terms, we control for systematic variations across states arising from policy or socioeconomic shifts. In some specifications we also control for time-varying covariates (X_i), interacting their values in the baseline with quarter dummies.[11] Finally, $\varepsilon_{i,t}$ is the idiosyncratic error term.

Moreover, we adopt the equivalent event study specification to evaluate whether treatment and control municipalities demonstrated similar trends in homicides before the legislative change. The event study specification is described by Equation (2):

$$\text{Homicides}_{i,t} = \sum_{t \neq 2017\text{Q1}} \beta_t \left(\text{Slaughter}_t \times \text{Donkeys}_i\right) + \theta_i + \mu_{s,t} + \gamma_t X_i + \varepsilon_{i,t} \qquad (2)$$

This equation presents a more adaptable version of the baseline model, facilitating an empirical assessment of the parallel trends assumption. The crucial distinction lies in the incorporation of a series of parameters, β_t, each corresponding to a specific quarter in our panel – except from the baseline, for which we use the first quarter of 2017. Assuming parallel trends, we expect the coefficients β_t for all periods before our treatment to demonstrate no significant deviation from zero.

Finally, all regressions are weighted by population. This ensures that municipalities with larger populations contribute proportionally to the estimation process, preventing biases and heteroskedasticity stemming from population size differentials in the crime rates (Solon et al., 2015). Also, to mitigate the potential underestimation of standard errors due to serial and spatial correlation in the residuals, we adopt a clustering approach for standard errors at the micro-region level – economically integrated groups of municipalities with similar geographic and productive characteristics, as defined by IBGE and widely used

[11] We use GDP per capita, the share of agriculture in GDP, traffic accidents and suicides per 100,000 inhabitants to control for different trends in municipalities with different levels of urbanization and development.

in the literature.[12] By doing so, we accommodate for arbitrary correlation structures over time and allow for unobserved shocks to be correlated in space.[13]

4 Effects of Donkey Market Regulation

4.1 Main results

Our main findings, shown in Table 1, focus on municipalities in the Northeast region. These municipalities were selected for several reasons. First, they hold 90% of Brazil's donkey population.[14] Second, this region is the primary hub for donkey slaughter and export to China, matching the locations of newly established slaughterhouses. Third, anecdotal evidence highlights a well-developed ecosystem around the donkey hide market in the region, from capturing free-roaming animals to their sale to slaughterhouses for export – even in the illegal period. Each column in Table 1 presents estimated coefficients based on Equation (1), using quarterly data described in Section 3.[15]

Column (1) uses a standard two-way fixed effects model, controlling for both quarter and municipality fixed effects. Column (2), our primary specification, includes municipality fixed effects alongside state-quarter fixed effects, accounting for systematic changes in crime activity driven by state-level policies or socioeconomic shifts. Column (3) extends the model by incorporating baseline municipal characteristics related to income, economic development, and urbanization, such as suicide and transit accident mortality rates per 100,000 inhabitants (measured in 2012), the share of agriculture in municipal GDP, and the natural logarithm of per capita GDP (both measured in 2010). These variables, interacted with quarter-fixed effects, capture municipality-specific socioeconomic patterns, and their inclusion yields negligible changes to our estimates.

Overall, the results in Table 1 demonstrate a statistically significant and positive causal

[12] Donkeys, particularly wild or feral ones, have relatively short home ranges, averaging about 32 square kilometers (Klingel, 1998; Rudman, 1998). This range indicates that clustering at the micro-region level is well-suited to capture potential spatial spillovers.

[13] We assess the statistical robustness of our results by using alternative spatial clustering methods in the Online Appendix. The findings remain consistent with the main results.

[14] This concentration is visually evident in Figure 1 and further detailed in Figure A.3, which shows the donkey population share across Brazil's regions.

[15] We also provide robustness checks using yearly data in the Online Appendix, where the results remain quantitatively and qualitatively consistent.

Table 1: Market regulation and crime rate

Dep. var: Homicides$_{i,t}$	OLS/DiD (1)	OLS/DiD (2)	OLS/DiD (3)
Slaughter × Donkeys	0.0729***	0.0743***	0.0277**
	(0.0208)	(0.0205)	(0.0124)
Observations	63,604	63,604	63,604
Adj. R^2	0.44852	0.48511	0.4743
Quarter fixed effects	✓		
Municipality fixed effects	✓	✓	✓
State-Quarter fixed effects		✓	✓
Baseline charac. × Quarter fixed effects			✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

impact of the institutionalization of the donkey market on local crime rates, as measured by homicide rates, in municipalities with higher donkey population densities. To quantify the economic significance, column (2) of Table 1, our preferred specification, shows that a one-standard-deviation increase in donkeys per thousand inhabitants leads to an increase of approximately 1.31 homicides per 100,000 inhabitants $[= (17.691) \times (0.0743)]$ in Northeast municipalities. Given the region's average quarterly homicide rate of about 9.95 per 100,000 inhabitants, this increase represents a rise of roughly 13% above the average rate. Additionally, moving a municipality from the 25th to the 75th percentile of donkey density corresponds to an increase of about 1.04 homicides per 100,000 inhabitants $[= (16 - 2) \times (0.0743)]$.

To establish the causal effects of the donkey market on crime rates, it is fundamental to test the validity of the parallel trends assumption. This assumption requires that municipalities with different donkey population density exhibit similar trends in homicide rates prior to the policy change. To examine this, we employ the event-study specification outlined in Equation (2), focusing on the interaction of the treatment indicator with the

respective quarter dummies.[16] Figure 4 illustrates the outcomes, along with 95% confidence intervals. Notably, the pre-treatment coefficients are shown not to be significant, both individually and collectively, at conventional significance levels. These results support the validity of the parallel trends assumption and strength the robustness of our research design. Moreover, note that the addition of state-specific time trends are sufficient to establish conditional parallel trends prior the policy intervention, which justifies the choice of our preferred specification. Even so, we report the results with the inclusion of baseline controls, which does not change our main findings.

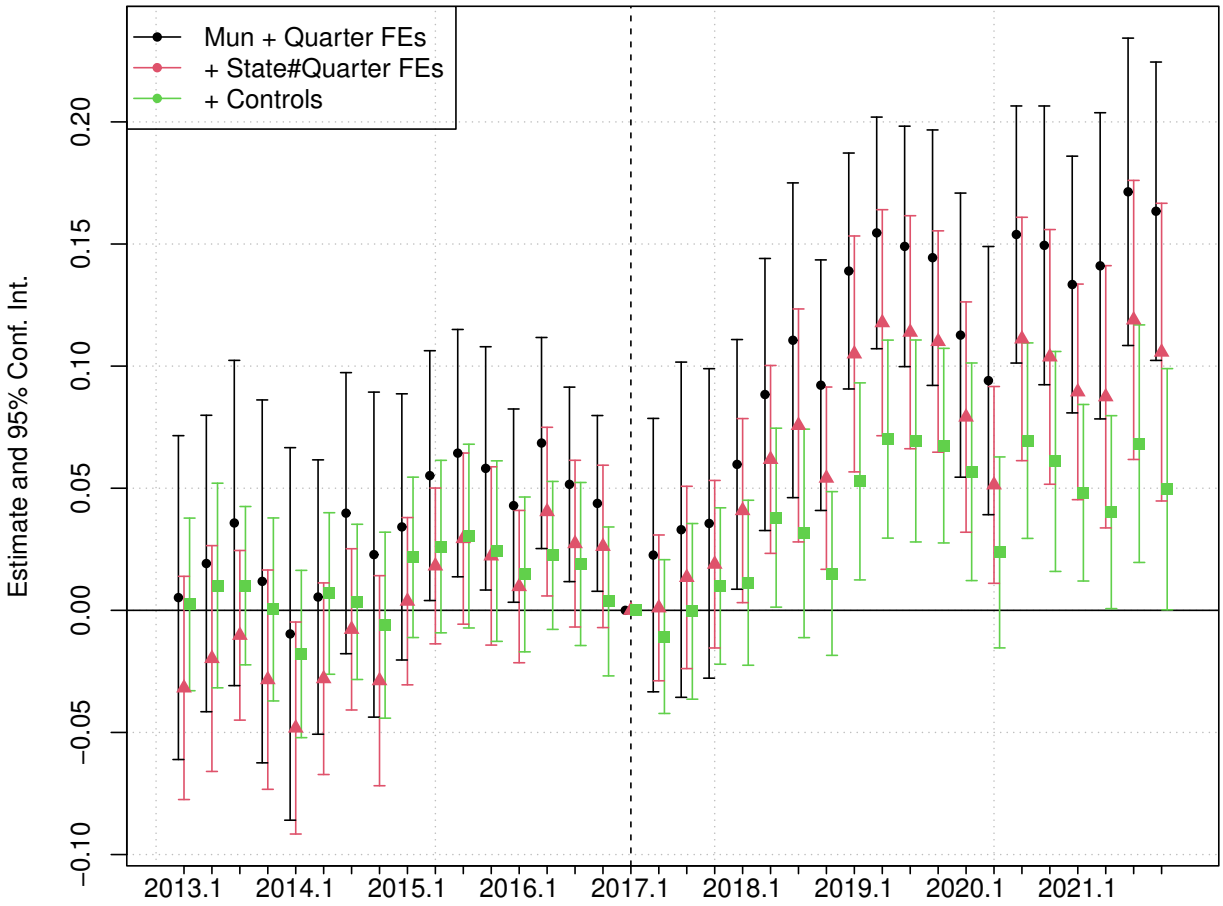
This flexible specification allows us to track the evolution of treatment effects over time. As shown in Figure 4, post-treatment coefficients become statistically significant about four quarters after the policy change. Notably, the impact on homicide rates intensifies following the temporary ban on donkey-related activities at the end of 2018. It is important to note that the dip in point estimates during the first two quarters of 2020 likely reflects reduced activity due to COVID-19 lockdowns.

