Kamikazes in Public Procurements: Bid-Rigging and Real Non-Market Outcomes *

Dimas Fazio Alminas Žaldokas

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Abstract

Bid-rigging in public procurements has severe implications for public service quality. We document a prevalent coordination strategy in Brazil, where the lowest bidder withdraws post-auction, allowing the second-lowest bidder to win at higher prices. This "kamikaze" strategy occurs in 17% of auctions, increasing prices by 11.7%. Evidence of coordination comes from ownership ties, common addresses, and repeated partnerships between kamikaze and winning firms. Coordination declined following transparency reforms that made ownership connections visible to auctioneers. Ultimately, this behavior correlates with adverse real non-price outcomes: higher mortality rates in public hospitals and increased road accidents after maintenance contracts.

Keywords: public procurement, bid-rigging, shared ownership, non-market outcomes, financially-constrained governments
JEL Classification: G34, G38, H41, H57, L22, L41

*Dimas Fazio and Alminas Žaldokas are at the National University of Singapore (NUS). Fazio: dimasfazio@nus.edu.sg. Žaldokas: alminas@nus.edu.sg. We thank Kei Kawai, Jūra Liaukonytė, Stefano Lovo, our discussants Decio Coviello, Ettori Croci, Matthew Denes, Livio Ferrante, Andrea Maria Günster, Ai He, Woojin Kim, Leon Musolff, Stefano Sacchetto, Martin Schmalz, David Schoenherr, Jian Sun, Ekaterina Volkova, Dong Yan, participants of the 2025 SAIF Annual Research Conference, the Journal of Corporate Finance Special Issue Conference 2025, the 2025 Hal White Antitrust Conference, SGF Conference 2025, EPCS Meeting 2025, MFA 2025, ASU Sonoran Winter Finance Conference 2025, the World Bank Public Institutions Conference 2025, HKUST IEMS Webinar 2025, WFA 2024, EFA 2024, CICF 2024, the Bank of Italy EPSI Conference 2024, FMA Asia 2024, Paris December Workshop 2024, Asia-Pacific Industrial Organization Conference (APIOC) 2023, IIOC 2023, CEPR-TCD-TIME Conference on Economic Development 2023; ZEW Economics of Public Procurement Workshop 2023, EFA 2023 (Poster Session), CEIBS Finance/Accounting Symposium 2023, the CRESSE Conference 2023, the "Owners as Strategists" Conference 2023, the Annual Lithuanian Conference on Economic Research 2022, and the seminars at Tel Aviv University, Hebrew University, HEC Paris, Universidade Católica de Brasília, Peking University (Guanghua), Sungkyunkwan University, Monash University, the HKUST Center for Economic Policy, and the departments of finance and economics at NUS for their comments. Dimas Fazio gratefully acknowledges financial support from the Singapore Ministry of Education AcRF Tier 1 Research Grant (no. A-8001709-00-00). Alminas Žaldokas appreciates the grant from the HKUST Institute for Emerging Market Studies for the support of this project.

Governments spend significant resources purchasing goods and services from private companies, with public procurements constituting 12% of the global GDP (Bosio et al., 2022). Given this economic significance, inefficiencies in the procurement process can have severe consequences (Transparency International, 2015), including on the quality of public service provision. For example, financially-constrained institutions that pay higher prices may deplete their budget for essential services, or they may award contracts to less efficient firms that deliver lower-quality services. One key source of both distortions is bid-rigging — when private firms collude to extract rents from the government — which can increase public costs by up to 20% (OECD, 2009). This paper examines how such collusive behavior can lead to inefficiencies that ultimately harm the provision of critical public services.

Quantifying these negative externalities of bid-rigging on public service quality is challenging for at least two key reasons. First, explicit coordination is usually only observable in prosecuted cases, which likely represent a small and potentially biased sample. Second, identifying the link between bidding practices and service quality requires both comprehensive procurement and outcomes data. We overcome these challenges by leveraging a novel dataset of Brazilian public procurements that contains the complete bidding process for 15 million distinct item purchases between 2005 and 2021. Government institutions conduct these purchases via first-price electronic reverse auctions, where bidders compete in real time by offering successively lower prices. Using this rich dataset, we identify a specific and prevalent pattern suggestive of bid-rigging: in 17% of the auctions, the lowest bidder ("kamikaze") withdraws post-auction, allowing the second-lowest bidder to win.[1] We then study how this behavior affects the quality of essential public services in two contexts: hospital mortality rates and highway accidents.

We first establish that this pattern is associated with significant overpricing. Procurement prices are 9.7-11.7% higher in auctions when the lowest bidder quits and the second-lowest bidder wins, compared to similar auctions without such withdrawals. This reduced competition is evident from bidding behavior in kamikaze auctions: non-kamikaze firms submit 0.8 to 1.1 fewer bids (a 18-26% reduction from the average of 4.7 bids per bidder) than they do in non-kamikaze auctions and kamikaze auctions exhibit 3-5% lower bid dispersion.

To understand this behavior, we develop a theoretical framework that highlights how kamikaze strategy affects bidding dynamics. While one might consider that non-kamikaze firms' bids are not affected by the presence of kamikaze firms, our framework shows why this is not necessarily the case. We assume that regular bidders observe the kamikaze firm's bid

[1] Similar practices have also been observed in the U.S. as the Department of Justice (2021) mentions that *"in some schemes, a low bidder will agree to withdraw its bid in favor of the next low bidder in exchange for a lucrative subcontract that divides the illegally obtained higher price between them."*

before submitting their bids and form a belief about its legitimacy while also facing fixed bidding costs, such as investing resources in participating in the bid. We show that when faced with fixed costs and higher uncertainty about whether the bids are placed by kamikaze, some competitors may opt out of bidding. Anticipating reduced competition, other bidders submit less aggressive bids, leading to higher prices.

We then investigate whether kamikaze behavior reflects random honest mistakes or strategic coordination by examining connections between kamikaze firms and eventual winners. The evidence points toward coordination. We find that kamikaze and winning firms frequently share the same ultimate owner and business address, and the same firms repeatedly collaborate, maintaining their kamikaze and winner roles. Moreover, kamikaze firms are smaller and younger than winners and frequently act as kamikazes across multiple auctions, suggesting they serve as special-purpose entities that facilitate collusive bidding strategies. Consistent with this bid-rigging interpretation, auctions where kamikazes and winners share the same owner, the same address, or have repeated pairings exhibit higher overpricing than in kamikaze auctions without such connections.

We provide further evidence of coordination by exploiting a 2014 transparency reform that allowed auctioneers to observe shared ownership between auction participants. This reform provides plausibly exogenous variation in the costs of coordination for firms with shared ownership. If kamikaze withdrawals were due to non-strategic reasons rather than coordination, this reform should have no effect on kamikaze behavior. However, using a difference-in-differences approach, we find that both kamikaze behavior and overpricing declined significantly after the reform, particularly among firms that previously coordinated through shared ownership. Supporting our identification strategy, we find no differential pretrends in procurement prices before the reform. In contrast, prices dropped significantly after 2014 for firms that previously engaged in coordination through shared ownership. Combined with the ownership and address connections, repeated pairings, and systematic overpricing we document, these findings provide strong evidence of deliberate coordination, which enables firms to extract higher prices from government contracts.

As a final piece of evidence of coordination, we employ a regression discontinuity design that exploits plausibly exogenous variation in which firms benefit from kamikaze withdrawals. We focus on auctions where the same kamikaze firm submits the lowest bid but connected and unconnected rivals place nearly identical bids for second place. Because Brazil's reverse auctions close at a random time, which firm ends just ahead in these near-ties is effectively random. Thus, kamikaze firms cannot predict during the auction whether their connected partner will finish in second place when bids are nearly identical. Yet, we find that they are significantly more likely to withdraw when connected firms narrowly secure this position,

providing evidence of deliberate coordination rather than mistakes.

Having established that kamikaze behavior is associated with overpricing and shows patterns consistent with strategic coordination, we examine how the resulting inefficiencies affect public service provision. Such an effect can occur through at least two channels. First, this systematic overpricing we document places financial strains on government institutions, as overspending can negatively impact future public budgeting. The financial constraints arising from higher prices could have negative externalities on the ability of the involved agencies to provide essential services to the public. Second, winners in kamikaze auctions might not be the most efficient providers, leading to lower quality public service provision.

We study these negative externalities in two contexts. First, we investigate how kamikaze bidding affects hospital mortality rates through the purchase of essential medicines. Using data on 61 federal hospitals in Brazil, we compare future mortality rates in hospitals that acquire medicines for the same disease in the same quarter but have different incidences of kamikaze firms in these procurements. Kamikaze auctions for essential medicines are associated with a 19% increase in hospital mortality rates in subsequent years, relative to the unconditional average. These effects persist even when comparing health outcomes within the same hospital in the same year, which controls for any time-varying differences in hospital quality, management, or other characteristics that might affect mortality rates. As essential medicines have precise specifications and do not differ in quality, this effect is likely explained by reduced residual budgets to acquire additional medicines or other supplies, detrimentally affecting hospital mortality.

Second, we find that kamikaze bidding results in lower road quality and increased number of road accidents. Roads maintained under kamikaze auction contracts require additional maintenance approximately one year earlier than comparable roads repaired through non-kamikaze auctions, indicating inferior repair quality and accelerated deterioration. Moreover, roads awarded in kamikaze auctions experience 13.7% more accidents due to poor road conditions and 9.6% more victims from such accidents, even after controlling for project complexity. We provide evidence strongly suggesting that these accidents are explained by low road quality: we find no impact on accidents that are not related to road quality (e.g., speeding, drunk or distracted driving). Unlike the procurement of specific medicine in hospitals, road maintenance quality is difficult to contract on. This suggests a second channel through which bid-rigging in kamikaze public procurements can affect real outcomes: the selection of less efficient suppliers, which compromises both infrastructure durability and public safety.

These two sets of results imply that overpricing in government auctions could result in

serious negative real effects beyond those on consumer welfare, labor or financial markets, i.e., it could also have strong *non-market effects*, e.g., on health and public services. These findings also bring attention to one particular coordination strategy — kamikazes — that is associated with significant overpricing. They also support Kumar et al. (2015), who suggest that one reason why firms exist is to give the impression of competition in public procurements. While this paper uses ex-post observable kamikaze strategy to proxy for bid-rigging behavior, the fundamental mechanisms — reduced competition through coordination or deterrence, leading to higher prices and less efficient providers — are likely to remain the same across different procurement formats and bid-rigging strategies, such as bid rotation, market division, and complementary bidding.

