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DETERMINANTS OF SMUGGLING AND TAX EVASION IN MUNICIPALITIES OF PARANÁ, BRAZIL: 2017–2022

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ABSTRACT

This article aimed at analyzing the determining factors of smuggling and contraband in the municipalities of Paraná-Brazil in the period of 2017 to 2022. To achieve this purpose, two spatial econometric estimations were conducted using the spatial Tobit model. The first estimation covered the years 2017, 2018, and 2019, while the second one encompassed the years 2020, 2021, and 2022, with focus on identifying possible changes in the determinants of smuggling and contraband resulting from the Covid-19 pandemic. The proximity to BR-277, geographical location near the borders of Paraguay and Argentina, levels of corruption among public servants, economic vulnerability, the formal crime control apparatus, and strict enforcement were identified as the main determinants of contraband crime in the municipalities of Paraná. Furthermore, it was observed that adverse events, such as the Covid-19 pandemic, can impact the determining variables of crime and alter the behavior of criminal organizations.

Keywords: Smuggling; Contraband; Determinants; Spatial Tobit; Covid-19.

1. INTRODUCTION

Smuggling refers to the importation or exportation of prohibited goods within a national territory, while tax evasion involves avoiding the payment of import taxes. These illegal activities incur significant costs to society, the economy, and public security, presenting challenges to the identification and law enforcement in such crimes.

Economically, smuggling causes substantial government revenue losses. By evading taxes, smugglers deprive the state of crucial resources for financing public services such as healthcare, education, and infrastructure (Miri and Ghasemi, 2019).

Moreover, smuggling distorts the market by creating unfair competition. Smuggled products are often sold at lower prices than legal goods, harming legitimate businesses. Law-abiding companies struggle to compete with the lower prices of smuggled products, leading to market losses, reduced production, and even business closures. This negatively impacts employment and workers' incomes, affecting the local economy directly (Barros, 2017).

Socially, smuggling can have adverse effects on public health and safety. Many smuggled products bypass quality and safety checks, posing risks to consumers. Counterfeit medications, adulterated foods, and low-quality products can jeopardize individuals' health, placing their lives at risk. Furthermore, smuggling is frequently linked to illegal arms trade, drug trafficking, and other illicit products, which fuels criminality and compromises societal security (Varela and Meireles, 2010).

Politically, smuggling provides fertile ground for corruption and organized crime. This illegal practice involves complex networks operating clandestinely, often with the involvement of corrupt public officials. Corruption undermines trust in government institutions and weakens the rule of law. Additionally, smuggling is commonly associated with other crimes, broadening the societal harm caused (Biz, 2010).

Brazil exhibits high levels of smuggling. According to "Contrabandômetro" [1] data, seizures grew by more than 1000% from 2015 to 2022, increasing from R$2 billion to R$31 billion. Notably, approximately R$28 billion of this amount pertained to illicit goods categorized as smuggling, with the remaining consisting of items imported without the necessary tax payments.

1 Available at: www.contrabando.org.br – a virtual portal that compiles statistics, news, and other official information regarding smuggling and tax evasion crimes in Brazil, created by the National Association of Federal Revenue Auditors.

The state of Paraná, located in southern Brazil, is considered one of the main entry points for smuggling into the country, primarily due to its border proximity with Paraguay and Argentina—countries where import and export activities are fundamental to economic development. Understanding the determinants of smuggling in Paraná is crucial for developing effective strategies to combat this illegal activity.

From a regional development perspective, smuggling and tax evasion directly influence the economic dynamics of localities, particularly in border regions such as Paraná. These illicit practices can undermine local productive structures by displacing formal economic activities, eroding the fiscal capacity of municipalities, and weakening public investments that are essential for fostering regional competitiveness and improving quality of life.

In this context, this article analyzed the determinants of smuggling and tax evasion in Paraná – Brazil, from 2017 to 2022. Two separate regression analyses were conducted: one covering the years of 2017, 2018, and 2019, and the other for the years of 2020, 2021, and 2022. The second regression specifically focused on identifying potential shifts in the determinants of smuggling/tax evasion due to the Covid-19 pandemic. Notably, from this point onward, the term "smuggling" refers to both smuggling and tax evasion activities.

Specifically, the spatial distribution of smuggling across Paraná municipalities was examined, investigating potential spatial spillovers and trends over time. The importance of factors such as corruption, unemployment, proximity to smuggling routes, and border location in determining smuggling across municipalities in Paraná was further explored.

To achieve these objectives, spatial econometric models (Spatial Tobit[2]) were employed. Spatial econometrics was necessary due to the high spatial dependence observed in the residuals of non-spatial estimations. Additionally, it is assumed that illicit smuggling activities propagate beyond municipal boundaries, justifying the use of a spatial model.

It is important to note that research specifically dedicated to smuggling is scarce. Moreover, most existing studies focus on measuring the consequences of this crime, whereas this research centers on analyzing the factors driving the occurrence of this illegal activity at a regional level. Even

2 This model was used due to the significant number of null values for the dependent variable corresponding to the number of smuggling cases recorded per municipality.

within international literature, specific approaches to smuggling are limited, often focusing on particular products, such as cigarettes (Burke, 2013). Therefore, this study contributes to the literature by providing a comprehensive regional perspective on the potential factors associated with smuggling and tax evasion.

Accordingly, this paper is divided into five sections, including this one. The second section addresses the definition, contextualization, and literature review on smuggling. This is followed by a presentation of the methodology, empirical strategy, and econometric model selected. The fourth section covers the analysis of results. Finally, the conclusion section offers final considerations.

2. SMUGGLING: DEFINITION AND DETERMINANTS

The etymological origin of the word "smuggling" comes from the Italian term "bando," meaning prohibition, interdiction, or announcement. Thus, smuggling denotes an act against prohibition. Merriman (2000, p.3) defines smuggling as "the evasion of taxes on consumer goods by circumventing border control mechanisms."[3]. This definition from Merriman (2000) is codified in Brazilian Penal Code Article 334 as the crime of "tax evasion" (descaminho), defined as "fraud employed to evade, fully or partially, the payment of import, export, or consumption taxes." Tax evasion is closely related to smuggling, which is defined by the Brazilian Penal Code as the unauthorized import or export of prohibited goods (BRASIL, 1940, art. 334-A). Popular understanding often conflates these two crimes, making it necessary to briefly differentiate them, as follows.

The crime of smuggling (BRASIL, 1940, art. 334-A) involves the clandestine import or export of prohibited goods into Brazilian territory. "Prohibited goods" refers to any merchandise subject to absolute or relative restrictions on entry or exit from the country. The primary distinction between smuggling and tax evasion lies in the restriction on goods. Tax evasion applies to attempts to import goods without paying the full import or export duties or consumption taxes (BRASIL, 1940, art. 334). These goods, although legal in Brazil, require tax payments for regulation.

According to Cunha (2019, p. 914), tax evasion (BRASIL, 1940, art. 334) involves evading taxes on a legally permissible product in Brazil, while smuggling pertains to the entry or exit of goods that are absolutely or relatively prohibited, making them illegal within national territory.