Juxtaposing these findings with Figures 2 and 3, we observe a substantial surge in homicide rates during the prohibition period in 2019. We interpret this phenomenon in light of a concurrent increase in the illegal slaughter of other equids in Bahia and the rise in exports (both value and weight) of donkey-hide-related products during this period, suggesting that the market persisted through illicit channels.[17] This persistence likely exacerbated adverse effects on crime dynamics, particularly in areas with a higher pre-treatment prevalence of donkeys. This logic suggests that if illegal market operations drive up average prices per donkey – due to a reduced supply, given the increased risk of capturing these animals and transporting them to illicit slaughterhouses, combined with relatively inelastic demand – the activity becomes more financially attractive to factions competing for control over these animals. This heightened incentive may have outweighed the expected costs of getting caught, likely increasing participation in this market – characterized by poorly defined property rights – and further intensifying criminal activities and associated negative externalities. We explore this channel in detail in Section 7.

[16] We conduct a similar analysis using yearly data in the Online Appendix, yielding consistent results.

[17] This interpretation is supported by anecdotal evidence of the activity's continuation, now conducted illegally, in the Northeast region following the federal government's ban. See, for example, journalistic reports by BBC-Brasil (2021), G1 - Globo (2022), and UOL (2023).

Figure 4: Dynamic impacts: market regulation and crime rates



Notes: Each point reflects an individual regression coefficient, at quarter frequency, $\hat{\beta}_t$ following Equation (2). Standard errors are adjusted to micro-region clusters. Solid lines show 95 percent confidence intervals.

4.2 Robustness

We conduct several exercises to asses the robustness of our main findings. First, we evaluate the robustness of our results across different samples of municipalities and regional units of analysis. While our primary analysis focuses on municipalities in the Northeast region, it is important to verify whether the results hold across alternative samples. Columns (1) to (3) of Table 2 present these outcomes. In column (1), we analyze municipalities within the Northeast region that reported a positive number of donkeys in 2017. Column

(2) narrows the focus to municipalities in Bahia state, where donkey slaughterhouses are concentrated. In column (3), we aggregate municipalities into micro-regions and use this aggregation as the unit of analysis in the regression.[18] Across all subsamples, the results consistently demonstrate that regulatory interventions in the donkey market have statistically significant and positive effects on homicide rates in localities with a higher density of donkeys per inhabitant.

Next, we explore whether the base year of our donkey population density measure, a key component of the treatment variable, influences our results. One concern is that municipalities with high donkey counts in the agricultural census might not coincide with those having large numbers of free-roaming donkeys. For instance, municipalities that underwent mechanization in the early 2000s could report fewer donkeys in 2017 despite a significant free-roaming population. To account for this, we construct the donkey density measure using an earlier wave of census data. Additionally, we may be capturing different dynamics in poor rural areas not controlled by the initial characteristics included in Table 1. To address this, we conduct a placebo test using the number of caprine stock (goats) per 1,000 inhabitants. We use goat population density as a placebo because, like donkeys, they are historically significant livestock in the region and a valuable asset in climate-vulnerable areas of Brazil (Da Mata & Resende, 2020), but their market was not affected by mechanization or exports to China.

Columns (4) and (5) of Table 2 summarize the results from estimating Equation (1) using an alternative year for constructing the donkey population density variable and conducting the placebo test with the goat population density as the treatment variable, respectively. Specifically, we use the 1995 Agricultural Census for donkeys and the 2017 census for goats.[19] Our findings show that using alternative treatment measures does not alter the main results. Furthermore, the placebo test yields a small, statistically insignificant coefficient, reinforcing our claim that changes in crime dynamics are due to the donkey market.[20]

Taken together, the consistency of results across different samples and the insignificance of the placebo test bolster our conclusions about the causal impact of the donkey market

[18]We assess the robustness of these micro-region-level results using alternative spatial clusters for the standard errors in the Online Appendix.

[19]Since the goat market was unaffected by mechanization or exports to China, and goats are valuable livestock with no free-roaming populations, endogeneity concerns are minimal when using 2017 data.

[20]We also conduct several sensitivity analyses in the Online Appendix, demonstrating the robustness of our main findings to the exclusion of observations from the sample.

Table 2: Robustness to alternative samples and treatments

Dep. var: Homicides$_{i,t}$	Alternative sample			Alternative treatment	
	Some donkey	BA only	Micro-region	Donkey rate 1995	Placebo
	(1)	(2)	(3)	(4)	(5)
Slaughter × Donkeys	0.0474**	0.0711*	0.1346***		
	(0.0190)	(0.0414)	(0.0383)		
Slaughter × Donkeys in 1995				0.0203***	
				(0.0063)	
Slaughter × Goats					0.0004
					(0.0003)
Observations	58,889	14,974	6,752	63,604	63,604
Adj. R^2	0.4572	0.4839	0.7667	0.4846	0.4828
Municipality fixed effects	✓	✓		✓	✓
Micro-region fixed effects			✓		
State-Quarter fixed effects	✓	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality in columns (1),(2),(3), and (5), and a micro-region in column (4). All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

on crime rates.

5 Falsification

In the previous section, we presented empirical evidence that the legalization of the donkey market in Brazil—marked by large free-roaming populations and ill-defined property rights—led to a significant increase in crime rates in areas with greater exposure to donkeys before the legislation. The underlying rationale is that the nature of the activity fosters conflict resolution through violence.

To further assess the validity of our findings, beyond the robustness and placebo tests, we conduct a falsification test. The logic is straightforward: if an omitted variable is driving the observed increase in homicide rates, we would expect the market legalization to also impact other causes of mortality, such as those related to local economic conditions or

cycles. For this falsification test, we examine the effects of market legalization on mortality rates from undetermined causes, from causes typically associated with income shocks (e.g., cardiovascular and liver diseases, as well as neoplasms), and on child mortality (under 14), which should remain largely unaffected by crime-related factors, given their lack of participation in the market.

The results are presented in Table 3. Notably, none of the coefficients associated with market legalization are statistically significant at conventional levels. Besides, even in the case of mortality rates for children from 0-6 years old where the coefficient is significant at the 10% significance level, the magnitude of the effect is *de minimis*. This indicates that the effect of market legalization on other causes of mortality is negligible, providing no evidence of a broader impact across unrelated mortality rates.[21]

Table 3: Falsification: effects of market regulation on specific mortality causes

Dep. var.: Mortality causes	Undetermined	Cardiovascular	Neoplasm	Liver	0-14 years	0-6 years	7-14 years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Slaughter × Donkeys	-0.0014	-0.0021	-0.0001	-0.0014	0.0099*	0.0093*	0.0006
	(0.0097)	(0.0124)	(0.0030)	(0.0097)	(0.0058)	(0.0050)	(0.0014)
Observations	63,604	63,604	63,604	63,604	63,604	63,604	63,604
Adj. R^2	0.4367	0.8695	0.2888	0.4367	0.8326	0.8456	0.1643
Municipality fixed effects	✓	✓	✓	✓	✓	✓	✓
State-Quarter fixed effects	✓	✓	✓	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered at the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

These findings suggest that there are no relevant omitted factors in our previous estimates that broadly impact mortality rates unrelated to criminal activity during the period. The specific mortality rates, theoretically independent of criminality or primarily driven by income variations, remain unaffected by the donkey market legalization. Alongside the robustness and placebo tests, this falsification test bolsters the robustness of our empirical approach and further validates the credibility of our identification strategy.

[21] In the Online Appendix, we present additional evidence for this falsification exercise from event study specifications demonstrating the negligible effects of donkey market regulation on these specific causes of mortality.

6 Mechanism Validation

Next, we evaluate the validity of our proposed mechanism underlying the effect of donkey market regularization on crime rates – that the characteristics of the market lead to increased violence as disputes over a now valuable resource with ill-defined property rights are resolved through violent means.