Our paper contributes to the literature on cartel detection (e.g., Porter and Zona, 1993, 1999; Bajari and Ye, 2003; Chassang et al., 2022; Houde et al., 2022; Kawai et al., 2023) by documenting bid-rigging behavior and showing how it is linked to negative real effects in public service provision. More generally, the literature has extensively documented different types of bid-rigging behavior as well as methods of detecting it (e.g., Porter, 2005; Whinston, 2008; Marshall and Marx, 2012; Andreyanov et al., 2018; Baránek et al., 2021). Instead, we use a bidding strategy consistent with coordination to study non-market outcomes, such as hospital mortality rates and road safety conditions, and to quantify the broader real outcomes resulting from firm coordination in procurement auctions. In doing so, we also contribute to studies on the broader macroeconomic implications and other externalities resulting from public procurement auctions such as employment Goldman (2020), firm growth (Ferraz et al., 2021), entrepreneurship (Pecenco et al., 2024), productivity (di Giovanni et al., 2024), healthcare access (Barkley, 2023), and infrastructure (Liscow et al., 2023). Our analysis also reveals *how* bid-rigging patterns harm public services by exacerbating financial constraints on public institutions and by leading to the selection of suboptimal contractors. These findings expose the risks of low competition in public procurements beyond immediate fiscal implications.

The public procurement literature has examined cases where abnormally low bids win the contract but later default or seek renegotiation due to cost miscalculations or financial distress (e.g., Spulber, 1990; Zheng, 2001; Decarolis, 2014).[2] However, unlike these scenarios where low bids are followed by renegotiations, kamikaze firms submit low bids but strategically withdraw before signing the contract, allowing the second-lowest bidder to win at a higher price. This is likely a deliberate form of coordination rather than cost misestimation,

[2]For example, the European Commission (2002) mentions that *"contractors who intentionally submit abnormal tenders might be those who seek an ex-post renegotiation (...) (or those) in bad financial conditions (...) in search of a contract in order to obtain a cash advance from their client or bank."*

highlighting a more covert form of bid-rigging that drives up prices, harming hidden costs on public budgets and limiting financial resources for public services.

Finally, as we observe that the coordination is prevalent in cases where the winning firm and the kamikaze share ultimate owners, we relate to the finding in Charoenwong and Asai (2020) who show that shared ownership networks are positively associated with higher contract prices in public procurement auctions.[3] In addition to these coordination mechanisms and related to the broader corporate ownership implications, we provide new evidence of how firm ownership can affect patient health outcomes (e.g., Azar et al., 2018; Eliason et al., 2019; Gupta et al., 2024; Ashtari Tafti and Hoe, 2022; Liu, 2022; Schmalz and Xie, 2022) and have other externalities such as reduced road quality. More broadly, firms actively design institutional arrangements to enable coordination, whether through ownership structures as we document here, through executive compensation that rewards collusion when enforcement weakens (Ha et al., 2024), or through political ties that reduce oversight and facilitate preferential treatment (Faccio et al., 2006; Schoenherr, 2019; Duchin and Sosyura, 2012).

1 Data

The main dataset comes from ComprasNet, the electronic platform where government institutions conduct procurements. As such, it contains information on the universe of federal public procurements in Brazil, including procurement outcomes, descriptions of the items (goods or services) purchased, a list of participants, and their bidding history from September 2005 to August 2021.[4] The data covers 4.8 thousand government institutions purchasing 139 thousand distinct items and services in 15 million auctions. An average auction in the data had seven participants, each making 4.7 bids, totaling about 450 million distinct bids.[5]

To ensure accurate categorization of goods and services, we match items with their official government registry, namely the *Cadastro dos Materiais* (CADMAT) for products and the *Cadastro dos Serviços* (CADSER) for services. Panel A of Internet Appendix Table A1 provides an example list with selected products and services, while Panel B presents a selected list of government institutions present in the database.

Our analysis of the real non-market outcomes relies on several secondary sources. We use the Transparency Portal (*Portal da Transparência*) to assess the quality of public contracts

[3] See Schmalz (2021) for a recent literature review on common ownership and industrial organization.

[4] Local governments can also use ComprasNet for at least a part of their purchases. In the total sample, these local government add up to 9% of the transactions.

[5] Internet Appendix Figures A1 and A2 show the geographical distribution of institutions and bidders.

through budget execution data. Hospital mortality data in the Brazilian Unified Health System (*Sistema Unificado de Saúde - SUS*) is obtained from DataSUS. Information on accidents and victims on Brazilian roads comes from the Federal Highway Patrol (*Polícia Rodoviária Federal*). Lastly, we gather firms' location, industry, size category, and ownership structures from the Brazilian Federal Revenue Service (*Receita Federal*).

Table 1 presents the summary statistics for the main variables used in our analysis. Across the entire sample period, 17% of the auctions had at least one kamikaze firm, and the average number of kamikaze firms per auction was 0.36.

2 Institutional Background

Brazil primarily conducts procurements for standardized goods and services via competitive bidding (*Pregão Eletrônico*), where the government awards public contracts to the lowest bidder in first-price electronic reverse auctions. Bidders compete in real time by offering successively lower prices for their goods and services, with the lowest price winning the contract. Electronic reverse auctions are a common procurement practice worldwide. The World Bank's Global Procurement Database reveals that 50 out of 152 surveyed countries employ similar systems, including the United States, the United Kingdom, France, Russia, Israel, India, and Mexico. In contrast, countries like Germany, Italy, Canada, South Korea, and Singapore tend to use first-price sealed bid auctions. These auctions can generate substantial savings: U.S. federal agencies reported 12-14% cost reductions (United States GAO, 2013).

In Brazil, the process begins with regulatory approval, followed by the issuance of a detailed notice explaining the objective of the purchase (e.g., acquisition of painting materials), the item(s) demanded (e.g., paint sealer, acrylic paint), and clarifying the other proceedings of the auction. Typically, the items in a single procurement notice share a common objective, but each item usually constitutes its own separate auction. The procuring institution then collects proposals from potential bidders. The procuring institution collects these proposals until the date when the electronic bidding is going to take place. These institutions then evaluate the proposals and approved bidders are authorized to participate in the electronic bidding stage, which takes place in the ComprasNet portal.

Bidders' initial proposals to the procuring institution automatically become their first bids. Once the bidding stage starts, participants can submit another bid, which must be lower than their previous bid but can be larger than the lowest overall bid at that moment. In real time, bidders observe their own bid and the overall lowest bid but not the history of the

bids, nor the identities of other bidders.[6] Meanwhile, the auctioneer observes the identities of all bidders and has the right to remove suspicious bidders from the auction. Since 2014, the auctioneer also has access to the ultimate ownership structures of the auction participants.

After the bidding ends, the auctioneer declares the lowest bidder the winner, who must then submit documents that prove the firm's going concern status. If approved, both parties sign the public contract. However, if the winner fails to meet requirements — whether by withdrawing, not submitting the required documents, or providing inadequate documentation — they are disqualified, and the second-lowest bidder becomes the new winner. This process continues until the contract is signed and the procurement ends.

In this paper, we study cases when original winners fail to sign the public contract and do so *within minutes* after the end of the auction. While this may result from honest mistakes or cost misestimations, e.g., as a result of a "winner's curse" realization, we analyze whether such behavior can be attributed to strategic coordination and whether that has any real non-market outcomes. Brazilian regulators suspect that this behavior may be part of a bid-rigging process,[7] and these bidders have been coined "kamikazes",[8] not least since they tend to have bids that are much lower than the second-lowest bid. We define potential winners that fail to sign the public contract as *kamikaze firms* and auctions that have at least one such kamikaze firm as *kamikaze auctions*.

Using data from ComprasNet, we find that such a pattern is relatively common. In Figure 1, we plot the fraction of kamikaze auctions in Brazil semiannually between 2007 and 2021. We see that, on average, 17% of procurement auctions in Brazil can be considered as having a kamikaze firm.

Figure 2 illustrates the bid dynamics for the final 45 minutes of the auctions. We plot the median bids for three types of bidders: the kamikaze bids (blue, circle) whose bids are eventually forfeited; the winners (red, square), defined as the lowest non-kamikaze bid; and "runner-up" bidders (orange, triangle), the next lowest in non-forfeited bids. All bid prices are normalized by the winning bid. To construct this plot, we gather bids for each auction at one-minute intervals, carrying forward the last bid if they do not update it within a minute. We then calculate the median across all bids in the sample for each bidder type and plot the findings. Three key patterns emerge. First, kamikaze bids are 15% lower than winning bids in the same auctions, which is an order of magnitude larger than the difference between

[6] Internet Appendix Figure A3 provides a screenshot of ComprasNet from the bidder's perspective.

[7] *Tribunal de Contas da União* (TCU)'s Acordao no. 1793/2011: *"it is possible that there are companies reducing prices (...) to discourage the participation of other bidders (...) later withdrawing from the bidding to benefit another company (...) participating in the collusion, which (...) ends up being hired without having presented the best proposal, thus causing damage to the Administration."*

[8] They have also been called "divers" or "rabbits".

lowest and second-lowest bids in non-kamikaze auctions, calculated to be 1% as shown in Internet Appendix Figure A4. Second, winners stop reducing the bid around 12 minutes before the end of the auction, which could reflect superior information about the kamikaze's withdrawal. Third, kamikaze firms continue to reduce the bids until the end of the auction, potentially deterring competition by non-kamikaze firms.

Despite the availability of potential solutions, such as the requirement to submit the documents for prequalification before the auction, the posting of a monetary commitment such as a surety bond, or the imposition of fines, the enforcement against kamikaze behavior is limited in Brazil. Federal Law No. 10,250/2002 allows for banning offenders from participating in public procurements for a maximum of five years. Such punishments are rarely given, weakening their deterrence effect. As per the Open Data on Public Purchases Portal, during our sample period, 83 thousand firms were disqualified after winning the auction, but only 13 thousand, or 15%, received legal action against this behavior. When penalized, these firms are banned from participating in federal public procurement by a median of 180 days, which is significantly less than the maximum of five years allowed by the law.