3 See Araújo Júnior and Fajnzylber (2000, 2001), Cerqueira and Lobão (2004), Shikida *et al.* (2006), Clemente and Welters (2004, 2007), Conti and Justus (2016).

Goods classified as smuggling offenses are seized when they do not constitute other crimes covered by specific laws, such as Law 11.343/2006 on drug trafficking. Cunha (2019, p.170) explains the distinction between smuggling and drug trafficking using the "lex specialis derogat legi generali" principle, or the principle of specialty, which dictates that specific laws supersede general laws for certain crimes.

According to studies by the Instituto de Desenvolvimento Econômico e Social de Fronteiras (IDESF, 2015, 2018), the most commonly seized smuggled goods include unregulated cigarettes, medications, and anabolic steroids without registration with the Brazilian Health Regulatory Agency (ANVISA), hookah tobacco, restricted military and security materials (such as bulletproof vests, pepper spray, helmets, etc.). In cases of tax evasion, where taxes are not fully or partially paid, the most frequently seized goods include electronics, cosmetics, beverages, and clothing.

This study excludes crimes related to Illegal Migration Promotion (Article 232-A) and Human Trafficking (Article 149-A), as these crimes involve human trafficking, while this research focuses on the smuggling of goods. It is also essential to clarify that drug trafficking, regulated under Article 33 of Law 11.343/2006, and international arms trafficking, outlined in Article 18 of Law 10.826/2003, are distinct criminal acts defined under special legislation and thus are not included in this study.

To facilitate understanding and continuity in this work, the definitions of smuggling and tax evasion from the Penal Code are considered together. From this point forward, these practices will be collectively referred to as "smuggling," particularly in the analysis of this research, as data collected for this study do not differentiate between the two crimes but rather address them jointly.

Specifically, smuggling has significant impacts on the national economy, affecting the trade balance, reducing tax revenue, and undermining the competitiveness of domestic businesses, with direct consequences for employment and income (Buehn and Farzanegan, 2012). Additionally, it poses a threat to public security, as it is associated with transnational organized crime and social violence (Ávila, 2014). Smuggling also poses risks to public health, as unauthorized goods enter the country without quality control checks (Varela and Meireles, 2010). These illegal activities hinder job and income generation, harm domestic competitiveness, and negatively impact the daily lives of individuals.

The following section presents literature on smuggling determinants, along with an overview of the primary entry routes for smuggling in Brazil.

2.1 DETERMINANTS OF SMUGGLING: THEORETICAL AND EMPIRICAL EVIDENCE

According to Cerqueira and Lobão (2004), there is no consensus on a universal truth that determines why a person commits crimes. However, from the perspective of public intervention, rather than searching for an absolute truth, it is more important to recognize if there is a statistical regularity of criminogenic factors in a particular region, allowing the state to address these factors. In this context, some of the potential determinants of smuggling are presented.

FORMAL CRIME CONTROL APPARATUS

Becker (1968) argues that, when comparing the gains and costs of an illegal activity, all individuals have the potential to become criminals. According to Becker, an individual will be willing to commit a crime if the expected utility outweighs the utility they could obtain by dedicating their time and resources to other legal activities—in other words, when the profit from the illegal activity exceeds that of a legal one. Therefore, some people engage in criminal activities not because their motivation differs from others, but because the costs and benefits are different for them. Becker emphasizes the importance of analyzing the cost imposed on society by criminal acts, the benefit the criminal gains, and the costs required for law enforcement.

This approach implies that there is a connection between the number of crimes committed by an individual, the probability of conviction, the penalty if convicted, and other variables, such as potential income from other activities and the frequency of seizures (Mijan, 2017).

In the context of smuggling or tax evasion, Buehn and Farzanegan (2012) explain that smugglers seek to maximize their gains relative to their costs, with the expected cost of smuggling stemming, among other factors, from the risk of being discovered and punished by authorities.

PROFITABILITY AND TAX SYSTEM

Smuggling entails unpredictable costs, such as losses from seized goods and bribes paid to avoid seizures. Despite these costs, studies show that the profit margin on smuggled goods can reach 900%, especially due to the high costs of legal products in the Brazilian context (Barros, 2017). Consequently, the appeal of illegal trade is intrinsically tied to the profitability disparity between legal and illegal goods, encouraging participation in this activity (Biz, 2010).

Thus, part of smuggling is carried out to avoid paying taxes on consumer goods and circumvent restrictions on certain products (Merriman, 2000). In this sense, tax rates are highlighted as one of the determinants of smuggling (Merriman, 2000). Additionally, the efficiency and functionality of the tax system also correlate with smuggling activity (Barros, 2017). The lack of resources and investments in mechanisms of control and improved revenue collection facilitate smuggling, while stricter enforcement raises smuggling costs, reducing its appeal to illegal agents (Buehn and Farzanegan, 2012).

CORRUPTION

The tax system relies on adequate resource collection, and its efficiency is linked to the appropriate application of these resources. The effectiveness of this process depends on the performance of those involved, making it essential to analyze their efficiency and reliability.

Research indicates a positive relation between corruption levels and the incidence of smuggling in a given region. Criminal groups rely on the support of corrupt public officials to engage in organized crime (Lucas, 2007). A more corrupt society facilitates smuggling, increasing profits for illegal traders (Buehn and Farzanegan, 2011).

Corruption in customs bureaucracy allows smugglers to escape punishment, as they may bribe officials to gain advantages (Biz, 2010). Governments with high corruption levels also facilitate non-compliance with laws, reducing the cost of supplying illicit goods (Biz, 2010).

EMPLOYMENT AVAILABILITY AND SMUGGLING

According to Stremel (2016), the increase in smuggling activity in the country is not only linked to tax and enforcement issues but also to unemployment and lack of income. Costa (2020) explains that in extreme need situations, such as hunger or poverty, some individuals may resort to crime, including involvement in smuggling.

Bochenek (2016) highlights that criminal organizations exploit people without formal employment options to transport illegal goods. The lack of alternatives in the regular labor market leads many to act as “mules” in smuggling operations (Cardin, 2006). Indeed, Costa (2020) emphasizes that survival instincts and the perception that crime benefits outweigh its drawbacks are determining factors for involvement in this illegal activity.

GEOGRAPHICAL LOCATION

Geographical location can influence smuggling, especially in regions with extensive borders or large coastlines, where controlling the flow of illegal goods is more challenging. Proximity to borders or smuggling routes may determine the rise of these crimes (Catta, 1994).

In Brazil, border regions, particularly with Paraguay, experience increased smuggling activity due to the ease with which smugglers can obtain products from neighboring countries (Barros & Mariotti, 2015). The extensive BR-277 and BR-163 highways, which connect multiple secondary routes, serve as key routes for smuggling across the country, supporting labor recruitment and infrastructure along these routes (Barros and Mariotti, 2015).

Moreover, the tri-border area between Brazil, Paraguay, and Argentina poses particular challenges due to its proximity to consumer markets and the leniency of authorities towards tax evasion, facilitating the entry of smuggled goods into Brazil (Azul, 2014).