6.1 Distance to slaughterhouses

First, if our hypothesis holds we expect the crime effects following the legislative change to be more pronounced in regions closer to slaughterhouses. The reasoning is straightforward: given the presence of free-roaming donkeys, the cost of capturing and transporting the animals is lower near slaughterhouses. Furthermore, if information networks play a role in such markets, players closer to the slaughterhouses are better informed on prices and the donkey demand. Consequently, the economic incentive to participate in this activity should be greater in these areas compared to more distant municipalities, where transportation costs are higher and there is less information.

We assess this mechanism in Table 4. Column (1) shows the baseline result from our preferred specification, while columns (2) to (4) focus on municipalities within 250 kilometers, 500 kilometers, and 1000 kilometers of the nearest slaughterhouse—either Amargosa or Itapetinga, both in Bahia, where donkey slaughter and export activities are concentrated. The results in Table 4 corroborate our hypothesis, indicating that proximity to slaughterhouses significantly amplifies the impact of donkey market regulation on homicide rates. Specifically, municipalities within 250 km of a slaughterhouse experience a nearly double increase in homicide rates compared to the baseline. Importantly, the effect diminishes steadily and monotonically as the distance from the slaughterhouse increases.

6.2 Prohibition and enforcement

Second, we examine the temporal overlap between the 2019 ban on the donkey market, the evidence of continued illegal activity, and the observed increase in homicide rates in the most affected municipalities. If our suggested mechanism is correct, we expect the policy change to have intensified crime rates during the ban, likely due to rising donkey prices and the increased economic benefits of participating in the exploitation of resources

Table 4: Effects of market regulation on crime rate per distance to slaughterhouse

	Distance to closest slaughterhouse			
Dep. var: Homicides$_{i,t}$	Baseline	250km	500km	1000km
	(1)	(2)	(3)	(4)
Slaughter × Donkeys	0.0743***	0.1450***	0.0870***	0.0553***
	(0.0205)	(0.0421)	(0.0326)	(0.0166)
Observations	63,604	9,889	18,824	53,924
Adj. R^2	0.4674	0.4210	0.4491	0.4268
Municipality fixed effects	✓	✓	✓	✓
State-Quarter fixed effects	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

with ill-defined property rights. However, the illegal nature of the activity may have also raised the cost of participation, especially with efficient enforcement.

To explore this, we estimate a modified version of Equation (1), which includes an additional treatment variable indicating the quarters when the activity was illegal. Specifically, we estimate the following triple-differences model:

$$\begin{aligned} \text{Homicides}_{i,t} = \alpha &+ \beta \left(\text{Slaughter}_t \times \text{Donkeys}_i\right) \\ &+ \delta \left(\text{Illegal}_t \times \text{Slaughter}_t \times \text{Donkeys}_i\right) \\ &+ \theta_i + \mu_{s,t} + \gamma_t X_i + \varepsilon_{i,t} \end{aligned} \tag{3}$$

where Illegal_t equals 1 between the fourth quarter of 2018 and the third quarter of 2019.

The results are summarized in Table 5. Across all specifications, from the canonical two-way fixed effects model in column (1) to the inclusion of state-quarter fixed effects and baseline characteristics in column (3), the impact of the legislative change on crime rates in more exposed municipalities intensifies during the ban. The larger coefficients during this period supports our hypothesis that the rise in crime is driven by increased economic benefits from capturing and selling donkeys to slaughterhouses, compounded by limited enforcement capabilities from local governments.

Table 5: Illegality and homicide rate

Dep. var: Homicides$_{i,t}$	OLS/DiD (1)	OLS/DiD (2)	OLS/DiD (3)
Slaughter × Donkeys	0.0664***	0.0681***	0.0243**
	(0.0201)	(0.0197)	(0.0121)
Illegal × Slaughter × Donkeys	0.0328***	0.0309***	0.0166**
	(0.0120)	(0.0092)	(0.0075)
Observations	63,604	63,604	63,604
Adj. R^2	0.4324	0.4675	0.4746
Municipality fixed effects	✓	✓	✓
State-Quarter fixed effects		✓	✓
Baseline charac. × Quarter fixed effects			✓

Notes: Standard errors (in parentheses) are clustered at the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

These findings have significant implications for policymakers regulating markets tied to natural resource exploitation. Like Chimeli and Soares (2017) and Araujo et al. (2024), we find that prohibiting an exploratory activity, without sufficient monitoring or effective enforcement, leads to unintended consequences. These include the persistence of the activity even during its illegality, amplifying negative externalities, especially increased criminality and violence in the most exposed municipalities of the Northeast region.

6.3 Characterizing the victims

Lastly, if our story is correct, we expect that individuals more likely to participate in the market are disproportionately impacted by the violence associated with it. Given that we are examining a resource-based market with violent resolution of ill-defined property rights, young males – who are more prone to engage in risky economic activities like capturing and transporting donkeys to slaughterhouses – are particularly vulnerable. This effect should manifest as a relative increase in homicide rates among specific groups. Table 6 provides further evidence supporting this narrative. To better understand the rise in

violence, we break down the dependent variable by characteristics typically associated with criminal violence, rather than domestic or interpersonal conflicts.

First, we restrict the analysis to homicides involving firearms versus non-firearm-related causes, as firearm violence is more indicative of criminal activity. Next, we examine homicides by gender, separating male and female victims. Finally, we focus on male homicides, specifically comparing young males (ages 20 to 40) with other age groups.

Table 6: Effects of market regulation on specific homicide rates

Dep. var: Specific Homicides$_{i,t}$	Baseline	Gun-related	Not Gun-related	Male	Female	Young Male	Not Young Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Slaughter × Donkeys	0.0743***	0.0717***	0.0025*	0.0713***	0.0030**	0.0416***	0.0326***
	(0.0205)	(0.0201)	(0.0014)	(0.0196)	(0.0014)	(0.0125)	(0.0083)
Observations	63,604	63,604	63,604	63,604	63,604	63,604	63,604
Adj. R^2	0.4674	0.4564	0.1298	0.4626	0.0664	0.3939	0.2968
Municipality fixed effects	✓	✓	✓	✓	✓	✓	✓
State-Quarter fixed effects	✓	✓	✓	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered at the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6 indicates that the increase in violence in donkey-dense areas after the market institutionalization is predominantly driven by firearm violence against prime-aged men. The point estimates in columns (2) and (3) show that firearm violence, compared to non-firearm causes, is the main driver of the homicide increase, underscoring the criminal nature of the violence. Comparing columns (4) and (5), we observe that this rise in homicide rates is almost entirely driven by male victims. When breaking down male homicides by age, columns (6) and (7) reveal that the increase is concentrated among men aged 20 to 40, though there is also a significant rise in homicide rates for men above this age threshold. These results suggest that the observed increase in violence in municipalities more exposed to the donkey market is more likely driven by criminal violence rather than domestic or family-related disputes.

In summary, the evidence across these channels – proximity to slaughterhouses, the effects of prohibition and enforcement, and the characterization of victims – collectively supports the validity of our proposed mechanism. Taken together, these findings reinforce the conclusion that the market's characteristics are directly linked to the rise in criminal violence, measured by homicides, in the more affected municipalities.

7 Concluding Remarks

The exploitation of resources through international trade is a long-standing issue in development economics. This paper investigates how the regulation of a new renewable-resource market – characterized by open access and poorly defined property rights – affects local violence. Focusing on the regulatory changes that established Brazil's donkey hide trade, we find that the market led to increased crime and violence in resource-rich regions. Importantly, our results show that both the foreign demand boom itself and the illegal activity in this market play important roles in explaining these results.

Our findings have important policy implications. First, they highlight the relationship between violence and property rights within a market. When property rights are poorly defined – such as with free-roaming donkeys in Brazil – the institutionalization of such markets can lead to unintended social consequences and welfare losses. Second, prohibition policies without proper enforcement capabilities may amplify such negative effects. We document that making the donkey market illegal doubles its effect on local crime rates and violence. Finally, our results point out to the global repercussions of resource exploitation. The widespread negative effects of the donkey hide trade across the world underscore the need of global regulation in markets where there is predatory exploitation of natural resources. In the case of the donkey hide market, the inefficiency of national-level bans is evident, and broader efforts, such as the recent African Union's continent-wide ban on donkey skin trade, represent a more coordinated and potentially positive approach. Nonetheless, our results suggest that global-level coordination may still be necessary in such cases, particularly given the extent of the social costs involved.

By way of conclusion, while this study offers valuable insights into the causal links between the donkey hide market and crime in Brazil, much remains to be explored regarding the broader implications of this trade in other developing regions. These findings resonate with a long-standing literature on trade and resource depletion, highlighting that issues from past centuries – such as the exploitation and eventual depletion of resources like the North American buffalo (Feir et al., 2024; Taylor, 2011) – persist today and continue to emerge across the developing world, with significant welfare implications.