Brazilian regulators attribute the limited enforceability of the law to the lack of sufficient resources in government institutions to proceed with the administrative processes against every firm that does not follow the auction rules by the book (Tribunal de Contas da União, 2011). This parallels the "wrist slap hypothesis" in procurement fraud more generally, where government monitors often lack sufficient resources and skills to impose significant penalties on contractors. An OECD study substantiates this concern, finding that only 21% of countries have certification processes for public procurement officials — deficiencies that create vulnerability to fraud throughout the procurement process (OECD, 2019). Even when firms are suspended or debarred, the penalty may have little practical effect as the sanctioned entities can often circumvent punishments by creating new companies or operating as subcontractors (Gordon, 2019). As noted by a U.S. Department of Defense deputy assistant inspector general, "For all intents and purposes, nobody ever monitors to see if [a contractor is] living up to the debarment" (White, 1986). Moreover, corporate lawyers argue against severe punishment for potential good-faith mistakes, citing the risk of overpricing in future auctions when the number of potential competitors gets reduced.[9]

[9]In Internet Appendix Section B, we highlight the difficulty in prosecuting kamikaze firms in a case study of an auction conducted by Brazil's National Institute for Colonization and Agrarian Reform (INCRA).

3 An Illustrative Model of Kamikaze Bidding

This section develops a conceptual framework to understand how kamikaze bidding can systematically increase procurement prices and proposes one set of conditions under which such strategies remain effective. We analyze two key mechanisms: strategic deterrence effects when bidders face fixed participation costs, and coordination advantages when some bidders possess superior information about withdrawals.

3.1 Strategic Environment

Consider a first-price procurement auction with N bidders: $N - N_K$ genuine bidders and N_K potential kamikaze bidders. In this auction, the lowest bid wins, and the winner gets awarded the contract in the value of their bid. Each genuine bidder has a private cost of providing the procured good c_i, independently drawn from a uniform distribution on $[0, 1]$. Genuine bidders have private costs and seek to maximize expected profit. The bidders face fixed costs $F > 0$ associated with bidding, such as the opportunity cost of time spent monitoring the auction or maintaining resources during the bidding period.

Kamikaze firms submit extremely low bids but withdraw post-auction, allowing other bidders to win. While the actual Brazilian public auctions follow an open format, we model the strategic decision-making of genuine bidders using a sealed-bid framework for analytical tractability. This simplification captures the key strategic uncertainty that genuine bidders face: after observing kamikaze bids during the open auction, they must form beliefs about withdrawal probabilities when making their final bidding decisions. The open nature of bidding does not eliminate this fundamental uncertainty about which low bids represent genuine competition. Regular bidders face uncertainty about whether kamikaze bids will be forfeited with probability $p \in [0, 1]$. Such p can be symmetric among all bidders ($p_i = \tilde{p}$) or differ with some bidder having a full knowledge ($p_i = 1$) and other bidders unaware of this collusion, believing forfeiture is less certain ($p_j < 1$).

3.2 Benchmark Case

Without loss of generality, consider the case with $N = 3$ bidders: two genuine bidders (A and B) and one kamikaze bidder (K). In this scenario, genuine bidders choose bidding strategies that maximize expected profit:

$$E[\pi] = p \cdot Pr(\text{win among genuine bidders}) \cdot (\text{bid} - \text{cost}) - F$$

Assume first that $F = 0$. Regular bidders A and B will compete with each other to be the second lowest bidder on the off chance that the kamikaze firm's bid will be forfeited. This makes the auction equivalent to one with two $(N - N_K)$ genuine competitors, already mechanically leading to higher expected prices than a standard auction with three (N) bidders. Because the kamikaze firm always withdraws its bid, the expected price in this scenario is the same as if the auction only had two genuine bidders: $E[\text{price}] = \frac{2}{3}$, which is higher than $\frac{1}{2}$ that would be the expected price in a scenario with three genuine bidders, demonstrating that kamikaze bidding reduces effective competition. We refer to Internet Appendix C for detailed analysis.

3.3 Fixed Costs and Strategic Withdrawal

The benchmark case assumes no bidding costs in auctions. However, when bidders face fixed costs $F > 0$ associated with bidding, such as the opportunity cost of time spent monitoring the auction or maintaining resources during the bidding period, kamikaze strategies become significantly more effective at inflating prices. The equilibrium price in this setting also increases as p decreases.

The introduction of fixed costs creates a circular dependence: participation decisions depend on expected profits, which depend on optimal bids, which in turn depend on winning probabilities that are influenced by other bidders' participation decisions. Due to this strategic interdependence, we solve the model numerically by iteratively updating bidding strategies and participation decisions until convergence.

Panel A of Figure 3 illustrates these patterns by plotting expected prices obtained from numerically solving the model with one kamikaze firm and two genuine bidders. With zero fixed costs ($F = 0$), prices remain stable around 2/3 regardless of p. However, with positive fixed costs ($F = 0.05$ and $F = 0.15$), prices are higher compared to zero fixed costs, especially for low values of p.

The mechanism operates through effective participation costs. As fixed costs F increase or the perceived probability p of kamikaze forfeiture decreases, regular bidders face higher effective participation costs (F/p). This shift prompts bidders to reassess their strategies: anticipating that other regular bidders may opt out due to these unfavorable conditions, remaining bidders submit less aggressive (higher) bids. These higher bids serve dual purpose: they increase profit margins, making participation worthwhile despite elevated risks, and compensate for the reduced winning probability due to potential kamikaze participation. Thus, the framework predicts that higher fixed costs combined with lower forfeiture probabilities lead to less aggressive bidding as bidders adapt to the changing auction environment.

3.4 Information Asymmetries and Coordination

We further relax the assumption of p being symmetric among all bidders ($p_i = \tilde{p}$). This extends the fixed costs model by allowing bidder A to collude with the kamikaze firm, giving this bidder the certainty that the kamikaze firm will always withdraw ($p_A = 1$). In contrast, bidder B, unaware of this collusion, believes forfeiture is less certain ($p_B < 1$).

Under this asymmetry, bidder B faces higher effective costs and increased uncertainty, leading them to bid less aggressively or not participate. Anticipating this reduced competition, bidder A strategically exploits its informational advantage by submitting higher bids. The numerical analysis presented in Panel B of Figure 3 shows that the equilibrium prices in this asymmetric case exceed those from the symmetric case where both bidders share the same beliefs about the probability that the kamikaze bid will be withdrawn ($p_A = p_B$).

This information asymmetry fundamentally alters auction dynamics: coordinated bidders need not submit the most competitive bids to win, as they know that apparently superior kamikaze bids will disappear. Most importantly, this mechanism can lead to systematically less efficient outcomes. Coordinating firms may win auctions despite having higher costs than genuine competitors, since their informational advantage allows them to avoid the aggressive bidding that non-coordinating firms would require to overcome kamikaze uncertainty.

3.5 Empirical Support for the Assumptions

The empirical evidence supports the assumptions behind these theoretical predictions. We discuss them in detail in Internet Appendix D. In summary, when multiple kamikaze firms participate in the same auction, they create a more genuine appearance of competition, thus also invoking higher uncertainty about whether the bids are legitimate. Our analysis shows that these cases are associated with higher prices, as regular bidders perceive a lower chance of winning and bid less aggressively. Moreover, we find that the overpricing is further exacerbated when there are simultaneous auctions of similar products. This occurs because capacity-constrained firms must decide how to allocate their limited resources across multiple auctions, making them less willing to respond aggressively to kamikaze bids when they could instead focus their efforts on other ongoing auctions.

4 Kamikaze Firms

Before we discuss the real non-market outcomes, we incrementally establish kamikaze behavior as a bid-rigging marker. In Section 4.1, we document that auctions with kamikaze firms, where lowest bidders withdraw shortly after winning, exhibit systematically higher

prices and reduced competition compared to similar auctions. In Section 4.2, we establish that kamikaze behavior represents coordination via three key pieces of evidence. First, firms acting as kamikazes share owners and addresses with the eventual winners, and repeat these roles over time. Second, we show that a 2014 transparency reform that made ownership ties visible to auctioneers decreased overpricing and coordinated behavior. Third, using a regression discontinuity design, we demonstrate that withdrawals occur strategically when connected firms stand to benefit. Taken together, this evidence demonstrates that such withdrawals result from strategic coordination rather than honest mistakes, strongly supporting a collusive interpretation of our results.

4.1 Overpricing

We first study whether auctions that present kamikaze behavior higher prices than other similar auctions. We define kamikaze behavior as cases where firms submitting the lowest bid do not win the procurement because they withdraw their bids, fail to deliver documents, or are disqualified due to inconsistencies.

4.1.1 Baseline Effects

We empirically investigate overpricing by comparing outcomes in auctions with and without kamikazes. We implement the following specification:

$$y_{ipt} = \alpha_{pt} + \alpha_{X_i t} + \beta \cdot HasKamikaze_{ipt} + e_{ipt} \tag{1}$$

$Has\ Kamikaze_{ipt}$ equals 1 if a firm has the lowest bid but does not win procurement i for item p in year t, and 0 otherwise. y_{ipt} is the logarithm of the price for item p procured in procurement i at time t. α_{pt} are item-by-year fixed effects; $\alpha_{X_i t}$ are interactions of other procurement i characteristics (X_i) and year fixed effects such as number of genuine participants-by-year fixed effects and government institution-by-year fixed effects.

Table 2 presents the results of the specifications in which the outcome variable is the logarithm of the procured price. Column I reveals that auctions with kamikaze firms have 11.7% higher prices than other similar auctions for the same items, the same number of bidders, and occurring in the same year. To address the alternative that this overpricing is not due to some government institutions being less efficient, we further compare auctions for the same institution and year in column II. Even after adding these controls, the kamikaze behavior is still associated with a 9.7% price increase, suggesting that the presence of kamikaze firms

significantly drives up costs, regardless of the procuring institution's efficiency.[10]

We now further investigate the bidding behavior of genuine bidders. We analyze two additional outcomes that capture competitive intensity among genuine participants: the number of bids submitted per non-kamikaze firm and the standard deviation of non-kamikaze bids normalized by the average bid. Columns III to VI of Table 2 show the findings: non-kamikaze firms submit, on average, 1.075 to -0.854 fewer bids in kamikaze auctions (columns III and IV), and exhibit 3-5% lower relative variability of their bidding (columns V and VI). These findings indicate that kamikaze presence systematically reduces competitive intensity, which is consistent with the higher prices.