Empirical studies, such as Merriman's (2000), use geographical proximity between regions to estimate cigarette smuggling, confirming the relation between geography and illicit activities.

2.3 CONTEXTUALIZATION OF MAJOR SMUGGLING ENTRY ROUTES IN BRAZIL

Due to its boundaries with Paraguay, Paraná serves as a major entry point for smuggled goods, given the proximity and availability of attractive imported products (Costa, Dolzan and Silva, 2019). During Alfredo Stroessner's dictatorial regime in the 1960s, re-export trade between the countries was facilitated and further intensified by the construction of the International Friendship Bridge in 1965, connecting Foz do Iguaçu (Paraná, Brazil) and Ciudad del Este (Paraguay). Notably, most of this commercial flow from Paraguay to Brazil occurs illegally, with estimates indicating that approximately 89% of re-exports enter Brazil irregularly (data from 2006 to 2016 - Costa, Dolzan and Silva, 2019).

The border region with Paraguay and Argentina is the primary entry route for smuggled products into Brazil, distributing goods to various parts of the country. The BR-277 highway is the most frequently used route for disseminating smuggled goods through Paraná, linking with other state and interstate highways (Barros and Mariotti, 2015). Most smuggled goods entering Brazil via

the Triple Border pass through BR-277, primarily destined for the state of São Paulo, where they are distributed to large warehouses and small retail outlets (Barros and Mariotti, 2015). Additionally, BR-163 serves as an access route to the southwestern, northern, and northeastern states of Brazil (Barros and Mariotti, 2015).

Figure 1a highlights the BR-277 route, which begins in the municipality of Foz do Iguaçu, on the border with Paraguay, and extends to Paranaguá on the coast. Figure 1b presents the "Integration Ring," formed by the main highways in the state, illustrating how the smuggling route can spread across the state through BR-277 and its connections. Figure 1c shows the BR-163 route, which crosses Brazil from South to North, underscoring its proximity to the Paraguay border in Paraná. This highway intersects with BR-277 in the municipality of Cascavel, connecting Paraná municipalities with various Brazilian states.

Thus, smuggling is a phenomenon that spans multiple regions in Brazil, with the state of Paraná—especially the area surrounding BR-277—acting as one of the main entry points for smuggled goods into the country, resulting in significant involvement in this criminal activity in the region.

It is worth noting that smuggling and tax evasion generate cumulative and persistent effects that undermine the ability of regions to sustain long-term growth. As highlighted by Myrdal (1957) in his theory of cumulative causation, negative economic shocks in a region may reinforce structural disadvantages, reducing its attractiveness to investment and limiting economic diversification and regional development. In the case of border regions such as Paraná, the prevalence of smuggling can displace formal activities, erode the tax base, and restrict public investment in infrastructure, education, and technological modernization—elements identified by Hirschman (1958) as crucial for fostering productive linkages and endogenous development.

Indeed, the literature shows that, by introducing goods at prices below those practiced in the formal market, smuggling distorts competitive mechanisms, weakens local production chains, and, in many cases, makes it unfeasible to maintain formal industrial activities. Yaskey (2022), analyzing cross-border illicit trade in the African context, demonstrated that such distortions lead to losses in competitiveness and business closures, thereby undermining the regional productive base.

On the theoretical plane, González-Parra et al. (2015) incorporate smuggling into a Solow-type growth model, showing that the unofficial flow of capital goods—such as machinery, fuels, and inputs—alters the expected stock of physical capital and, consequently, the pace of regional growth. This perspective reinforces the view that regional economies are not structured solely through formal flows, but are also significantly influenced by parallel markets.

Figure 1 | Route of BR-277 (a), the Integration Ring of Paraná highways (b), and the Route of BR-163 (c)

Source: (a) www.ruta277.blogspot.com; (b) www.parana-historia-geografia.blogspot.com; (c) www.gov.br/transportes/pt-br

The Brazilian case offers concrete examples of this dynamic. Margarido, Shikida, and Komesu (2025) analyze the seizure of smuggled cigarettes in Paraná between 2014 and 2024, employing time series techniques to identify cycles of expansion and contraction. The authors associate the persistence of the phenomenon with the tax differential between neighboring countries and infer that this disparity not only stimulates the inflow of illicit products but also undermines regional public revenues and the capacity for local investment.

From an institutional standpoint, Krylova et al. (2023) point out that strategic border regions, such as the Triple Frontier between Brazil, Paraguay, and Argentina, operate as "hubs" of illicit activities in which smuggling is intertwined with other crimes, such as drug trafficking and counterfeiting. This criminal convergence weakens governance structures, reduces the attractiveness of formal investment, and perpetuates a cycle of regional underdevelopment.

Overall, the literature indicates that smuggling, by operating in parallel with formal trade, undermines the productive structure, tax revenues, and institutional cohesion of the affected regions. Its effects go beyond fiscal loss, also impacting the competitive capacity of local economies.

Given the above, this study analyzes, on a regional scale, the determinants of smuggling, focusing on Paraná's municipalities, which theoretically experience a greater intensification of illegal practices of this crime due to their geographic location.

3. METHODOLOGY

With the objective of identifying the determinants of smuggling and tax evasion—hereafter referred to as "smuggling"—in the state of Paraná from 2017 to 2019 and 2020 to 2022, and considering the theoretical and empirical literature on smuggling presented earlier (Section 2.1), an Exploratory Spatial Data Analysis (ESDA) on smuggling was initially conducted, followed by the estimation of a spatial econometric model. The following sections provide a brief overview of the estimation method (Spatial Tobit), followed by the empirical strategy employed.

3.1 *SPATIAL TOBIT*

The Tobit model is widely used in economics to estimate dependent variables that are constrained to zero or within a restricted range. This model aims to estimate correlations involving censored dependent variables. The Spatial Tobit model is an adaptation of this approach within the context of Spatial Econometrics.

Using the Spatial Tobit model, it is possible to estimate parameters that describe the relation between dependent and independent variables, as well as quantify the spatial influence on these relations. Both spatial and non-spatial Tobit models rely on truncated multivariate conditional normal distributions to model unobserved latent utilities (Araújo, 2014, p. 92).

Spatial Tobit estimations can be performed using the spatial autoregressive model (SAR), which considers the spatial lag of the dependent variable. Another applicable model is the spatial error autoregressive model (SEM), where errors are an average of neighboring errors plus a random component. In addition, the Spatial Tobit model can also be estimated using local and global spatial dependence models—Spatial Durbin (SDM) and Spatial Durbin Error Model (SDEM)—which allow for capturing both global and local spatial spillover effects simultaneously.

3.2 EMPIRICAL STRATEGY

Analyzing the theoretical and empirical literature on smuggling presented in Section 2.1 and following Burke's (2013) model, this study estimates the determinants of smuggling across municipalities in the state of Paraná from 2017 to 2022.