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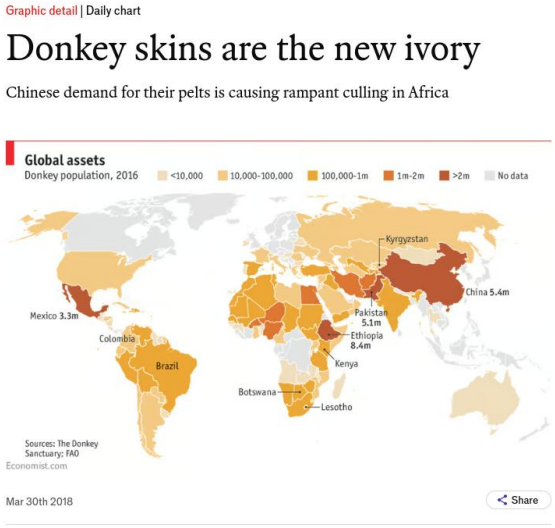
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Appendix

Figure A.1: Institutional background



(a) The Economist (2018)



(b) *Ejiao* products. Source: The Donkey Sanctuary.

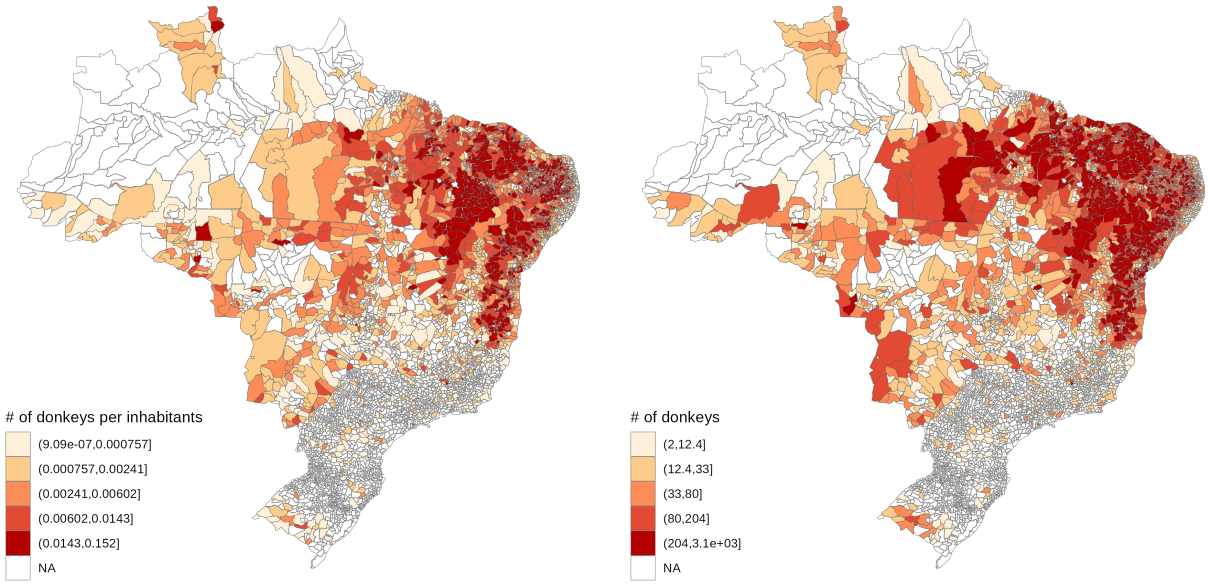


(c) Free-roaming donkeys in Northeast of Brazil. Source: G1.



(d) Chinese slaughterhouse in Amargosa - BA. Source: G1.

Figure A.2: Spatial distribution of donkeys in Brazilian municipalities (2017)



(a) Number of donkeys per capita

(b) Number of donkeys

Source: Data on donkey population is from the Agricultural Census.

Figure A.3: Distribution of donkeys per region in Brazil (2017)

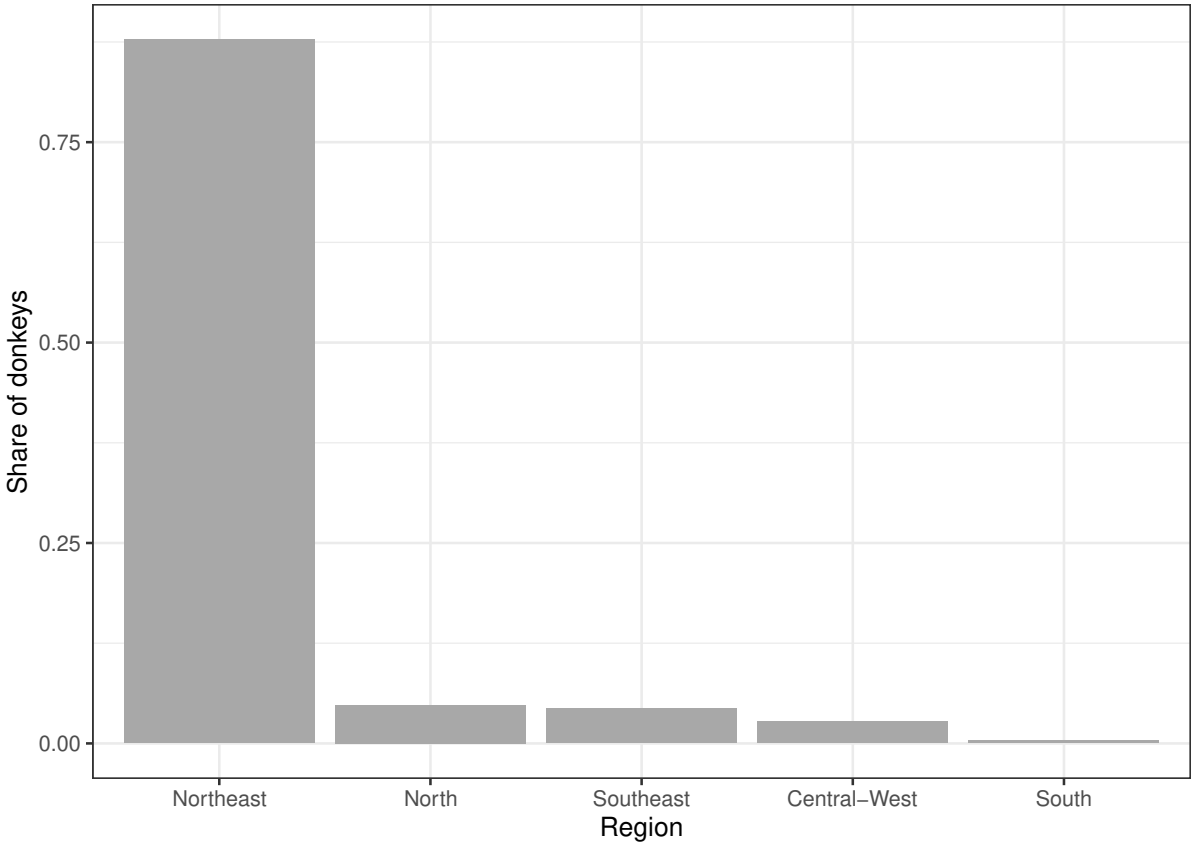


Table A.1: Descriptive statistics – quarterly data

Variables	*Source*	*Mean*	*Standard Deviation*	*Min*	*Max*	*Observations*
Homicide Rate	DATASUS	6.45	9.29	0.00	215.98	63,604
Donkey Rate	IBGE	12.59	17.69	0.00	152.49	63,604
Population	IBGE	32104.47	119368.73	1228.00	2953986.00	63,604
GDP per Capita (2010)	IBGE	6038.38	8816.70	2404.20	296884.69	63,604
Agr. Share in GDP (2010)	IBGE	0.15	0.12	0.00	0.67	63,604
Goat Rate	IBGE	314.12	774.11	0.00	8674.18	63,604
Traffic Mortality Rate (2012)	DATASUS	29.21	22.03	0.00	160.32	63,604
Suicide Mortality Rate (2012)	DATASUS	4.82	7.90	0.00	77.97	63,604

Online Appendix

.1 Yearly outcomes

In this section we present the same sequence of results from Tables 1, 2, and 4 using yearly data in our estimations. The results are notably similar to those presented in Section 3.