We address two potential explanations for the observed overpricing in kamikaze auctions that are alternative to lower competition. First, the effect on prices might be due to differences in winner characteristics in kamikaze and non-kamikaze auctions. Overpricing could be explained by winners in kamikaze auctions being less efficient, having higher costs, or using different technologies, and thus consistently charging higher prices for their items than winners in non-kamikaze auctions. We address this alternative by comparing procurements within the same winner by controlling for winner-by-item-by-year fixed effects in Table 3. The magnitude of the coefficient on price drops to about 3.4% (column I) from 11.74%, but it remains statistically significant. Overall, while kamikaze auctions seem to have winners that generally charge larger prices than winners in non-kamikaze auctions, we still find significant overpricing when we compare procurements within the same eventual winner.[11]

Second, we further examine whether winner firm's relationships with a particular government institution or even auctioneer might fully explain our findings. In column III of Table 3, we compare kamikaze and non-kamikaze auctions for the same winner-government institution-item-year combination. If institutional favoritism were driving our results, we would expect similar overpricing regardless of kamikaze presence when the same institution and winner are involved. However, we find that overpricing persists with coefficients virtually unchanged from specifications in columns I and II, suggesting that winner favoritism is unlikely to explain these outcomes. In column IV of Table 3, we refine our analysis by comparing outcomes at the winner-auctioneer-item-year level. This specification serves

[10] In Internet Appendix Figure A5, we progressively remove auctions below different value thresholds and conclude that the kamikaze effect on prices remains stable (8.2% when excluding the bottom half of procurements versus 11.7% in the benchmark specification), and that they are not driven by small-value auctions. Furthermore, Internet Appendix Figure A6 shows that the kamikaze overpricing effect is persistent across years in our sample period.

[11] Another explanation for the lower estimated effect when bids are compared within the same winner is that these winners use other bid-rigging strategies in non-kamikaze auctions. Thus, the control observations may also involve bid-rigging. Still, this would suggest that given the institutional environment in which these firms operate, they find kamikaze strategies a more effective bid-rigging technique.

two important purposes: it addresses an alternative explanation to collusion that individual auctioneers within the same institution might favor different firms. When comparing procurements managed by the same auctioneer, we find that the coefficients' magnitude remains similar to our main specifications in Table 2, suggesting that the observed overpricing in kamikaze auctions is not driven by differences in winner-auctioneers match.[12] While these findings cannot definitively rule out all forms of institutional favoritism or corruption (Faccio et al., 2006; Duchin and Sosyura, 2012), they substantially narrow the range of potential alternative explanations.[13]

4.2 Coordination

The findings we have documented thus far raise natural questions about whether kamikaze withdrawals represent honest mistakes or strategic coordination. We now turn to empirically examine the linkages between kamikaze firms and eventual winners to ascertain whether withdrawals reflect coordination or honest mistakes. We provide evidence of systematic coordination. First, kamikaze and winner firms are more likely to be connected. Second, the coordination patterns react to a transparency reform that made ownership ties between the firms more salient. Third, we show that kamikaze firms are more likely to withdraw when connected firms stand to benefit. Collectively, this evidence supports that withdrawals reflect strategic coordination rather than honest mistakes.

4.2.1 Firm Connections: Shared Owners, Addresses, and Repeated Interactions

To test for coordination, we examine connections between kamikaze firms and auction winners using both observable corporate links and patterns of repeated interactions. Coordination predicts systematic relationships between kamikaze firms and the eventual winners in these auctions, while honest mistakes should produce random patterns with no consistent connections between specific firms. We match bidders to their geographic location and ownership structures using the Brazilian firm registry by *Receita Federal* to identify observable connections. Additionally, we track repeated kamikaze-winner partnerships across multiple procurement instances in the last year to capture coordination that may occur through un-

[12] In Internet Appendix Table A5, we further show that the overpricing does not vary significantly across institutions or items with higher versus lower incidence of kamikaze firms. In addition, overpricing does not differ when we compare purchases by federal and local governments. These findings reinforce the notion that institution-specific characteristics or item types do not seem to significantly explain the overpricing effect.

[13] A remaining concern is that unobserved auction characteristics might attract both kamikaze bids and higher prices. Internet Appendix Table A2 shows that when the same firm submits the lowest bid, prices are 10.3% higher when the firm quits (kamikaze) compared to when the same firm does not withdraw. The similar magnitude rules out auction-specific confounders that might attract particular bidder types.

observable networks, as persistent relationships between the same firm pairs would indicate strategic coordination rather than random bidding errors.

For this test, we focus on non-kamikaze participants in auctions with kamikazes and estimate:

$$y_{ipj} = \alpha_{ip} + \beta \cdot X_{ipj} + e_{ipj} \tag{2}$$

where y_{ipj} is *p(winner)*$_{ipj}$—a dummy equal to 1 if bidder j at procurement i for item p is the winner and zero otherwise. The main explanatory variables, X_{ipj}, include indicators for whether firm j shares owners or addresses with the kamikaze firm, and whether firm j previously won an auction in the past year with the same firm currently acting as a kamikaze. This specification adds procurement-by-item fixed effects, which effectively compares the characteristics of firms participating in the same auction.

Table 4 presents the findings. Winning firms are systematically more likely to be connected to kamikaze firms than the other participants in the same procurement.[14] Participants with at least one owner in common with the kamikaze firm are 7.82% more likely to win the procurements (column I), while those sharing an address with the kamikaze firm are 6.81% more likely to win the procurements. Finally, firms with established kamikaze partnerships, i.e., those that won auctions where the same firm acted as kamikaze within the last year, are 18.7% more likely to win the current auction (Column III). Column IV tests whether these effects reflect learning rather than coordination by controlling for general prior winning experience and prior experience with any kamikaze firm. If firms were simply learning about kamikaze behavior, we would expect general kamikaze experience to predict success. However, neither prior win with kamikaze nor prior win in general seems significantly related to winning probability, while the relationship with a specific kamikaze partner does. This suggests that success is linked to relationships with particular kamikaze firms rather than acquired knowledge about kamikaze behavior generally. Column V includes all connection variables simultaneously, and all three types of connections remain significant, indicating that ownership ties, address sharing, and repeated partnerships represent distinct coordination mechanisms.[15]

[14] The practice of allowing affiliated firms to participate in the same auction is common across jurisdictions. The European Court of Justice (Case C-538/07) and U.S. Government Accountability Office (B-183642, 1975; B-206080, 1982) have explicitly ruled that affiliated companies can submit separate bids in the same tender. This reflects the view that systematically excluding affiliated firms would reduce competition, and that ownership ties alone do not necessarily determine bidding behavior.

[15] Additionally, we find that kamikaze firms are systematically smaller and younger than winners, and maintain persistent roles across auctions—patterns consistent with special-purpose entities designed for coordination (Internet Appendix Section E provides details).

To assess the prevalence of coordination in kamikaze behavior, we define coordinated kamikaze behavior as cases where at least one of these connection indicators is present: shared owners between kamikaze and winning firms, shared business addresses, or repeated partnerships. When defined this way, we can infer that 67% of kamikaze procurements exhibit observable coordination markers.

We next investigate how these coordination mechanisms affect overpricing. We re-estimate equation (1) by interacting the *Has Kamikaze* dummy with the dummy on whether kamikaze firms and winner firms are connected, i.e., either have shared ownership or share addresses. Table 5 presents the estimates. Columns I and II show that procurements with common owners and kamikazes are 7.25-9.93% more overpriced than procurements with kamikaze firms but without common owner winning firms, representing 75-85% of the unconditional effect of having a kamikaze firm in an auction. Moreover, columns III and IV show that sharing the same address increases overpricing by 3.4-5.2%, representing up to 44% of the unconditional effect of having a kamikaze firm in an auction. For repeated partnerships, kamikaze auctions with established partnerships (upper quartile of partnership intensity) exhibit 5.6-5.8% higher overpricing than those without such history, representing 56-67% of the unconditional kamikaze effect (columns V and VI). Thus, overpricing is systematically higher when kamikaze-winner pairs have connections.

These findings provide suggestive evidence of coordination between winners and kamikaze firms. The systematic patterns of shared ownership, addresses, and repeated partnerships, combined with the associated higher overpricing, strongly indicate that kamikaze behavior reflects strategic coordination rather than honest mistakes or random occurrences. Moreover, this evidence points specifically to *ex-ante* coordination between winners and kamikaze firms. One alternative explanation could have been that kamikaze firms do not coordinate their behavior with the winning firms *ex-ante* but rather "blackmail" them *ex-post*. The overpricing then could reflect the anticipated side payment to the kamikaze firm. Given that kamikaze and winning firms are more likely to have systematic relationships, such arm's-length *ex-post* bargaining is less likely. The dropping out of the auction is also quite immediate — within minutes — which is unlikely with *ex-post* bargaining, unless it is quite sophisticated.

4.2.2 Transparency Reform and Coordinated Kamikaze Behavior

High-dimensional fixed effects in Section 4.1 likely control for most unobserved factors that could be related to both the selection of firms into kamikaze behavior and procurement prices. Yet to provide additional evidence that we are capturing bid-rigging behavior related to overpricing, we study a 2014 transparency reform introduced in the ComprasNet

electronic procurement system. This reform allowed auctioneers to access information on participants with overlapping ownership, presumably increasing the costs of coordinating kamikaze behavior among firms with shared ownership. Indeed, as shown in Internet Appendix Figure A7, the fraction of public procurements with participants that shared ownership with other participants in the same auction dropped after 2014.[16] This suggests that firms that relied on shared ownership to coordinate their kamikaze strategies found such actions more costly after the reform and might have ceased their actions or turned into second-best strategies.

To analyze the impact of this transparency reform, we employ a difference-in-differences (DID) approach. The regression specification is as follows:

$$y_{ijpt} = \alpha_j + \alpha_{pt} + \alpha_{X_it} + \beta \cdot SharedOwnership_j \cdot Post_t + e_{ijpt} \tag{3}$$

where i refers to the procurement, j to the firm, p to the item, and t to the quarter. The variable $Post_t$ is a dummy equal to 1 if the year is greater than or equal to 2014 and zero otherwise. $SharedOwnership_j$ represents the fraction of kamikaze auctions won by firm j before 2014, in which it also shared ownership with the kamikaze firm. We restrict our sample to firms that won at least once in kamikaze auctions before 2014.

We look at three outcomes: the price for item p in procurement i; the probability of firm j winning procurement i with the use of kamikaze strategy; and the probability of firm j having shared ownership with another participant in the procurement i.

Table 6 presents the estimates from specification (3). Our findings indicate that the introduction of the shared ownership alert had the effect of decreasing prices charged in procurements after 2014. A 10 p.p. increase in $SharedOwnership_j$ is associated with a 3% decrease in prices for the same item around this transparency reform (columns I and II). The probability of winning a kamikaze auction also decreases significantly, with a 10% increase in $SharedOwnership_j$ being associated with a 0.7% reduction in the winning probability (columns III and IV). Finally, columns V and VI show that the probability of firms sharing ownership in the same procurement declines substantially after the reform for firms with higher $SharedOwnership_j$ value.