Burke (2013) estimated the effect of taxes on the consumption of smuggled cigarettes, analyzing U.S. states from 1990 to 2009. He used the percentage of smuggled cigarette sales as the dependent variable, with explanatory variables including taxes, per capita income (a proxy for population wealth), education level, the number of police officers per thousand inhabitants (measuring enforcement efficiency), adult population (a proxy for demand for smuggling), and the number of public officials convicted of corruption.

Given the scarcity of empirical studies on the regional determinants of smuggling, Burke's (2013) application was partially followed, with adaptations to account for the lack of certain municipal-level variables in Paraná and the inclusion of other elements presented by various authors (as outlined in Section 2.1).

In this context, the dependent variable used was the number of smuggling cases (Cont) from 2017 to 2019 and from 2020 to 2022. This allows the estimation of an econometric model for a pre-Covid-19 pandemic period (theoretically a "normal" environment) and another during the pandemic. Smuggling data were aggregated over the three years, considering that many investigations initiated in one year may have been extended into subsequent periods. Additionally, a regression was performed for the pandemic period to identify possible changes in smuggling determinants due to pandemic-related restrictions on circulation and economic activities.

It is important to note that the smuggling data may be underestimated due to heterogeneity in the enforcement measures taken by different municipalities in Paraná, as there may be variations in seizure practices and investments in security and monitoring. This limitation should be kept in mind when interpreting the results, as the numbers may not fully reflect the actual level of smuggling in Paraná.

The econometric models included the following explanatory variables:

- Tax System Efficiency (TRIB) - This variable measures the efficiency of municipal revenue collection, serving as an indirect indicator of the institutional capacity to enforce taxation and control tax evasion. While it does not capture the specific tax rate applied to imported goods, its theoretical relevance lies in reflecting the municipality's ability to impose and collect taxes—an aspect linked to the opportunity cost of engaging in smuggling. According to Merriman (2000) and Barros (2017), higher tax burdens on legal goods increase the potential profitability of smuggling, while Buehn and Farzanegan (2012) emphasize that more efficient enforcement raises the cost of illicit activity and can deter participation.

- Formal Employment (EmF) - The level of formal employment may present a dual effect. On one hand, as Stremel (2016) and Costa (2020) argue, low formal employment and income scarcity push individuals toward smuggling as an alternative source of livelihood. On the other hand, Bochenek (2016) and Cardin (2006) indicate that areas with concentrated wealth and formal economic activity may also attract illicit trade, given the increased purchasing power of potential consumers and the logistical advantages for distribution.
- Number of Public Security Officers (SESPSEG) - This variable aggregates data from the State Secretariat for Public Security and other security agencies, serving as a proxy for municipal capacity to deter and control crime. In Becker's (1968) economic model of crime, as well as in Mijan (2017), the probability of detection and punishment influences the decision to commit crimes. Buehn and Farzanegan (2012) reinforce that a stronger security apparatus increases the perceived cost of smuggling, reducing its incidence.
- Population (POP) - Population size functions as a proxy for potential market demand for smuggled goods. Merriman (2000) demonstrates that larger consumer markets tend to attract greater smuggling flows due to increased sales opportunities and economies of scale for illicit networks.
- Municipal Corruption Level (CORR) - Corruption facilitates the operation of smuggling networks by lowering the risk of punishment through bribery and collusion with authorities. Lucas (2007), Buehn and Farzanegan (2011), and Biz (2010) find a positive correlation between corruption and smuggling, as a more permissive institutional environment reduces enforcement costs and increases profitability for illegal traders.
- Border Interaction (FrPY; FrAR) - These dummy variables identify whether the municipality is located on the Brazilian border with Paraguay or Argentina. Geographic proximity to borders is a well-documented determinant of smuggling, as highlighted by Catta (1994), Barros and Mariotti (2015), and Azul (2014), given the logistical ease of acquiring and transporting goods from neighboring countries.

- Proximity to Major Smuggling Routes (BR277; BR163) – These variables indicate whether the municipality is located near BR-277 or BR-163, highways identified as strategic corridors for smuggling in Brazil. Barros and Mariotti (2015) emphasize that these routes integrate multiple secondary roads, facilitating the nationwide distribution of smuggled goods and supporting the infrastructure required for illicit trade.
- Presence of a Federal Police Post (PRF) – A binary variable indicating whether the municipality hosts a Federal Highway Police post. In line with Becker's (1968) theoretical framework, the presence of federal enforcement agents increases the likelihood of inspections and seizures, raising the expected cost of smuggling and potentially deterring the activity.

Typically, unemployment is used in the literature to capture labor market effects, such as wage loss. However, in the case of participation in illegal activities such as smuggling, the final effect may be underestimated due to support programs like unemployment insurance. Furthermore, recent unemployment data at the municipal level were unavailable, so formal employment (EmF) was used as a proxy to measure economic vulnerability or, alternatively, criminal opportunity (Source: RAIS).

Regarding TRIB, this variable was created to test the hypothesis that the tax system influences smuggling incidence. Since tax rates are the same across all municipalities, a proxy was developed to measure tax efficiency by calculating each municipality's own revenue relative to total revenue. Own revenue (RP) included municipal taxes and fees, and the value was divided by total revenue (RT), as shown in Equation (1), using data from FINBRA:

$$TRIB = \frac{\sum RP}{RT} \quad (1)$$

A negative sign is expected for this variable, as higher revenue collection efficiency theoretically reduces smuggling.

To account for heterogeneity in anti-smuggling measures among municipalities, estimates were made with various crime control variables to mitigate potential endogeneity. Formal security presence can influence the number of smuggling cases ambiguously: higher smuggling rates may

lead to more recorded cases, but stronger municipal security may increase the likelihood of seizures. Therefore, for crime control, data on registered private security agents (RAIS) were combined with public security personnel data from the State Secretariat for Public Security (SESPPR)[4].

The Corr variable was created to test the hypothesis that corruption levels positively affect smuggling. Data on anti-corruption legal proceedings (PJ) by municipality were used. These data are available from the Federal Public Prosecutor's Office Anti-Corruption Portal, distributed by judicial subsection. The number of cases per subsection was divided by the subsection's total population, then multiplied by each municipality's population within that subsection to obtain a per capita average of anti-corruption cases by judicial subsection, as shown below:

$$Corr_{it} = \left(\frac{PJ}{\sum Pop_{it}}\right) POP_{it} \quad (2)$$

Explanatory variables (except dummies) were input at the initial year of each period (2017 for the first model and 2020 for the second) to minimize endogeneity.

The data refers to smuggling (import or export of prohibited goods) and tax evasion (tax avoidance). Drug and arms trafficking, as these represent different criminal typologies, are excluded from the smuggling data used in this study.

The estimated model corresponds to a Spatial Tobit (Equation 3). Among spatial models, SAR provided the best fit, eliminating spatial residual effects (tested by Moran's I) and capturing the theoretical spillover effect of smuggling. Additionally, the spatial matrix with one neighbor (Appendix) showed the highest Moran's I for non-spatial model residuals.