Table OA.1: Descriptive statistics – yearly data

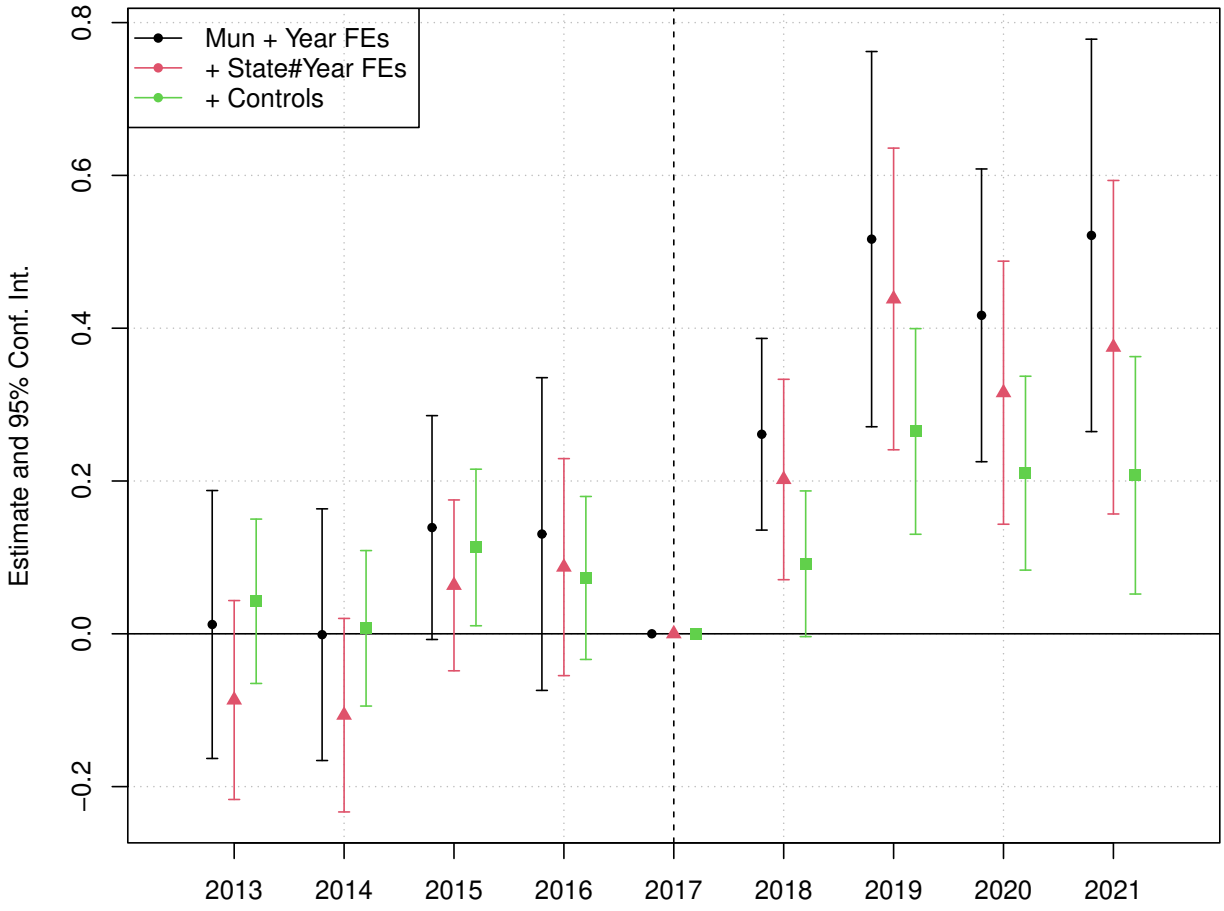
Variables	*Sources*	*Mean*	*Standard Deviation*	*Min*	*Max*	*Observations*
Homicide Rate	DATASUS	25.43	25.87	0.00	304.35	16,146
Donkey Rate	IBGE	12.73	17.90	0.00	152.49	16,146
Population	IBGE	31684.94	118511.17	1228.00	2953986.00	16,146
GDP per Capita (2010)	IBGE	6031.45	8757.80	2404.20	296884.69	16,146
Agr. Share in GDP (2010)	IBGE	0.15	0.11	0.00	0.67	16,146
Goat Rate	IBGE	320.04	784.54	0.00	8674.18	16,146
Traffic Mortality Rate (2012)	DATASUS	29.22	22.28	0.00	160.32	16,146
Suicide Mortality Rate (2012)	DATASUS	4.82	7.97	0.00	77.97	16,146

Table OA.2: Market regulation and crime rate – yearly outcome

Dep. var: Homicides$_{i,t}$	OLS/DiD (1)	OLS/DiD (2)	OLS/DiD (3)
Slaughter × Donkeys	0.2723***	0.2757***	0.0953**
	(0.0830)	(0.0800)	(0.0486)
Observations	16,146	16,146	16,146
Adj. R^2	0.6732	0.7175	0.6908
Municipality fixed effects	✓	✓	✓
State-Year fixed effects		✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure OA.1: Event study (yearly) – Northeast region municipalities



Notes: Each point reflects an individual regression coefficient, at year frequency, $\hat{\beta}_t$ following Equation (2). The regression includes municipality and state-time fixed effects. Standard errors are adjusted municipality clusters. Dashed lines show 95 percent confidence intervals.

Table OA.3: Robustness to alternative samples and treatments – yearly outcomes

	Alternative sample			Alternative treatment	
Dep. var: Homicides$_{i,t}$	Some donkey	BA only	Microregion	Donkey in 1995	Placebo
	(1)	(2)	(3)	(4)	(5)
Slaughter × Donkeys	0.1778**	0.2260	0.5088***		
	(0.0758)	(0.1579)	(0.1508)		
Slaughter × Donkeys in 1995				0.0739***	
				(0.0247)	
Slaughter × Goats					0.0014
					(0.0011)
Observations	14,931	3,753	1,692	16,146	16,146
Adj. R^2	0.6997	0.7346	0.8529	0.7168	0.7145
Municipality fixed effects	✓	✓		✓	✓
Micro-region fixed effects			✓		
State-Year fixed effects		✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality in columns (1),(2),(3), and (5), and a micro-region in column (4). All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table OA.4: Effects of market regulation on crime rate per distance to slaughterhouse – yearly outcome

	Distance to closest slaughterhouse			
Dep. var: Homicides$_{i,t}$	Baseline	250km	500km	1000km
	(1)	(2)	(3)	(4)
Slaughter × Donkeys	0.2757***	0.5357***	0.2994**	0.1981***
	(0.0800)	(0.1584)	(0.1236)	(0.0637)
Observations	16,146	2,475	4,725	13,707
Adj. R^2	0.6804	0.6576	0.6910	0.6676
Municipality fixed effects	✓	✓	✓	✓
State-Year fixed effects	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

.2 Homicides per place of residence

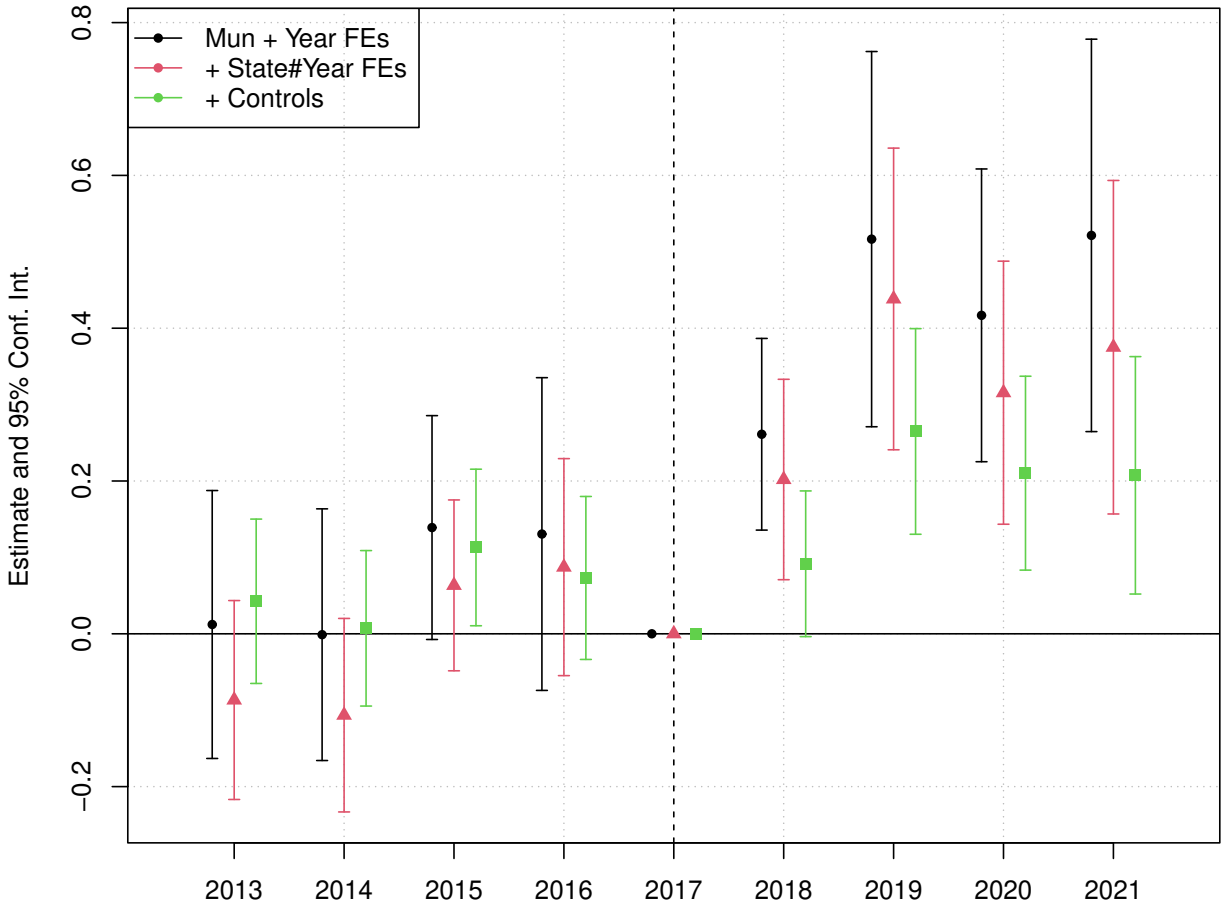
Next, we perform a similar robustness exercise using yearly data in our estimations but now considering the homicide rate per place of residence. Again, the results are quite similar to those presented in Section 3.