Finally, to validate the use of this transparency reform for identification, we look at the

[16]The transparency reform enhanced visibility of shared ownership between bidders. Discussions with competition lawyers suggest 2014 as the effective enforcement date of this reform, coinciding with Brazil's anti-corruption law (Lei 12.846/2013), which imposed substantial fines for collusive bidding. Simultaneously, the Brazilian Federal Court of Accounts (or *Tribunal de Contas da União*, TCU) jurisprudence evolved to treat firms with shared ownership as potentially compromising competition, creating a decisive enforcement shift that altered firms' behavior.

pre-trends in price behavior for treated versus control firms. Figure 4 plots the evolution of prices for procurements involving treated and control firms over time, both before and after the transparency reform in 2014. This figure shows no differential trends in the procurement prices between firms with higher and lower $SharedOwnership_j$ before the reform in 2014, which is consistent with the validity of the parallel trends assumption. On the other hand, after 2014, prices seem to drop for firms with higher $SharedOwnership_j$ value.

Overall, these estimates provide evidence that the introduction of the shared ownership alert in the ComprasNet system reduced prices, the likelihood of firms engaging in kamikaze behavior with shared ownership, and the prevalence of shared ownership among firms in procurement auctions. Taken together, these findings suggest that shared ownership has been used to coordinate the behavior between the kamikaze and winner firms.

4.2.3 Regression Discontinuity Evidence of Strategic Coordination

We provide additional evidence of coordination using a regression discontinuity design (RDD) that directly isolates strategic incentives from honest mistakes or selection bias explanations. This RDD exploits quasi-random variation in who benefits from kamikaze withdrawals. We examine auctions in the same year and with the same potential kamikaze firm submitting the lowest bid, but the second and third-lowest bidders alternating between connected and unconnected firms with very similar bid values.

Following Ferraz et al. (2021), we leverage the fact that Brazil's electronic reverse auctions end at a random time and focus on auctions with active bidding until the final moments.[17] When connected and unconnected firms have nearly identical bids for second place, the identity of the firm just ahead when the auction ends is as-good-as-random from the kamikaze firm's perspective. This randomness is evidenced by the fact that looking back just 5 seconds from the auction's end, the firm that eventually became the second-lowest bidder was in second place only 50% of the time, demonstrating that final rankings among closely competing firms are highly unpredictable. Therefore, any difference in withdrawal behavior must therefore be due to the strategic value of benefiting connected firms rather than firm-specific traits that drive both connections and mistakes.

We estimate the following specification:

$$\mathrm{y}_{ipt} = \alpha_{jt} + \beta \cdot \text{Connected Ahead}_{ipt} + f(\text{Bid Gap}_{ipt}) + e_{ipt} \tag{4}$$

[17] We restrict our analysis to auctions with at least two bidders submitting bids in the final 30 seconds to ensure that final rankings reflect the unpredictable nature of auction endings rather than early strategic positioning.

where y_{ipt} is an indicator for whether the lowest bidder withdraws in procurement i for item p. Connected Ahead$_{ipt}$ is a dummy variable equal to one when the connected firm has the lower bid (is in second place), and zero otherwise. Connected firm is defined as a firm that share ownership, addresses, or has had repeated partnerships with the kamikaze firm within the last year. Our running variable (Bid Gap$_{ipt}$) is the bid difference between connected and unconnected firms competing for second place: (Connected firm's bid - Unconnected firm's bid). $f(\cdot)$ is a flexible polynomial function of the running variable.

If withdrawals reflect honest mistakes, firms should be equally likely to withdraw regardless of whether a connected or unconnected firm would benefit. Thus, withdrawal rates should be smooth across the threshold ($\beta = 0$). However, we observe in Table 7 a sharp discontinuity at the threshold: the same lowest-bidding firm is 5.4 to 9.8 p.p. more likely to withdraw when the connected firm is barely ahead for second place compared to when the unconnected firm is barely ahead for second place. This represents a 15.2 to 27.6% increase relative to the baseline withdrawal rate and is robust across different bandwidths (5%, 2.5%, and optimal). These results are also presented in a visual format in Internet Appendix Figure A8.

This jump at the threshold confirms that kamikaze withdrawals represent deliberate coordination rather than honest mistakes. Importantly, this effect likely understates the full coordination impact, as this particular design only identifies on the cases when genuine competitors remained in close contention despite kamikaze presence and not when intimidation successfully deters aggressive bidding by non-coordinating firms.

5 Real Effects

So far, this paper has shown that kamikaze behavior has a strong effect on the prices of items purchased by government institutions. We further discuss how such kamikaze behavior is related to real non-market outcomes, i.e., going beyond product markets, labor markets, or financial markets. We argue that such effects can happen in at least two ways. First, bid-rigging in general and kamikaze behavior in particular place financial strains on government institutions, and such overspending can negatively impact the remaining budgets of these institutions. The financial constraints arising endogenously from collusion could have negative externalities on the ability of the involved agencies to provide essential services to the public. To this effect, we first show in an overall sample that more purchases in the kamikaze auctions are related to higher financial strain on government institutions by reducing the likelihood that they will purchase items in the future. We then zoom in to one particular sector to study whether this is associated with the negative effects of the public

service provision. In particular, we study the medical sector after the essential medicine procurements had the involvement of kamikaze firms.

Second, the quality of public services can be compromised because the winners in kamikaze auctions are not necessarily the most efficient firms with the highest-quality suppliers. This, in turn, hampers public institutions from delivering high-quality public services. We study this by examining service quality in terms of the cost overruns and the days of contract completion across all auctions in our data. We then again investigate the real effects in one particular sector: road accidents that are likely to occur due to lower-quality road maintenance by the winners of kamikaze auctions.

5.1 Institution Budgets

To understand how kamikaze auctions affect future public purchases for the same item as well as for other items, we estimate the following specifications:

$$log(q)_{ap,t+1:t+4} = \alpha_{ap} + \alpha_{at} + \alpha_{pt} + \beta \cdot Kamikaze\ Share_{apt} + e_{apt} \tag{5}$$

$$log(q)_{ap,t+1:t+4} = \alpha_{ap} + \alpha_{at} + \alpha_{pt} + \beta \cdot Kamikaze\ Share_{ap^*t} + e_{apt} \tag{6}$$

where in specification (5) the independent variable $Kamikaze\ Share_{apt}$ is the fraction of total quantity purchased in kamikaze procurements by institution a for item p at year t. In specification (6), $Kamikaze\ Share_{apt}$ is the fraction of total value purchased in procurements with kamikaze firms as a fraction of total procured by institution a for other items $p^* \neq p$ at year t. The dependent variable is the logarithm of total quantity purchased by institution a for item p during the following four quarters.

Panel A of Table 8 shows that a larger share of kamikaze auctions for item p is linked to lower future purchases of the same item. This holds either at the intensive margin (column I) or at the extensive margin (column II), and similar effects appear when looking at value instead of quantity (column III). Panel B shows similar results for the cross-item effects: the larger the share of kamikaze procurements for other items $p^* \neq p$ by institution a at year t, the lower the quantity of item p purchased in the subsequent year, both in quantity (columns I and II) and value terms (column III). Overall, kamikaze auctions can affect the likelihood of future purchases due to the added pressure on the institutional budget constraints.

Back-of-the-envelope calculations on the cross-item effects in Panel B suggest consistent effects. The average annual institution expenditure across all items except p is 277 million Brazilian Reais (BRL). A 1 p.p. increase in kamikaze auctions (with 17% average overpricing) results in an average 470.9 thousand BRL (86.5 thousand USD) extra expenditures due to

kamikaze bid-rigging. With an average item purchase of 277 thousand BRL across typically 50 items, the elasticity in Column III of Panel B suggests that a 1 p.p. increase in kamikaze auctions and 471 thousand BRL overpricing is associated with lower expenditures by 277 thousand BRL in the following period.

5.2 Contract Quality

Next, we study the budget and contract execution of kamikaze auctions, where the lowest bidder withdrew after winning and the contract went to the second-lowest bidder. We observe information at the procurement-firm level regarding whether the government institution canceled the contract after it was signed with the auction winner, the amount of cost overruns, the difference between predicted and actual payments, and the days until contract completion. We estimate the following regression:

$$y_{ijt} = \alpha_{at} + \beta \cdot HasKamikaze_{ijt} + e_{ijt}, \tag{7}$$

where y_{ijt} are contract quality outcomes for procurement i, with winner firm j at time t. Has Kamikaze$_{ijt}$ is a dummy equal to 1 if procurement i, firm j, time t had a kamikaze firm and 0, otherwise. We add government institution-by-year fixed effects (α_{at}) to control for any institution time-varying shock to contract quality and incidence of kamikaze firms.

We compare these outcomes for procurements with and without kamikaze firms in Table 9. Our findings indicate that procurements influenced by kamikaze bids are 3.2% more likely to be canceled by the procuring institution due to incomplete execution (or 16.7% increase compared to the average cancellation rates). We also find a 0.6% greater chance of cost overruns, meaning expenses that exceed the initial budget projections. Additionally, the comparison of actual payments to predicted costs reveals a 1 p.p. higher ratio in instances of kamikaze bidding. Lastly, these procurements commonly encounter extended delays, with 16% longer delivery timelines than that of comparable procurements without kamikaze bids. All in all, winners in kamikaze auctions deliver inferior contract performance, adding on to overpricing and further straining government resources.

5.3 Hospital Mortality

We analyze data on hospital mortality for 61 federal hospitals in Brazil obtained from DataSUS. To investigate whether bid-rigging behavior is associated with worse mortality rates, we identify hospital-disease pairs where a high proportion of emergency room medication

purchases are made in kamikaze procurement auctions.[18] For each of these hospital-disease pairs, we select control hospital-disease pairs that purchase emergency room medications in the same quarter that are not predominantly made in kamikaze auctions. In the end, we have information from 34,782 essential medicines purchases. Of these, 1,527 were awarded in kamikaze auctions and 33,255 in non-kamikaze auctions. We then stack these events into cohorts and compare health outcomes around the purchase date in a "stacked" DID method (e.g., Gormley and Matsa, 2011; Cengiz et al., 2019; Deshpande and Li, 2019) as follows:

$$y_{iet} = \alpha_{ie} + \alpha_{et} + \beta \cdot KamikazeAuction_{ie} \cdot Post_{et} + u_{iet} \tag{8}$$

where y_{iet} refers to the mortality rate of hospital i in cohort e at time t. *Kamikaze Auction*$_{ie}$ is a dummy equal to one if the procurement in hospital i for cohort e is a kamikaze auction and zero otherwise. $Post_{et}$ is a dummy equal to one after the purchase in cohort e and zero otherwise. We control for cohort-by-year fixed effects and hospital-by-cohort fixed effects, with the latter effectively accounting for time-invariant differences in hospital characteristics, such as hospital quality, allowing us to isolate the impact of kamikaze auctions on mortality.