The municipalities of Paraná were selected for this analysis due to their strategic location bordering Paraguay and Argentina, the main sources of smuggled goods, and their access to key highways, BR-277 and BR-163, connecting Paraná to other regions. Data analysis covers 2017-2022, reflecting data availability and the need to assess pandemic dynamics.

$$CONT_{it*} = f(TRIB_{it}; EmF_{it}; SESPSEG_{it}; POP_{it}; CORR_{it}; BR277_{it}; BR163_{it}; FrPY_{it}; FrAR_{it}; PRF_{it}) \quad (3)$$

4 The model was estimated considering each of the variables related to formal crime control (private and public security) to determine which would provide results most consistent with the spatial distribution of smuggling crime in the state. It was found that the variable yielding the best results was the combined total of private and public security agents in formal crime control (SESPSEG).

where i represents the municipality, t is the initial year (2017 or 2020), and t refers to the summed data for 2017-2019 in the first estimate and 2020-2022 in the second.

4. SMUGGLING/TAX EVASION IN PARANÁ MUNICIPALITIES AND THEIR DETERMINANTS

Smuggling and tax evasion are illicit practices that have significant impacts on the economy, society, and politics. These activities involve the illegal import or export of goods and the evasion of tax payments. The state of Paraná, located in southern Brazil, has historically been associated with smuggling due to its strategic location bordering Paraguay and Argentina—countries known for high levels of smuggling and illegal trade, which makes the state particularly vulnerable to such activities.

Smuggling not only hinders state revenue collection but also undermines the competitiveness of legal commerce and poses threats to public health and safety. Therefore, it is crucial to understand the determinants of smuggling and tax evasion—hereafter referred to as "smuggling"—and their distribution in order to analyze their societal impacts and develop effective measures to combat these activities, fostering a safer and more economically sustainable society.

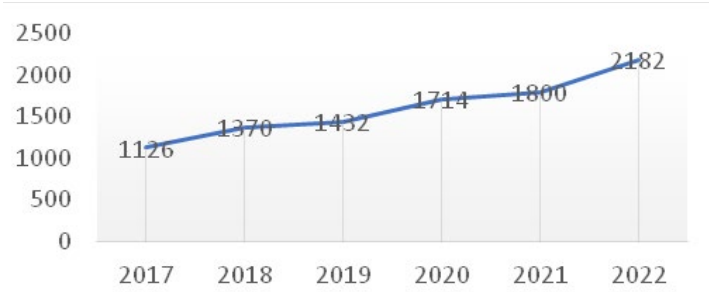
4.1 EVOLUTION AND SPATIAL DISTRIBUTION OF SMUGGLING IN PARANÁ-BR

Graph 1 shows the evolution of smuggling in the state of Paraná from 2017 to 2022. A steady increase in the number of recorded smuggling cases is evident over the years, with an increase of over 90% from 2017 to 2022.

It is important to note that, throughout the analyzed period, there were two public recruitment events for entry into the Federal Highway Police, as reported by the Brazilian Center for Research in Evaluation, Selection, and Promotion of Events (CEBRASPE). The first recruitment occurred in 2018; however, the approved candidates were only hired in 2020 after completing professional training. The second recruitment took place in 2021, with the successful candidates hired in 2022, following their training completion.

This information is relevant as the years when these recruits were hired coincide with the periods of the highest growth in recorded smuggling cases in Paraná, as illustrated in Graph 1, suggesting that an increase in police presence on highways may have led to more seizures. This highlights the significant increase in police force during the second analyzed period, reinforcing the necessity of separately analyzing 2017-2019 and 2020-2022.

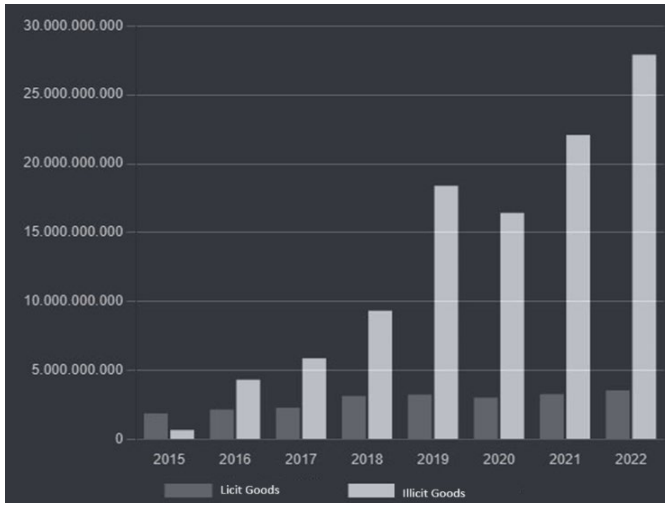
Graph 1 | Evolution of Recorded Smuggling Cases in Paraná – 2017 to 2022



Source: SESP, data organized by the Research

During the same period, Brazil as a whole also recorded a significant increase in smuggling seizures (Figure 2), with growth exceeding 300% from 2017 to 2022. Comparing Figures 1 and 2 reveals a similar growth trend in smuggling cases when comparing Paraná to Brazil. Notably, there was a slight decline in recorded values for Brazil in 2020, whereas in Paraná, the number of smuggling cases continued to rise.

Figure 2 | Evolution of Smuggling in Brazil - Seized Values – 2015 to 2022 (R$)



Source: www.contrabandometro.org.br

Table 1 presents statistics on the incidence of smuggling in the municipalities of Paraná, divided into two periods: the pre-pandemic period (2017, 2018, and 2019) and the pandemic period (2020, 2021, and 2022), characterized by pandemic-related effects such as highway blockades, social isolation, business closures, and layoffs of public employees, among others.

The analysis of Table 1 revealed that the percentage of municipalities with recorded smuggling cases showed little variation during the first three years of the study, corresponding to the pre-pandemic period. However, during the years affected by the Covid-19 pandemic, an increase was observed in the number of municipalities with at least one recorded case. This same pattern is evident in the average number of smuggling cases per municipality, suggesting that the adversities encountered during the pandemic may have influenced the distribution routes of illicit goods, resulting in an increase in the involvement of more municipalities in seizure incidents.

Table 1 | Descriptive Statistics on Smuggling – Municipalities of Paraná – 2017 to 2022