Table OA.5: Market regulation and crime rate – yearly outcome per place of residence

Dep. var: Homicides$_{i,t}$	OLS/DiD (1)	OLS/DiD (2)	OLS/DiD (3)
Slaughter × Donkeys	0.2628***	0.2669***	0.1108**
	(0.0777)	(0.0729)	(0.0442)
Observations	16,146	16,146	16,146
Adj. R^2	0.6391	0.6884	0.6964
Municipality fixed effects	✓	✓	✓
State-Year fixed effects		✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure OA.2: Event study (yearly) – Northeast region municipalities per place of residence



Notes: Each point reflects an individual regression coefficient, at year frequency, $\hat{\beta}_t$ following Equation (2). The regression includes municipality and state-time fixed effects. Standard errors are adjusted municipality clusters. Dashed lines show 95 percent confidence intervals.

Table OA.6: Robustness to alternative samples and treatments – yearly outcomes per place of residence

	Alternative sample			Alternative treatment	
Dep. var: Homicides$_{i,t}$	Some donkey	BA only	Microregion	Donkey in 1995	Placebo
	(1)	(2)	(3)	(4)	(5)
Slaughter × Donkeys	0.1905***	0.2189	0.4621***		
	(0.0705)	(0.1354)	(0.1397)		
Slaughter × Donkeys in 1995				0.4621***	
				(0.0230)	
Slaughter × Goats					0.0014
					(0.0010)
Observations	14,931	3,753	1,692	16,146	16,146
Adj. R^2	0.6693	0.7104	0.8484	0.6876	0.6852
Municipality fixed effects	✓	✓		✓	✓
Micro-region fixed effects			✓		
State-Year fixed effects		✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality in columns (1),(2),(3), and (5), and a micro-region in column (4). All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table OA.7: Effects of market regulation on crime rate per distance to slaughterhouse – yearly outcome per place of residence

	Distance to closest slaughterhouse			
Dep. var: Homicides$_{i,t}$	Baseline	250km	500km	1000km
	(1)	(2)	(3)	(4)
Slaughter × Donkeys	0.2669***	0.4756***	0.2792**	0.1941***
	(0.0729)	(0.1421)	(0.1082)	(0.0557)
Observations	16,146	2,475	4,725	13,707
Adj. R^2	0.6474	0.6128	0.6516	0.6373
Municipality fixed effects	✓	✓	✓	✓
State-Year fixed effects	✓	✓	✓	✓

Notes: Standard errors (in parentheses) are clustered for the micro-region level. Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

.3 Robustness to alternative clusters

In this section, we evaluate the robustness of our main results to alternative spatial clusters for the standard errors. Table OA.8 shows the comparison between our baseline estimates in column (2) and alternative spatial structures.

Table OA.8: Market regulation and crime rates – alternative clustering

	Alternative clusters			
Dep. var: Homicides$_{i,t}$	Municipality	Micro-region	Meso-region	State
	(1)	(2)	(3)	(4)
Slaughter × Donkeys	0.0743***	0.0743***	0.0743***	0.0743**
	(0.0174)	(0.0205)	(0.0207)	(0.0236)
Standard-Errors	Municipality	Micro-region	Meso-region	State
Observations	63,604	63,604	63,604	63,604
Adj. R^2	0.4851	0.4851	0.4851	0.4851
Municipality fixed effects	✓	✓	✓	✓
State-Quarter fixed effects	✓	✓	✓	✓

Notes: Unit of analysis is a municipality. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

We also perform a similar robustness exercise for the specification using micro-regions as the unit of analysis. The results are summarized in OA.9.

Table OA.9: Market regulation and crime rates – Micro-region aggregation and alternative clustering

	Alternative clusters		
Dep. var: Homicides$_{i,t}$	Micro-region	Meso-region	State
	(1)	(2)	(3)
Slaughter × Donkeys	0.1346***	0.1346***	0.1346***
	(0.0383)	(0.0401)	(0.0390)
Standard-Errors	Microregion	Mesoregion	State
Observations	6,752	6,752	6,752
Adj. R^2	0.7667	0.7667	0.7667
Municipality fixed effects	✓	✓	✓
State-Quarter fixed effects	✓	✓	✓

Notes: Unit of analysis is a micro-region. All specifications are weighted by population. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

.4 Sensitivity analysis

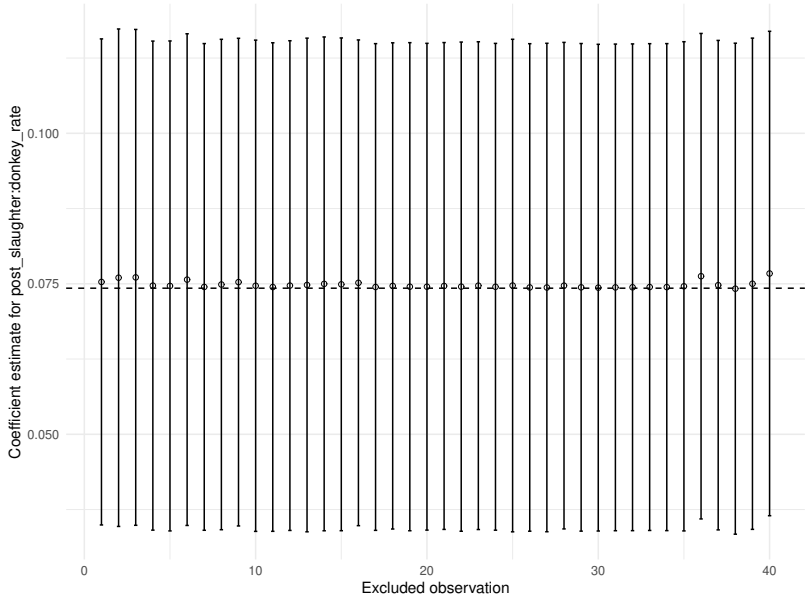
To further evaluate the robustness of our main results, presented in Table 1, we perform a simple sensitivity analysis for the coefficients associated with the impacts of the donkey market regulation on local crime rates.

First, we estimated the preferred specification by removing, in each regression, one of the top and bottom 40 municipalities, respectively, in terms of i) the donkey population density, and ii) the average homicide rate for the period of analysis.

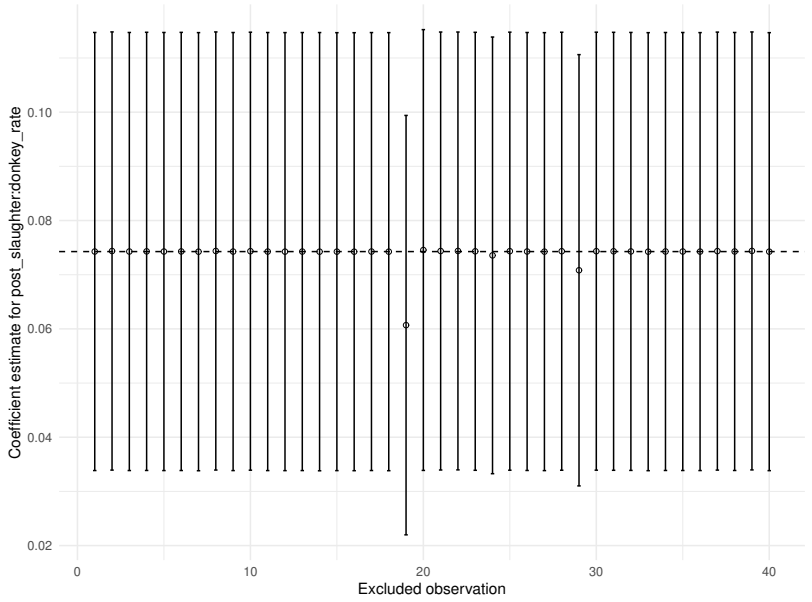
Figures OA.3 and OA.4 graphically present the results of the estimations removing the top- and bottom-ranked municipalities in terms of donkey population density and average homicide rates respectively, emphasizing the coefficient of interest and the 95% confidence interval for each one of the regressions. The dotted black line describes the coefficient obtained in our baseline regression.