Table 10, columns I and II, show that kamikaze auctions of essential medicines are associated with a 0.78-0.79 p.p. higher mortality rate for the particular cause, looking at 2- and 3-years windows around the event, respectively. This corresponds to an approximately 19% increase from the unconditional average mortality rate. These initial estimates are robust to time-invariant factors at the hospital-cause level and allow for comparisons of mortality rates across different hospitals for the same cause.

One alternative explanation of these findings is that hospitals experiencing kamikaze procurements might be simultaneously experiencing an unrelated decline in overall patient care effectiveness. To address this, columns III and IV introduce additional controls in the form of hospital-event-year fixed effects. These controls account for any hospital time-varying factors that might influence mortality rates independently of whether the procurement had kamikaze incidence or not. That is, we identify the effect for the same hospitals in the same year across different medical causes that differed in the incidence of kamikaze auctions in the procurement of the medicine to treat these causes. The estimates from this more stringent specification remain robust. For the 2-year window (column III), the estimated effect slightly increases to 0.85 p.p., reinforcing our initial findings. In the 3-year window (column IV), the effect decreases to 0.53 p.p.

[18] We classify hospital-disease pairs as "treated" when at least 90% of their purchases in the same quarter are made in kamikaze auctions. For each illness type, we take the essential medicines used to treat these diseases from the World Health Organization (2013) report and listed in Internet Appendix Table A11.

To further explore the impact of kamikaze auctions, we focus on the top three causes of mortality (infections, circulatory diseases, and respiratory diseases) in columns V and VI. We find even larger estimates, ranging from 0.93 to 1.09 p.p. This represents an increase of 10-11% increase from the unconditional average mortality rate for the main causes. These findings suggest that kamikaze auctions may have a particularly pronounced impact on the most critical medical supplies.

Finally, we investigate whether the trends in the mortality outcomes are different for hospitals with kamikaze auctions compared to those without them before the respective auctions. In Panel A of Figure 5, we provide a visual representation of the effect of kamikaze auctions on hospital mortality that tests the parallel trends assumption. The graph shows that the differences in the mortality rates are only observable after the occurrence of the kamikaze auctions. Before these auctions, treated and control hospitals seemed to follow similar trends, providing support to our identification strategy.

The increase in mortality rate is comparable to that found in the literature for other hospital policies. For instance, Nelly et al. (2010) documents a decrease of 18% in the mortality rate after a hospital training program by the Veterans Health Association. To further validate our mortality estimates against existing medical literature, we calculate the elasticity between reduced medical spending and mortality outcomes. With kamikaze bidding present in 17% of auctions (Table 1), we document a 47% reduction in future purchases, based on the log-linear regression ($1 - e^{-0.0377 \cdot 17}$, where -3.77% comes from Table 8, Panel A). Kamikaze auctions are associated with a 0.78 p.p. increase in mortality, representing a 19% increase from the 4.1% baseline rate. The resulting elasticity of -0.40 (19%/47%) is smaller than existing estimates of lower medical spending elasticities from Martin et al. (2008) (-1.4 for circulatory diseases, -0.5 for cancer) and Almond et al. (2010) (-1.2 for low birth weight infants),[19] suggesting our mortality effects are within bounds consistent with the literature.

Overall, these findings suggest that for financially constrained government institutions such as medical hospitals, bid-rigging could lower the budgets available for other procurement auctions and thus reduce the quality of public service provision.

5.4 Road Accidents

In addition to hospital mortality, we also look at the effects on road quality as another real outcome of bid-rigging in kamikaze auctions. We take information from 1061 road repair contracts. Of these, 389 were awarded in kamikaze auctions and 672 in non-kamikaze

[19] This elasticity is derived from 11% increase in hospital charges for infants below 1,500 grams and a 0.7 p.p. decrease in mortality (13% of the average). See Almond et al. (2010) for details.

auctions. We then compare road accidents from *Polícia Rodoviária Federal* data following the road repairs that involve kamikaze auctions and those that do not involve kamikaze auctions. That is, for each road repair with kamikaze auction, we select non-kamikaze road repairs awarded in the same quarter as a control group.

To directly measure quality differences in road repairs, we conduct a cross-sectional analysis comparing the timing of when the road maintenance gets recontracted for new maintenance. We compare the timing for kamikaze and non-kamikaze road repairs in Panel A of Table 11. Using procurement data, we find that 36% of the roads in our sample undergo more than one repair, and among these roads requiring multiple repairs, subsequent maintenance occurs 3.5 years after the previous maintenance work. However, roads repaired through kamikaze auctions require subsequent maintenance 25.8% sooner than this standard cycle (column I), representing about 0.93 years earlier maintenance (column II). Columns III and IV show that kamikaze auctions also increase the probability of requiring any further maintenance by 10.7 p.p. and the probability of early recontracting (within 3 years, which is the median in our sample) by 21 p.p. According to established industry guidelines (Minnesota Department of Transportation, 2000), properly executed road surface maintenance treatments typically last between 3 to 8 years, depending on the specific method used. This shortened lifespan in kamikaze auction projects suggests that the firms ultimately winning these contracts are less qualified to provide quality services, despite charging higher prices than would have resulted from genuine competitive bidding.

These quality deficiencies are reflected in increased safety incidents. Panel B of Table 11 shows the estimates comparing accidents between road maintenance contracts awarded in kamikaze versus non-kamikaze auctions using a "stacked" DID approach similarly as in the specification (8) above. In addition, we control for the length of the road extension which compares maintenances of similar complexity. For this analysis, we distinguish between two types of accidents: (1) those caused by road fault conditions — including potholes, uneven pavement, poor signage, inadequate lighting, slippery surfaces, among others — and (2) those not due to road conditions, such as speeding, drunk driving, and distracted driving.[20]

The findings reported in column I show that roads maintained by kamikaze auction winners are associated with a 13.7% higher number of accidents due to road conditions, while column III shows a 9.6% increase in victims from such accidents.[21] At the same time, columns II and IV report that kamikaze auctions have no significant effect on non-road-fault acci-

[20] Internet Appendix Table A12 presents a list of the accident causes from Brazil's Federal Highway Patrol.

[21] This increase in accidents is comparable to other findings in the literature: Faccio and McConnell (2020) document 48% more accidents and 27% more injuries following the introduction of Pokémon GO in the US, while Grundy et al. (2009) show 42% fewer casualties after implementing 20mph zones in London.

dents or their victims. This non-effect on non-road-fault accidents suggests that alternative reasons unrelated to kamikazes auctions that could explain the increase in accidents in these areas, such as changes in driver behavior or increased traffic, are unlikely.

Another identification challenge is that kamikaze contracts could have been systematically awarded to roads already experiencing worsening accident trends, and so our estimates would capture these pre-existing differences rather than effects of maintenance quality. Panel B of Figure 5 shows that the effect on accidents due to road conditions only comes after the purchase and that there are no clear diverging trends before the procurement. The combination of parallel pre-trends and the specificity of the effects to road-fault accidents in Table 11 is strong evidence that our findings are explained by lower quality maintenance in contracts awarded through kamikaze auctions rather than other confounding factors.

We posit that the reasons why kamikaze auctions result in lower-quality public services could be different than those explaining an increase in hospital mortality rates. In the latter case, the essential medicines have precise specifications and are unlikely to differ in quality but can differ in procured price. This, however, implies reduced residual budgets to acquire other medicines and services, which eventually affect hospital mortality, especially in preventable cases. On the other hand, different from hospitals, the procured service quality in road repair is difficult to contract and verify. Our findings on shortened maintenance cycles provide direct evidence that kamikaze auctions lead to inferior road quality. This illustrates another channel through which bid-rigging in public procurements can affect real outcomes — via lower quality of the procured services themselves.

6 Conclusion

This study documents that bid-rigging in public procurement auctions is associated with both overpricing and worse quality of public services. We use the kamikaze strategy as a bid-rigging marker and show that this tactic, observed in about 17% of Brazilian procurement auctions, inflates prices by 11.7% and often involves firms that share common owners and business addresses. Beyond fiscal costs, this behavior affects real outcomes by constraining institutional budgets and by selecting suboptimal government suppliers. Ultimately, we document that kamikaze auctions correlate with increased hospital mortality rates and more road accidents following maintenance services. Our findings highlight the broader implications of bid-rigging in public procurements on public service provision.

Our findings about the effects of bid-rigging have broader implications beyond the specific kamikaze strategy we study. In different procurement formats, such as first-price sealed bid

auctions, firms can coordinate to reduce competition through various strategies, such as bid rotation (Kawai et al., 2023), market division (Pesendorfer, 2000), or complementary bidding (Porter and Zona, 1993; Bajari and Ye, 2003; Clark et al., 2018). Like the kamikaze strategy, these methods all serve to reduce competition, whether through explicit coordination or strategic deterrence. While the implementation differs, the fundamental economic forces remain the same: successful coordination raises prices and depletes public budgets at the same time as favoring cartel firms over potentially more efficient providers. Thus, our findings likely extend to other collusive strategies across different institutional contexts.

Moreover, our research yields a few policy recommendations. First, it documents that more transparency on ownership ties among auction participants can raise the costs of implementing bid-rigging strategies. This finding supports policies that improve data-sharing practices, particularly with auctioneers involved in the procurement process. Second, and more broadly, our findings suggest that antitrust authorities could be granted direct mandates to consider non-market outcomes — such as public health and infrastructure quality — in their investigations. Expanding the scope of antitrust supervision would more effectively address the significant negative spillovers of bid-rigging in public procurements.