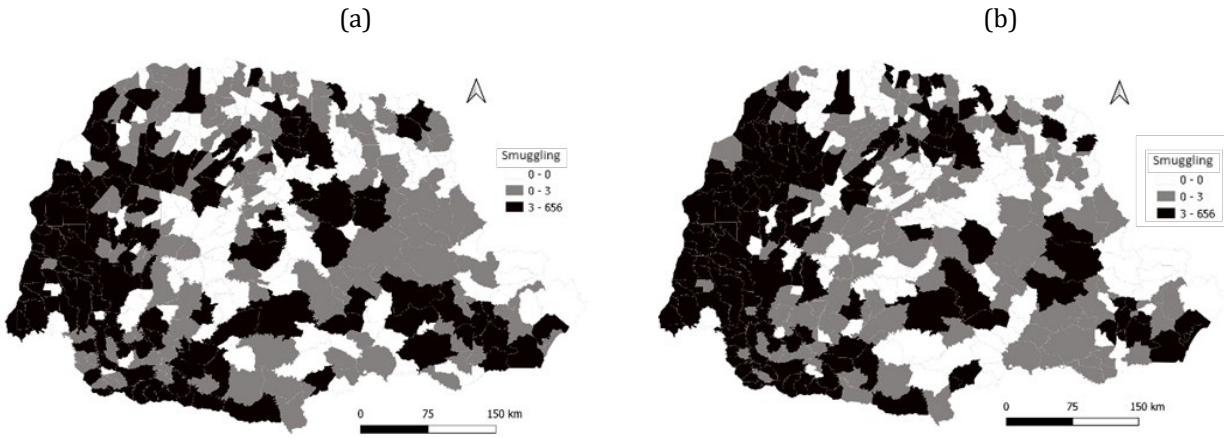
Description	Pre-pandemic Period			Pandemic Period		
	2017	2018	2019	2020	2021	2022
Mean	2.82	3.43	3.58	4.29	4.51	5.46
Standard Deviation	13	18.27	12.90	15	16.85	21.88
Maximum Value	194	317	150	181	208	236
Percentage of Municipalities with at least one recorded case	44.61%	45.61%	44.86%	47.86%	46.86%	46.36%

Source: SESP, data organized by the Research

The municipalities of Foz do Iguaçu and Guaíra recorded the highest numbers of smuggling cases during most of the study period, except for 2021, when Curitiba had the highest number of cases, and 2022, when the largest number of cases was recorded in Cascavel. These findings suggest that proximity to state borders and the connection of highways BR-277 and BR-163 likely played a significant role in the incidence of these crimes. Furthermore, it is noteworthy that both Curitiba and Cascavel only stood out in one year each, coinciding with the period heavily impacted by the Covid-19 pandemic. This indicates that in adverse times, such as a pandemic, organized crime may adapt by shifting its activities to areas with higher population density.

Figure 3 shows the distribution of smuggling cases in Paraná, considering the periods 2017 to 2019 and 2020 to 2022. An intensification of cases is evident in the second period, with seizures particularly concentrated along the border region with Paraguay and Argentina. Additionally, a considerable distribution can be identified along major highways, such as BR-277 and BR-163, as well as along Paraná's Highway Integration Ring.

Figure 3 | Number of Smuggling Cases – Municipalities of Paraná – 2017 to 2019 (a), 2020 to 2022 (b)



Source: SESP, data organized by the Research

Spatially, it is possible to observe a certain proximity among municipalities with a higher incidence of smuggling, indicating a pattern of spatial concentration. This phenomenon is confirmed by Moran's I statistic, which was positive and statistically significant regardless of the spatial matrix used (Table 2). Thus, municipalities with a high number of smuggling cases tended to be surrounded by municipalities with similar characteristics, and vice versa.

Table 2 | Moran's I - Smuggling in Paraná Municipalities – 2017 to 2019 and 2020 to 2022

	2017 to 2019	2020 to 2022
Queen	0,271*	0,152*
Rook	0,271*	0,152*
1 Neighbor	0,266*	0,210*
5 Neighbors	0,211*	0,143*
10 Neighbors	0,123*	0,094*

Source: Research Results

Note: * 5% significance level

4.2. DETERMINANTS OF SMUGGLING IN PARANÁ MUNICIPALITIES

After examining the spatial distribution of smuggling in the state of Paraná and its evolution in recent years, potential elements related to the occurrence of this type of criminal activity were evaluated. Table 3 presents the estimation results for the pre-pandemic period (2017 to 2019).

The tax burden is considered one of the factors highlighted in the literature as a determinant of smuggling. Some studies, such as those by Buehn and Farzanegan (2012) and Biz (2010), suggest a negative correlation between tax rates and the incidence of this crime. They argue that regions with high tax rates tend to invest more in enforcement mechanisms, which inhibits criminal practices. Conversely, studies by Barros (2017) and Conti and Justus (2016) indicate a positive relation between tax burden and smuggling, inferring that high tax rates increase the final price of legal goods, making the profit margin on illegal products more attractive.

In the case of Paraná municipalities, there is no variation in the tax burden. Therefore, a proxy was constructed to assess revenue collection efficiency, using the metric of "each municipality's own revenue relative to total revenue" to analyze its effect on smuggling.

As a result, for the period from 2017 to 2019, this variable was not statistically significant, as shown in Table 3. It is important to note that the proxy used reflects only an approximate estimate of municipal revenue collection efficiency, and the analysis was limited to the state of Paraná. In a nationwide analysis, it would be possible to capture potential correlations between tax burden and smuggling incidence, as tax values vary between states. This approach could lead to conclusions different from those obtained in this study.

From a regional development perspective, the absence of significance for this variable in the pre-pandemic period suggests that differences in local fiscal capacity did not directly alter smuggling incentives in Paraná, indicating that other structural and locational factors play a more decisive role in shaping the regional economic environment.

Table 3 | Spatial Tobit Model (SAR) for 2017 to 2019 - Municipalities of Paraná

		Coefficient	Direct Effect	Indirect Effect
TRIB17	4.125e+01	20.810	2.932	23.743
Corr17	5.335e-01*	0.269*	0.037	0.307*
EmF17	-1.466e-03**	-0.0007**	-0.0001**	-0.0008**
BR_277	2.315e+01*	11.683**	1.650*	13.333**
BR_163	-1.268e+01	-6.397	-0.9008	-7.298
FrPY	1.293e+02**	65.224**	9.212**	74.436**
FrAR	8.558e+01**	43.180**	6.112**	49.293**
SESPSEG17	-7.433e-03	-0.003	-0.0005	-0.004
POP17	6.201e-04 **	0.0003**	0.00004**	0.0003**
PRF	1.085e+01	5.475	0.764	6.240
Rho	1.314e-01*			

Source: Research Results

Note: Significant at '*' 1% and "**" 5%.

Another significant factor mentioned in the literature as a determinant of smuggling is corruption. Buehn and Farzanegan (2011) suggest that criminal activity increases in more corrupt societies. Similarly, Biz (2010) emphasizes that the likelihood of seizure and punishment decreases as public officials' corruption levels rise, making the perceived utility of engaging in illegal trade higher compared to legal activities. In the case of municipalities in Paraná, similar findings were observed (Table 3).

Indeed, a positive and statistically significant coefficient was found for the corruption variable, suggesting that a more corrupt public sector environment tends to increase local smuggling incidence (direct effect). However, the indirect effects were not statistically significant, indicating that, on average, the effects of corruption in one municipality do not spill over to neighboring municipalities in terms of smuggling incidence. This may be because the public officials responsible for anti-smuggling efforts in one municipality are not necessarily the same as those in neighboring municipalities.

These results also have implications for regional development, as higher corruption levels weaken institutional quality, reduce investor confidence, and can perpetuate a cycle of informality and reduced fiscal capacity in affected territories (Buehn e Farzanegan, 2011; Biz, 2010).