Next, we perform a similar sensitivity analysis, but now we drop the top- and bottom-ranked municipalities following the same criteria one to many. That is, we sequentially drop the top- and bottom-ranked local economies from the estimation up to 40 munici-

palities. Figures OA.5 and OA.6 present, respectively, the results for excluding regions classified by donkey population density and average homicide rates. Again, we emphasize the coefficient of interest and the 95% confidence interval for each one of the regressions. The dotted black line describes the coefficient obtained in our baseline regression.



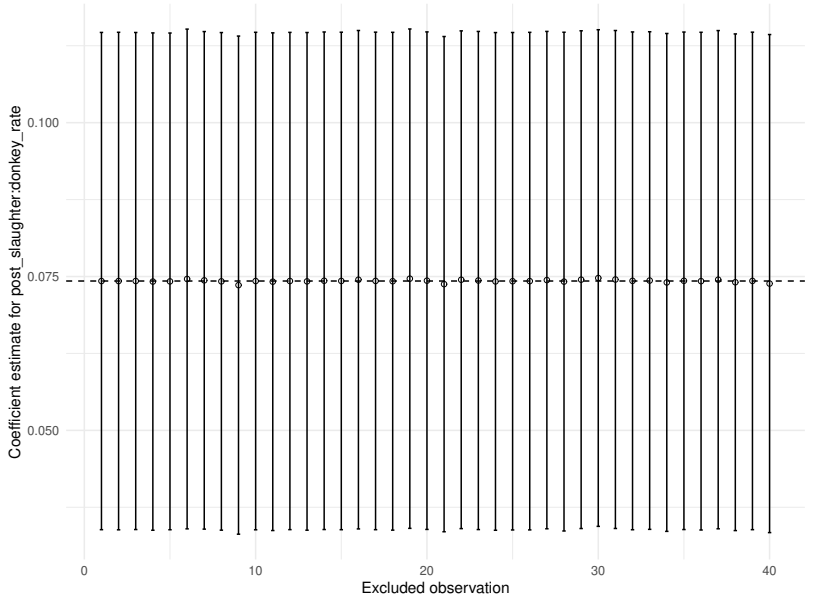
(a) Top municipalities



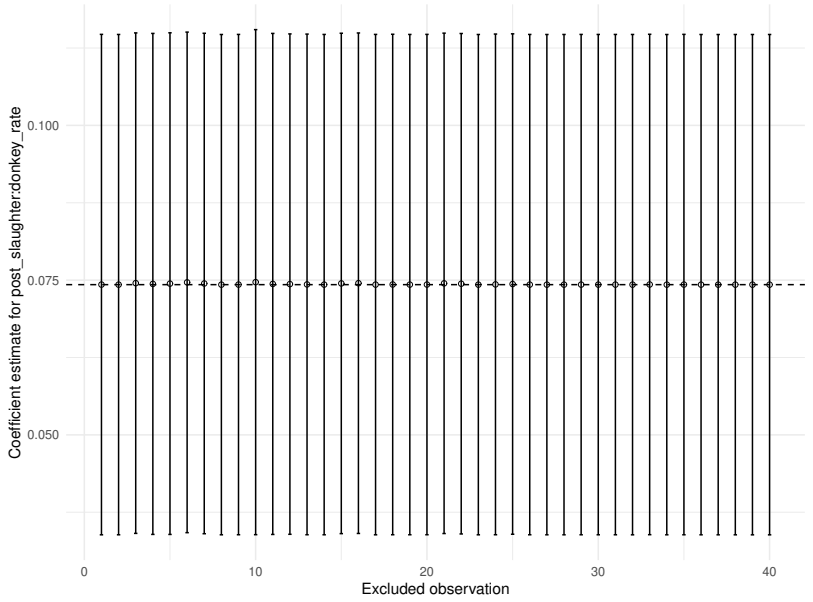
(b) Bottom municipalities

Figure OA.3: Market regulation and crime rates
(Exclusion of municipalities - Top and bottom 40 based on donkey population density)

Notes: The figure shows the robustness of the results to excluding, one by one, the top 40 municipalities with the highest and lowest donkey population density. The estimated coefficients and confidence intervals at 95 percent are reported. Each estimated coefficient and confidence interval emanate from a single estimation.



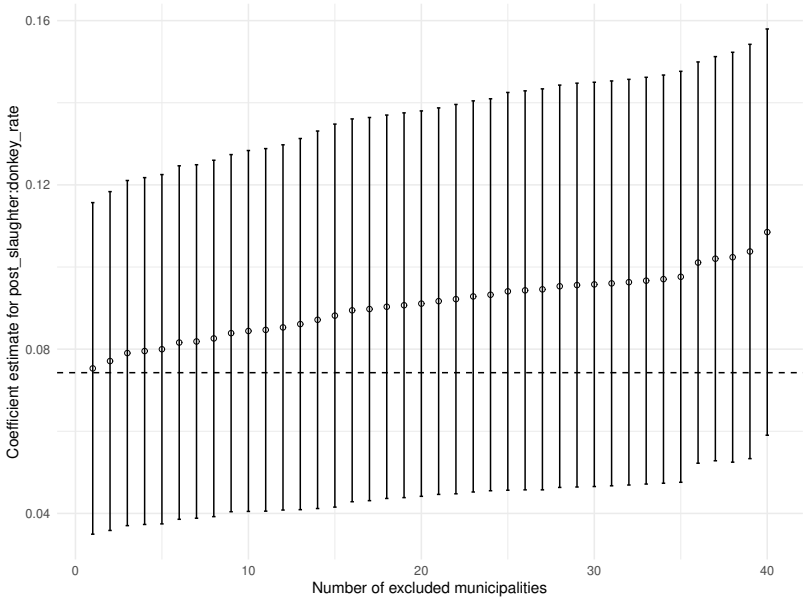
(a) Top municipalities



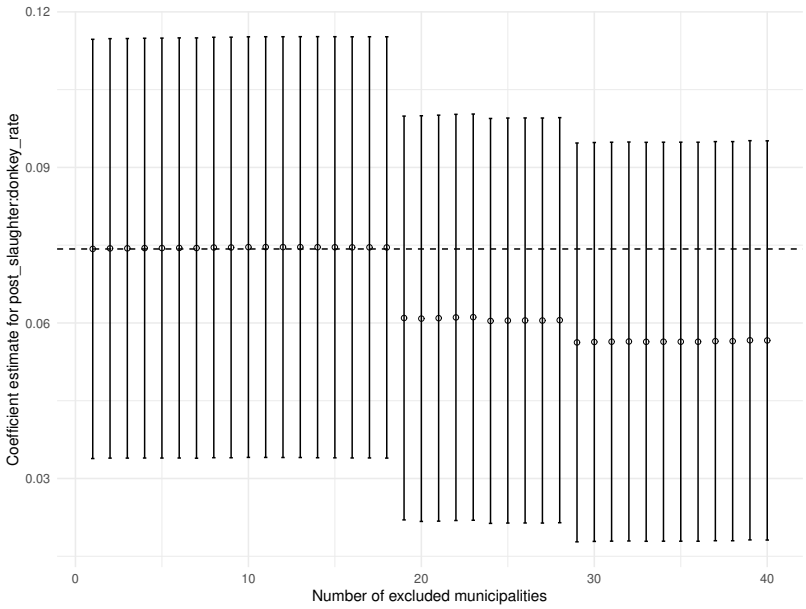
(b) Bottom municipalities

Figure OA.4: Market regulation and crime rates
(Exclusion of municipalities - Top and bottom 40 based on homicide rates)

Notes: The figure shows the robustness of the results to excluding, one by one, the top 40 municipalities with the highest and lowest average homicide rates. The estimated coefficients and confidence intervals at 95 percent are reported. Each estimated coefficient and confidence interval emanate from a single estimation.