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Table 1: *Summary Statistics*

	n	mean	std dev	p1	median	p99
Auction Variables						
$\log(\text{price})_{ipt}$	14,967,474	3.107	2.324	-2.303	2.996	9.401
Has Kamikaze_{ipt}	14,967,462	0.171	0.376	0.000	0.000	1.000
# $\text{Participants}_{ipt}$	14,967,474	6.838	5.509	1.000	5.000	165.000
# $\text{Kamikaze firms}_{ipt}$	14,967,464	0.357	1.095	0.000	0.000	54.000
# $\text{bids per bidder}_{ipt}$	14,913,088	4.263	5.510	1.000	2.060	33.500
$\sigma(bid)/\overline{bid}_{ipt}$	14,913,075	0.748	0.977	0.000	0.407	5.349
Has $\text{Shared Owners}_{ipt}$	14,967,474	0.020	0.139	0.000	0.000	1.000
Has $\text{Shared Address}_{ipt}$	14,967,474	0.030	0.172	0.000	0.000	1.000
Frac Repeat Partnership_{ipt}	2,586,304	0.084	0.146	0.000	0.0227	1.000
Auction-Participant Variables						
Repeat Partnership_{ipj}	19,362,473	0.381	0.486	0.000	0.000	1.000
Same Address_{ipj}	19,362,473	0.023	0.048	0.000	0.000	1.000
Same Owners_{ipj}	19,362,473	0.001	0.031	0.000	0.000	1.000
p(winner)_{ipj}	19,362,473	0.132	0.338	0.000	0.000	1.000
Procurement-Winning Firm Variables						
p(canceled)_{ijt}	571,931	0.192	0.394	0.000	0.000	1.000
$\text{p(cost overrun)}_{ijt}$	571,931	0.051	0.219	0.000	0.000	1.000
$\text{Payment/Predicted}_{ijt}$	571,931	0.602	0.591	0.000	0.643	3.815
$\log(\text{days})_{ijt}$	557,985	4.846	0.964	2.565	4.890	7.085
Hospital-Cause-Cohort Variables						
$\text{mortality (all)}_{iet}$	997,503	0.041	0.058	0.000	0.021	0.308
$\text{mortality (main)}_{iet}$	168,186	0.095	0.070	0.000	0.078	0.333
Road-Cohort Variables						
$\log(\text{accidents})_{iet}$ (road-fault)	28,207	2.218	1.111	0.000	2.303	4.477
$\log(\text{accidents})_{iet}$ (non-road-fault)	30,942	3.830	1.595	0.000	4.174	6.672
$\log(\text{victims})_{iet}$ (road-fault)	27,035	1.813	1.063	0.000	1.946	4.060
$\log(\text{victims})_{iet}$ (non-road-fault)	30,519	3.451	1.434	0.000	3.761	5.999

This table presents summary statistics for key variables (2005-2021). Subscripts i, p, t, and j denote procurement, item, time, and participating firm, respectively. Log(price)_{ipt} is the purchase price logarithm. $\text{Has Kamikaze}_{ipt}$ indicates procurements that had firms that had the lowest bid but did not win the procurement because they did not satisfy the final formalities required to be declared the winner by, for instance, withdrawing, not submitting the required documents, or providing inadequate documentation. # $\text{Participants}_{ipt}$ and # $\text{Kamikaze firms}_{ipt}$ count bidders and kamikaze firms. # $\text{bids per bidder}_{ipt}$ and $\sigma(bid)/\overline{bid}_{ipt}$ measure bidding behavior and dispersion among non-kamikaze firms. Has $\text{Shared Owners}_{ipt}$, Has $\text{Shared Address}_{ipt}$, Same Address_{ipj}, Same Owners_{ipj} capture observable relationships between bidders. Frac Repeat Partnership_{ipt} measures the frequency of prior kamikaze-winner partnerships between the same firm pairs relative to the winner's total victories within the last year (variable calculated only for procurements with kamikaze behavior). Repeat Partnership_{ipj} is a dummy variable indicating whether firm j has previously partnered with the kamikaze firm within the last year. P(winner)_{ipj} is bidder j's winning probability. For winning firms, p(canceled)_{ijt}, $\text{p(cost overrun)}_{ijt}$, $\text{Payment/Predicted}_{ijt}$, and $\log(\text{days})_{ijt}$ measure execution outcomes. Hospital variables track mortality rates, while road variables measure accidents and victims by cause (road-fault vs. non-road-fault).

Table 2: *Kamikaze Firms and Procurement Outcomes*

	$\log(\text{price})_{ipt}$		# bids per bidder_{ipt}		$\sigma(bid)/\overline{bid}_{ipt}$	
	I	II	III	IV	V	VI
$\text{Has Kamikaze}_{ipt}$	0.1174***	0.0970***	-1.075***	-0.8540***	-0.0531***	-0.0347***
	(0.0054)	(0.0043)	(0.0217)	(0.0152)	(0.0033)	(0.0024)
Obs	14,967,462	14,967,462	14,967,403	14,967,403	14,967,403	14,967,403
R^2	0.865	0.870	0.178	0.227	0.366	0.431
Item*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
# of Genuine Bidders*Year Fes	Yes	Yes	Yes	Yes	Yes	Yes
Gov Institution*Year FEs		Yes		Yes		Yes

This table compares outcomes of procurements with and without the presence of Kamikaze firms. Kamikaze firms are those that have the lowest bid but do not win the procurement because it does satisfy the final formalities to be declared the winner. We implement the following specification:

$$y_{ipt} = \alpha_{pt} + \alpha_{X_i t} + \beta \cdot HasKamikaze_{ipt} + e_{ipt}$$

$\text{Has Kamikaze}_{ipt}$ equals to 1 if a firm has the lowest bid, but does not win procurement i for product p in year t, and 0 otherwise. y_{ipt} is is either log of the price for item p purchased in procurement i at time t (columns I and II), the average number of bids per bidder of log of procurement i for item p at time t (columns III and IV), or the ratio the standard deviation of the bid value to the average bid value (columns V and VI). # bids per bidder_{ipt} and $\sigma(bid)/\overline{bid}_{ipt}$ are constructed by only considering bids of non-kamikaze firms. α_{pt} is a item-year fixed effects; $\alpha_{X_i t}$ are interactions of procurement i characteristics (X_i) and year fixed effects such as # of participants x year fixed effects and government institution x year fixed effects. Column I adds Item-Year and # of Genuine Bidders*Year fixed effects, effectively comparing procurements with the same item purchased and the same number of non-kamikaze bidders in the same year. Column II also includes Gov Institution-Year fixed effects. Finally, column III includes Gov Institution*Year and # of Participants-Item-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance of 10%, 5%, 1%, and 0.1%, respectively.

Table 3: *Kamikaze Firms and Procurement Outcomes: Additional Specifications*

	$\log(\text{price})_{ipjt}$			
	I	II	III	IV
Has Kamikaze$_{ipt}$	0.0349***	0.0307***	0.0227*	0.0242*
	(0.0047)	(0.0050)	(0.0102)	(0.0111)
Obs	14,965,838	14,965,838	14,965,838	14,765,552
R^2	0.928	0.930	0.946	0.873
Winner*Item*Year FEs	Yes	Yes		
# Genuine Bidders*Year FEs	Yes	Yes	Yes	Yes
Gov Institution*Year FEs		Yes		
Winner*Gov Institution*Item*Year FEs			Yes	
Winner*Auctioneer*Item*Year FEs				Yes

This table extends the analysis of procurement auctions with and without the presence of kamikaze firms presented in Table 2. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The dependent variable is the logarithm of the price for item p purchased in procurement i with winner firm j at time t. Has Kamikaze$_{ipt}$ is equal to 1 if procurement i for item p at time t has a kamikaze firm and 0, otherwise. Column I includes Winner-by-Item-by-Year and # Genuine Bidders-by-Year fixed effects; column II also addsGovernment Institution-by-Year fixed effects; column III includes Winner-Government Institution-Item-Year fixed effects and # Genuine Bidders-by-Year fixed effects; column IV includes Winner-by-Auctioneer-by-Item-by-Year fixed effects and # Genuine Bidders-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 2 for further details of the specifications.

Table 4: *Relationships between Kamikaze Firms and Winners*

	p(winner)$_{ipj}$				
	I	II	III	IV	V
Same Owners$_{ipj}$	0.0782***				0.0522*
	(0.0219)				(0.0207)
Same Address$_{ipj}$		0.0681***			0.0378**
		(0.0142)			(0.136)
Repeat Partnership$_{ipj}$			0.1875***	0.1843***	0.1842***
			(0.0021)	(0.0021)	(0.0021)
Repeat Win With Kami$_{ipj}$				0.0042*	0.0042*
				(0.0020)	(0.0020)
Repeat Win$_{ipj}$				0.0196***	0.0196***
				(0.0027)	(0.0027)
Obs	19,362,473	19,362,473	19,362,473	19,362,473	19,362,473
R^2	0.155	0.155	0.201	0.201	0.201
Procurement*Item FEs	Yes	Yes	Yes	Yes	Yes

This table examines whether firms with connections to kamikaze firms are more likely to win procurements. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. We estimate the following specification:

$$y_{ipj} = \alpha_{ip} + \beta \cdot X_{ipj} + e_{ipj}$$

where the dependent variable y_{ipj} is p(winner)$_{ipj}$ — a dummy equal to 1 if bidder j at procurement i for item p is the winner and zero otherwise. The independent variables are Same Owners$_{ipj}$, indicating whether firm j has the same owner as the kamikaze firm (column I), Same Address$_{ipj}$, indicating whether firm j shares the same address as the kamikaze firm (column II), and Repeat Partnership$_{ipj}$, indicating whether firm j and the current kamikaze firm have formed the same kamikaze-winner partnership in other auctions within the past 12 months (column III). Column IV includes Repeat Win With Kami$_{ipj}$, indicating whether firm j previously won any auction with any kamikaze firm in the past 12 months, and Repeat Win$_{ipj}$, indicating whether firm j won any auction in the past 12 months regardless of kamikaze presence. Column V includes all connection variables simultaneously. All columns control for Procurement-by-Item fixed effects (α_{ip}). The sample includes all participating firms except the kamikaze firms themselves, allowing us to test whether firms connected to kamikaze firms have a higher probability of winning compared to unconnected firms. Standard errors clustered at the firm level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 5: *Kamikaze Firms and Procurement Outcomes: Ownership, Address, and Partnership Effects*

	$\log(\text{price})_{ipt}$					
	I	II	III	IV	V	VI
Has Kamikaze$_{ipt}$	0.1163***	0.0964***	0.1163***	0.0966***	0.1034***	0.0839***
	(0.0054)	(0.0043)	(0.0054)	(0.0043)	(0.0044)	(0.0037)
Has Shared Owners$_{ipt}$	0.0959***	0.0702***				
	(0.0200)	(0.0158)				
Has Shared Owners & Kamikaze$_{ipt}$	0.0993^{+}	0.0725^{+}				
	(0.0537)	(0.0384)				
Has Shared Address$_{ipt}$			0.0457***	0.0212*		
			(0.0101)	(0.0099)		
Has Shared Address & Kamikaze$_{ipt}$			0.0521*	0.0341^{+}		
			(0.0256)	(0.0197)		
High Repeat Partnership$_{ipt}$					0.0589***	0.0563***
					(0.0056)	(0.0056)
Obs	14,967,462	14,967,462	14,967,462	14,967,462	14,967,462	14,967,462
R^2	0.865	0.870	0.865	0.870	0.865	0.870
Item*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
# Genuine Bidders*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Gov Institution*Year FEs		Yes		Yes		Yes

This table extends the analysis of procurement auctions with and without the presence of kamikaze firms presented in Table 2 and focuses on how the effect of kamikaze firms on pricing varies with whether they share ownership and same business address with the winners. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The dependent variable is the logarithm of the price for item p purchased in procurement i at time t. Has Kamikaze$_{ipt}$ is equal to 1 if procurement i for item p at time t has a kamikaze firm and 0, otherwise. Has Shared Owners$_{ipt}$ is a dummy equal to 1 if firms in procurement i for item p in year t have at least two firms with the same owner. Has Shared Owners & Kamikaze$_{ipt}$ equals 1 if the kamikaze firm and the winning firm share the same owner in procurement i for item p at year t. Has Shared Address$_{ipt}$ is a dummy equal to 1 if at least two firms in the procurement share the same business address, and Has Shared Address & Kamikaze$_{ipt}$ equals 1 if the kamikaze firm and the winning firm share the same business address. High Repeat Partnership$_{ipt}$ is a dummy equal to 1 if the share of the winner's victories involving the same kamikaze firm is in the upper quartile within the past 12 months. Columns I, III, and V control for Item-by-Year and # Genuine Bidders-by-Year fixed effects. Columns II, IV, and VI also include Government Institution-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 2 for further details of the specifications.