The results for economic vulnerability (EmF) were significant, aligning with the literature, indicating that an increase in formal employment (reflecting lower economic vulnerability) is associated, on average, with a decrease in smuggling cases. These findings support Costa's (2020) observations, which linked the growth in smuggling to rising unemployment, suggesting that the illegal market becomes an alternative source of income for those excluded from the formal labor market.

These results support the hypothesis that unemployment influences the increase in smuggling. Analyzing the direct and indirect effects of formal employment, it can be concluded that a municipality's economic vulnerability affects smuggling incidence both within the municipality itself and in neighboring municipalities, demonstrating a spillover effect. This phenomenon may be attributed to the reduced regional economic dynamism, which prompts local and neighboring agents to engage in illicit activities.

This dynamic directly relates to regional development theory (Myrdal, 1957), as negative economic shocks - such as declining employment - can trigger cumulative causation processes, reinforcing structural disadvantages and hindering long-term growth prospects.

Another factor theoretically associated with smuggling in municipalities in Paraná is proximity to BR-277, as this highway serves as a primary distribution route for smuggling in the region. The results presented in Table 3 reveal a positive and statistically significant correlation, indicating that municipalities along BR-277 tend to have, on average, a higher number of recorded smuggling cases.

Barros and Mariotti (2015) emphasize BR-277 as the main distribution route for smuggling throughout Paraná, as well as for the South and Southeast regions of Brazil. This highway plays a fundamental role in the state's road infrastructure, traversing from east to west, connecting the border with Paraguay and Argentina to the coast and providing access to all regions of Paraná and to other Brazilian states such as Santa Catarina, São Paulo, and Mato Grosso do Sul through various interconnected highways. Consequently, as noted by the authors, BR-277 has established itself as the primary route used for distributing smuggled goods.

The results obtained for direct, indirect, and total effects reveal that being located along BR-277 impacts smuggling not only within the municipality but also increases, on average, the incidence in neighboring municipalities. This phenomenon can be explained by the fact that various other locations can be reached through the multiple highways connected to BR-277 and the municipalities it crosses.

The existence of such transport corridors, while essential for market integration and regional competitiveness (Hirschman, 1958), also facilitates illegal flows when governance and enforcement are insufficient, potentially diverting the economic benefits of connectivity away from formal activities and towards illicit trade.

However, the results for BR-163 were not statistically significant, indicating that for the period analyzed, proximity to this highway was not a determining factor for the increase in smuggling cases in Paraná municipalities. It is worth noting that this study covered the entire state of Paraná, and BR-163 only crosses a small portion of the state's municipalities. This may explain why other variables proved to be more significant in explaining smuggling rates in the state. Nevertheless, on a national scale, IDESF (2016) studies indicate that BR-163 ranks second in terms of smuggling seizures, following only BR-277.

The importance of proximity to the Paraguayan and Argentine borders was also investigated. The analysis yielded positive and statistically significant coefficients, suggesting that being near the border increases, on average, the incidence of smuggling. These results support the arguments made by Barros and Mariotti (2015), who note that proximity to the border facilitates smuggling. The proximity to neighboring countries and accessible land routes to these countries allow access to foreign-origin products at lower prices, making them more attractive compared to domestic goods. Catta (1994) also notes that instabilities in border regions foster the growth of illegal activities such as smuggling, and the results in Table 3 reinforce this theory.

Examining the indirect effects of proximity to the Paraguay and Argentina borders, it was found that smuggling incidence in neighboring municipalities is influenced by border municipalities. This suggests that an increase in smuggling cases in border municipalities results, on average, in a rise in cases in neighboring areas, likely due to easier access to smuggled goods. Azul (2014) highlights that Brazil's border with Argentina and Paraguay is possibly the most problematic in the country, attributing another reason to this: easy access to smuggling distribution routes via BR-277, along with proximity to the South and Southeast regions of Brazil, where the majority of the consumer market for smuggled goods is located.

From a development standpoint, these results reinforce that the geographic positioning of border municipalities can be both a comparative advantage and a vulnerability: while it may facilitate cross-border

trade and integration, it also increases exposure to illicit flows that erode the tax base, distort competition, and compromise the potential for sustainable local development.

The variable SESPSEG was adopted as a proxy to assess formal crime control in municipalities and investigate whether the number of recorded smuggling cases might be associated with a larger security apparatus. The underlying assumption was that a larger security force might lead to more seizures, while fewer security professionals could lead to underreporting. However, for the period analyzed, this variable was not statistically significant, suggesting that the increase in smuggling records may not necessarily be related to the number of public or private security personnel.

In the same context, this study also examined the influence of proximity to Federal Highway Police (PRF) posts, considering the possibility that this might lead to a higher average number of smuggling cases, as there could be more seizures in these locations compared to other areas. However, the results were not statistically significant, suggesting that under typical conditions, the presence or absence of PRF posts, where officers monitor highways, does not positively or negatively impact the average smuggling records.

Finally, an analysis was conducted on the relation between population density and smuggling incidence, resulting in a positive and statistically significant coefficient. This finding can be explained by the fact that higher population density is associated with greater demand for products, which, in turn, leads to a greater concentration of smuggling activities in densely populated regions. Moreover, the indirect effect of this variable was also statistically significant, aligning with theoretical expectations. This may be due to the fact that residents in neighboring municipalities can more easily access smuggled goods in nearby large population centers rather than directly from the product's country of origin. Therefore, a municipality's population size influences both its own smuggling incidence and that of neighboring municipalities.

In summary, for the period 2017 to 2019, corruption, proximity to BR-277, border location, and population concentration had a positive correlation with smuggling, while formal employment showed a negative and statistically significant relation.

4.2.1 DETERMINANTS OF SMUGGLING IN PARANÁ MUNICIPALITIES DURING THE COVID-19 PANDEMIC

It is important to emphasize that the previous analysis was conducted using data from a period considered typical for society. However, in Table 4, the Spatial Tobit model was re-estimated for smuggling in Paraná municipalities, focusing on the period from 2020 to 2022, which is marked as atypical due to the Covid-19 pandemic.

At the end of 2019, the global population was confronted with a health crisis caused by the Covid-19 pandemic. The high contagion rate of the disease prompted various measures to contain the virus's spread, primarily based on the key recommendation from health authorities: social isolation. These measures impacted various sectors affecting social life, such as the economy, education, health, etc. (Neves, 2022, p.5). Given this context, it was deemed important to conduct an analysis of the determinants of smuggling specifically for the period when the Covid-19 pandemic affected the state of Paraná, with the results shown in Table 4.

Unlike the results obtained for the pre-pandemic period, the variable related to tax system efficiency (TRIB) yielded positive and statistically significant results, both for the average smuggling incidence within the municipality itself and for neighboring municipalities. This finding supports the theory proposed by Conti and Justus (2016), who argue that smuggling activities arise due to taxation laws, suggesting that the dynamics of tax creation on goods incentivize smuggling activities.

The discrepancy in results across the studied periods can be attributed to the implementation of restrictive government measures, particularly during the pandemic. These measures included the need to avoid gatherings, establishment of restricted operating hours for businesses, and suspension of activities, all of which directly impacted the economy, resulting in reduced consumption of goods and services and business closures. This, in turn, led to decreased corporate revenues, which subsequently resulted in job losses and lower tax revenue collection (Alves et al., 2023).