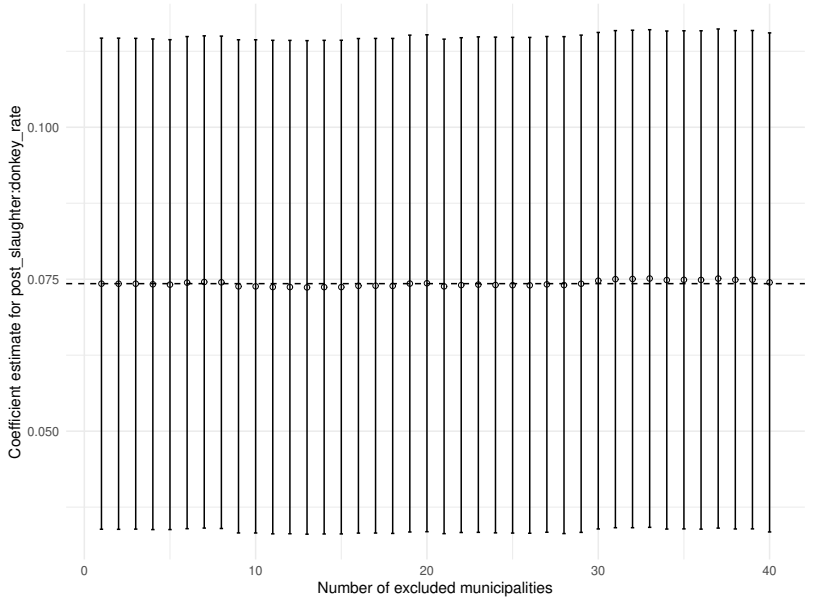
(a) Top municipalities



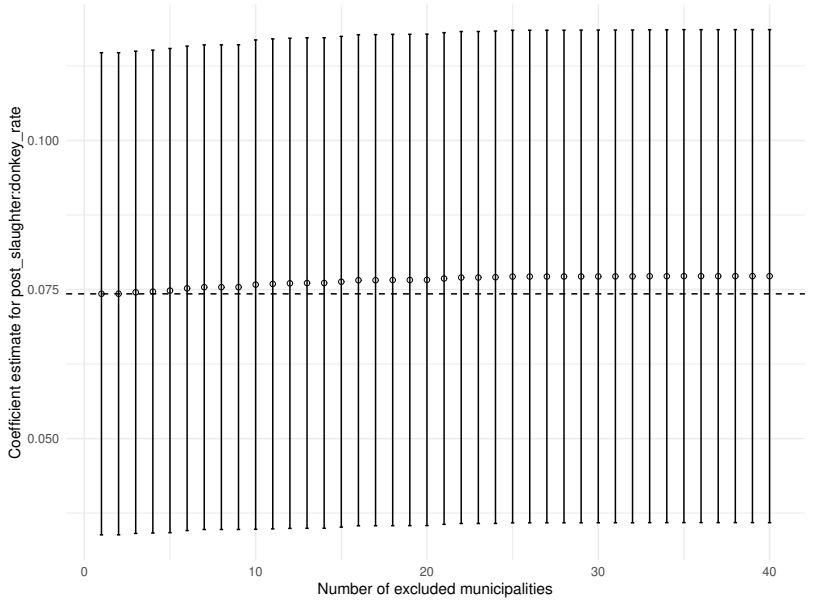
(b) Bottom municipalities

Figure OA.5: Market regulation and crime rates
(Exclusion of municipalities - First and last 40 based on donkey population density)

Notes: The figure shows the robustness of the results to excluding the top and bottom 40 municipalities in terms of donkey population density. The estimated coefficients and confidence intervals at 95 percent are reported. Each estimated coefficient and confidence interval emanate from a single estimation.



(a) Top municipalities



(b) Bottom municipalities

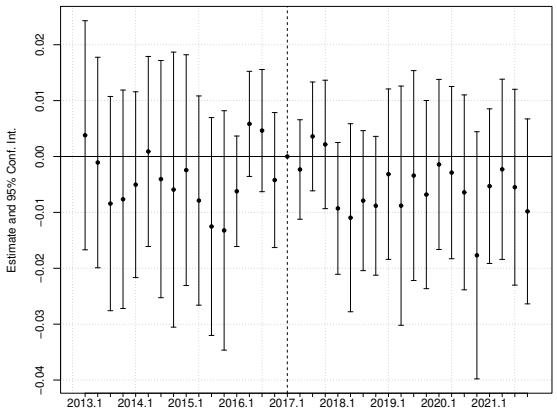
Figure OA.6: Market regulation and crime rates
(Exclusion of municipalities - First and last 40 based on homicide rate)

Notes: The figure shows the robustness of the results to excluding the top and bottom 40 municipalities in terms of average homicide rates. The estimated coefficients and confidence intervals at 95 percent are reported. Each estimated coefficient and confidence interval emanate from a single estimation.

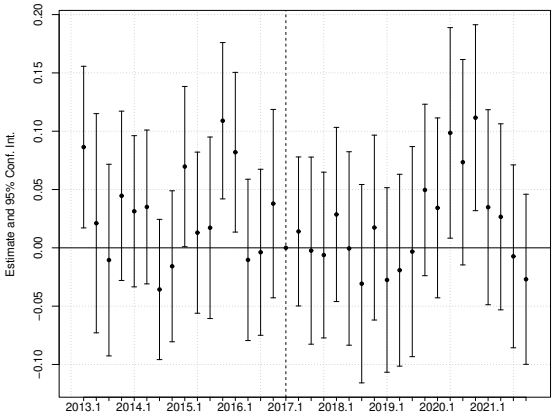
.5 Falsification exercise dynamic effects

Lastly, Figure OA.7 presents the dynamic effects of donkey market regulation on specific causes of mortality used in our falsification exercise, as examined in Table 3. Each point in the figure represents an individual regression coefficient, $\hat{\beta}_t$, estimated at the quarterly level following Equation (2), with the respective cause of mortality as the dependent variable. Standard errors are clustered at the micro-region level, and the solid lines depict the 95 percent confidence intervals.

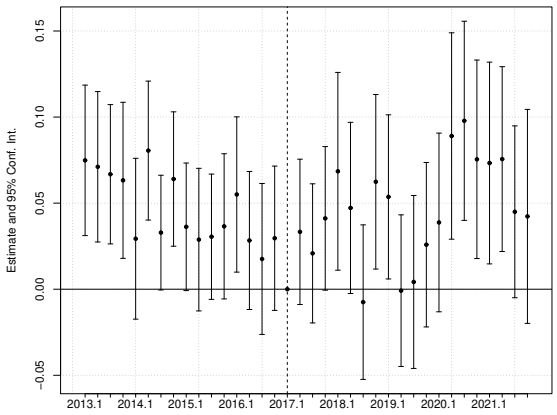
Figure OA.7: Dynamic effects for falsification



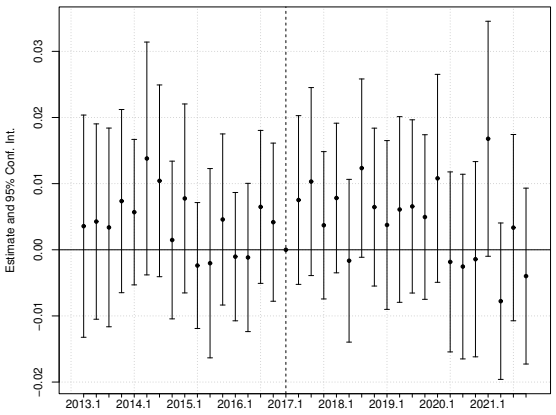
(a) Undetermined



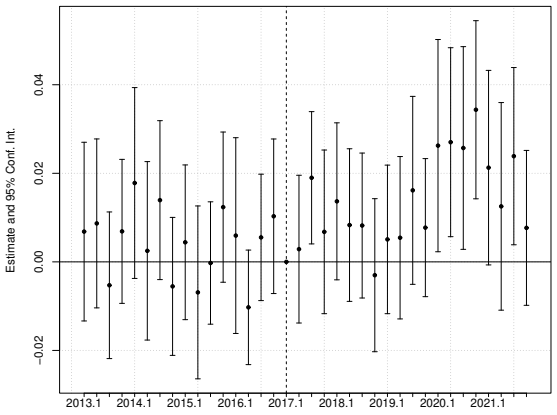
(b) Cardiovascular



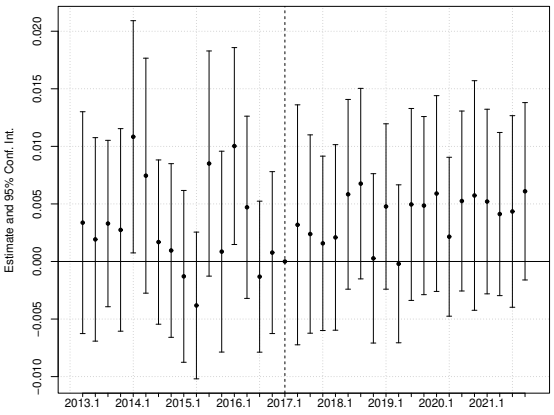
(c) Neoplasm



(d) Liver



(e) 0-6 years



(f) 7-14 years