The authors also highlight federal government incentive measures, including extensions on tax payment deadlines, which were also adopted by other government entities. The absence of tax payments during the usual period is another factor that may have influenced changes in the municipalities' own revenue indexes, alongside business closures and the consequent reduction in job positions.

In this context, it can be inferred that the variable related to municipal revenue collection showed distinct results due to the impacts of the pandemic. However, it is essential to consider the limitations of this variable, as it represents only an estimate of each municipality's revenue collection efficiency. Therefore, it is advisable to deepen the analysis by using different samples and more precise data on product taxation. This approach would enable a more complete and accurate understanding of the pandemic's effects on municipal revenue collection.

The variable Corr, representing the level of corruption in municipalities, became even more significant during the pandemic, showing evidence of spatial spillover effects. This indicates that during this period, corruption levels on average influenced not only the number of smuggling cases within a municipality but also in neighboring municipalities. The increase in the variable's significance level and the spatial spillover observed during this period may be attributed to difficulties in meeting the demand for stricter enforcement during the pandemic, creating more opportunities for bribery of public officials and thereby facilitating criminal activities.

Table 4 | Spatial Tobit Model for 2020 to 2022 – Municipalities of Paraná

	Coefficient	Direct Effect	Indirect Effect	Total Effect
TRIB20	1.343e+02**	66.71**	8.73**	75.44**
Corr20	1.771e+00**	0.87**	0.11**	0.995**
EmF20	3.117e-04	0.0001	0.00002	0.0001
BR_277	1.632e+01*	8.10*	1.05	9.16*
BR_163	4.922e+01**	24.44**	3.19**	27.64**
FrPY	1.148e+02**	57.00**	7.48**	64.49**
FrAR	5.933e+01**	29.47**	3.88**	33.35**
SESPSEG20	-2.546e-02**	-0.01*	-0.001	-0.014*
POP20	1.315e-04	0.00006	0.000008	0.00007
PRF	4.039e+00	2.00	0.26	2.27
Rho	1.081e-01 *			

Source: Research Results

Note: Significant at '*' 1% and "**" 5%.

Despite various impacts on economic vulnerability during the pandemic, the formal employment index (EmF) variable did not yield significant results, indicating that, on average, the decline in employment opportunities did not affect smuggling incidence in the municipalities. This may be explained by the federal government's initiative to create the Emergency Aid program, which provided financial assistance to individuals in economically vulnerable situations. In addition to this, other government programs to support micro and small businesses to minimize layoffs, such as the Emergency Employment and Income Maintenance Program, the Emergency Employment Support Program, and the National Support Program for Micro and Small Enterprises (PRONAMP), may have played a role (Alves et al., 2023). These efforts likely helped prevent individuals from resorting to informal or illegal activities to supplement their income.

For the BR_277 and BR_163 variables, results differed from those found in the pre-pandemic period. BR-277 became less significant for smuggling incidence, whereas BR-163—which previously showed no significant results—had positive and statistically significant coefficients during the pandemic. For BR-163, indirect effect results indicate the presence of spatial spillover, affecting the smuggling average in neighboring municipalities, unlike the indirect effects found for BR-277. This suggests that adverse conditions during the pandemic may have altered organized crime behavior, forcing smugglers, for example, to seek new routes due to blockages along sections of BR-277.

Another hypothesis is that during the pandemic, police forces previously stationed on BR-277 were reassigned to border areas for pandemic checkpoint operations, reducing surveillance along this highway and increasing it on BR-163, the route closer to the border. This shift may have led to more seizures, making the smuggling index in the region more apparent. Additionally, due to travel restrictions and highway blockades, the sample of vehicles subject to inspection on BR-163 may have decreased, increasing the likelihood of identifying vehicles carrying smuggled goods.

The FrPY and FrAR variables did not undergo significant changes compared to the pre-pandemic period, indicating that proximity to the border remains a significant factor for smuggling incidence in municipalities, whether under normal or atypical societal conditions.

It is worth noting that transit between the countries in the triple border area was blocked from at least March to October 2020 (Neves, 2022), theoretically reducing the flow of smuggled

goods in the region. However, as shown in the results in Table 4, proximity to the border remained a significant factor for increased smuggling. This suggests that the main means of entry for smuggled goods may not necessarily be highways linking the countries but rather alternative routes, such as illegal crossings by boat on the Paraguay River, located precisely at the border between the three countries.

The SESPSEG variable, related to the level of personnel in formal crime control, was significant with a negative coefficient, indicating that an increase in municipal security levels resulted, on average, in a decrease in smuggling cases. This result diverges from the findings for the pre-pandemic period and may be linked to strengthened monitoring on highways and within municipalities during the pandemic, aiming to reduce Covid-19 transmission risks through stringent control over the movement of people.

In contrast to the pre-pandemic period, the POP variable was not statistically significant during the pandemic. This suggests that social isolation and concerns over uncertain economic impacts reduced the demand for smuggled goods. It can be inferred that population concentration ceased to influence smuggling rates during social isolation, as the reduction in people movement also led to decreased commerce and, consequently, lower demand for smuggled products.

Regarding the presence of Federal Highway Police units in municipalities, the results remained similar to the pre-pandemic period, indicating that the location of PRF posts does not impact smuggling incidence in Paraná municipalities.

FINAL CONSIDERATIONS

This study achieved its objective of analyzing the determinants of smuggling in the municipalities of Paraná, identifying structural, economic, and territorial factors that influence the incidence of this illicit activity across different contexts, including the pre-pandemic period and the atypical scenario brought about by Covid-19. The application of the spatial econometric model revealed that corruption, economic vulnerability, strategic location near borders, and the presence of distribution highways act as key elements in understanding the dynamics of smuggling, generating both direct and indirect effects that extend to neighboring municipalities.

Conversely, greater formalization of employment and the strengthening of security apparatuses were found to be associated with a reduction in crime incidence, reinforcing the role of productive inclusion policies and institutional efficiency in combating such practices. From a regional development perspective, the results confirm that smuggling undermines the formal productive base, erodes tax revenues, and weakens governance structures, perpetuating inequalities and limiting the capacity for investment in infrastructure and innovation.

Thus, by empirically demonstrating the interaction between local and regional factors, this study not only fulfilled its initial purpose but also contributed to the debate on integrated policies that combine targeted enforcement, institutional reforms, and incentives for formal economic activity, with the aim of breaking the self-reinforcing cycle that sustains smuggling and fostering more balanced and sustainable development trajectories.

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APÊNDICE

Moran's I for the residuals of the non-spatial model

	2017 a 2019	2020 a 2022
1 neighbor	0.426*	0.240*
2 neighbors	0.341*	0.143*
3 neighbors	0.284*	0.132*
4 neighbors	0.248*	0.142*
5 neighbors	0.214*	0.113*
10 neighbors	0.112*	0.070

Source: Data organized by the research

*Note: significant at a 5% significance level