Table 6: *Transparency Reform and Procurement Outcomes*

	$\log(\text{price})_{ipt}$		$\text{p(win \& kamikaze)}_{ijpt}$		$\text{p(shared owner)}_{ijpt}$	
	I	II	III	IV	V	VI
Shared Ownership$_j$ x Post$_t$	-0.3072***	-0.2860***	-0.0730***	-0.0722***	-0.6079***	-0.5599***
	(0.0714)	(0.0782)	(0.0203)	(0.0201)	(0.0985)	(0.0845)
Obs	78,148,237	78,148,223	78,148,223	78,148,223	78,148,237	78,148,223
R^2	0.883	0.886	0.048	0.060	0.309	0.249
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Item * Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Genuine Bidders*Year FE		Yes		Yes		Yes

This table presents the DID estimates of the introduction of a shared ownership alert in the electronic procurement system in 2014. We estimate the following specification:

$$y_{ijpt} = \alpha_j + \alpha_{pt} + \alpha_{X_i t} + \beta \cdot SharedOwnership_j \cdot Post_t + e_{ijpt}$$

The treatment variable, Shared Ownership$_j$, represents the fraction of procurements pre-2014 in which firm j won an auction where a kamikaze firm participated (i.e., a kamikaze auction) and also shared ownership with the kamikaze firm in that procurement. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. $Post_t$ equals to 1 after 2014 and 0, otherwise. The dependent variables are the logarithm of the price for item p purchased in procurement i at time t, the probability a firms wins an auction that contains a kamikaze bidder in procurement i for item p in year t, and the probability of a firm sharing ownership with another firm in procurement i for item p in year t. Columns I, III, and V include Firm fixed effects and Item-by-Year fixed effects. Columns II, IV, and VI additionally control for the # Genuine Bidders-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^+$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 7: *Regression Discontinuity Evidence of Strategic Coordination*

	p(withdraw)$_{ipt}$					
	I	II	III	IV	V	VI
Connected Ahead$_{ipt}$	0.0982***	0.0747***	0.0838***	0.0633***	0.0725***	0.0540***
	(0.0045)	(0.0032)	(0.0042)	(0.0031)	(0.0042)	(0.0034)
Obs	326,113	326,113	260,019	260,019	160,016	160,016
R^2	0.677	0.784	0.678	0.783	0.649	0.766
Bandwidth	5%		2.5%		Optimal	
Firm*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Gov Institution*Year FEs		Yes		Yes		Yes

This table presents regression discontinuity estimates examining whether kamikaze firms are more likely to withdraw when connected firms would benefit from the withdrawal. We estimate the following specification:

$$\text{p(withdraw)}_{ipt} = \alpha_{jt} + \beta \cdot \text{Connected Ahead}_{ipt} + f(\text{Bid Gap}_{ipt}) + e_{ipt}$$

where the dependent variable p(withdraw)$_{ipt}$ is an indicator for whether the lowest bidder withdraws in procurement i for item p at time t. Connected Ahead$_{ipt}$ is a dummy equal to one when the connected firm has the lower bid (is in second place), and zero otherwise. Bid Gap$_{ipt}$ is the normalized bid difference between connected and unconnected firms competing for second place: (Connected firm's bid - Unconnected firm's bid). The sample includes auctions where connected and unconnected firms have very similar bids for second place, creating quasi-random variation in which type of firm would benefit from kamikaze withdrawal. The optimal bandwidth is based on the selection method from Calonico et al. (2014). Standard errors clustered at the firm level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 8: *Effect of Kamikaze Auctions on Future Purchases*

	$\log(q)_{ap,t+1:t+4}$	$q_{ap,t+1:t+4}/q_{ap,t}$	$\log(value)_{ap,t+1:t+4}$
	I	II	III
Panel A: Within-Product Effects			
Kamikaze $Share_{apt}$ (Quantity)	-0.0282^{+}	-0.0170***	-0.0377*
	(0.0148)	(0.0017)	(0.0189)
Obs	417,886	2,868,024	417,243
R^2	0.970	0.532	0.952
Gov Institution*Item FEs	Yes	Yes	Yes
Gov Institution*Quarter FEs	Yes	Yes	Yes
Item*Quarter FEs	Yes	Yes	Yes
Panel B: Cross-Product Effects			
Kamikaze $Share_{ap^*t}$ (Value)	-1.482**	-0.5110***	-2.046**
	(0.5356)	(0.0368)	(0.7281)
Obs	417,243	2,858,749	417,243
R^2	0.970	0.532	0.952
Gov Institution*Item FEs	Yes	Yes	Yes
Gov Institution*Quarter FEs	Yes	Yes	Yes
Item*Quarter FEs	Yes	Yes	Yes

This table shows the effect of kamikaze auctions on future purchases. The data is collapsed at the government institution a, item p and quarter t level. Kamikaze procurements are defined to be those auctions in which a kamikaze firm participated. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. We estimate the following specifications:

$$\begin{aligned} log(q)_{ap,t+1:t+4} &= \alpha_{ap} + \alpha_{at} + \alpha_{pt} + \beta \cdot Kamikaze\ Share_{apt} + e_{apt} \\ log(q)_{ap,t+1:t+4} &= \alpha_{ap} + \alpha_{at} + \alpha_{pt} + \beta \cdot Kamikaze\ Share_{ap^*t} + e_{apt} \end{aligned}$$

where in the first specification the independent variable $Kamikaze\ Share_{apt}$ is the fraction of total quantity purchased in kamikaze procurements by institution a for item p at quarter t (Panel A). In the second specification, $Kamikaze\ Share_{ap^*t}$ is the fraction of total value purchased in kamikaze procurements by institution a for other items $p^* \neq p$ at quarter t (Panel B). The dependent variables are the logarithm of total quantity purchased by institution a for item p during the following 4 quarters, i.e., t+1 to t+4 (column I); the ratio between the quantity procured by institution a purchase item p in the following 4 quarters and in the current quarter (column II); and the logarithm of total value purchased by institution a for item p during the following 4 quarters, i.e., t+1 to t+4 (column III). All columns control for Government Institution-by-Item (α_{ap}), Government Institution-by-Year (α_{at}), and Item-by-Quarter (α_{pt}) fixed effects. Standard errors clustered at the institution-item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 9: *Kamikaze Auctions on Contract Quality*

	p(cancelled)$_{ijt}$	p(cost overrun)$_{ijt}$	$\left(\frac{Payment\$}{Predicted\$}\right)_{ijt}$	log(days)$_{ijt}$
	I	II	III	IV
Has Kamikaze$_{ijt}$	0.0322***	0.0060***	0.0105***	0.1602***
	(0.0017)	(0.0010)	(0.0020)	(0.0036)
Obs	571,931	571,931	571,931	557,985
R^2	0.162	0.253	0.255	0.205
Unconditional Avg	0.0963	0.0247		
Gov Institution*Year FEs	Yes	Yes	Yes	Yes

This table compares outcomes of procurement auctions with and without the presence of kamikaze firms. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. We estimate the following specification:

$$y_{ijt} = \alpha_{at} + \beta \cdot \text{Has Kamikaze}_{ijt} + e_{ijt}$$

where y_{ijt} are contract quality outcomes for procurement i, with winner firm j at time t: the probability that the contract is canceled for procurement i for winner firm j at time t (column I); the probability that the contract has cost overruns for procurement i by winner firm j at time t (column II); the fraction of actual payment over predicted one for procurement i for winner firm j at time t (column III); and the logarithm days for completion of contracts for procurement i by winner firm j at time t (column IV). Has Kamikaze$_{ijt}$ is equal to 1 if procurement i by winner firm j at time t has a kamikaze firm and 0, otherwise. All specifications control for Government Institution-by-Year fixed effects (α_{at}). Standard errors clustered at the contract-item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 10: *Kamikaze Essential Medicine Procurements and Hospital Mortality*

	mortality rate$_{iet}$					
	All Causes				Top 3	
	I	II	III	IV	V	VI
KamikazeAuction$_{ie}$·Post$_{et}$	0.0078***	0.0079***	0.0085*	0.0053^{+}	0.0093*	0.0109**
	(0.0020)	(0.0020)	(0.0033)	(0.0030)	(0.0039)	(0.0041)
Window	2y	3y	2y	3y	2y	3y
Obs	675,718	997,503	675,718	997,503	113,673	168,186
R^2	0.769	0.719	0.788	0.746	0.906	0.872
Hospital*Cohort*Cause	Yes	Yes	Yes	Yes	Yes	Yes
Cause*Cohort*Year	Yes	Yes	Yes	Yes	Yes	Yes
Hospital*Cohort*Year			Yes	Yes		

This table compares hospital excess death outcomes between essential medicine purchased via kamikaze versus non-kamikaze auctions. Kamikaze auctions are defined to be those auctions in which a kamikaze firm participated. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. For each kamikaze auction, we select non-kamikaze auctions that happened in the same quarter. We stack these events in a "stacked" DID design as in the following equation:

$$y_{iet} = \alpha_{ie} + \alpha_{et} + \beta KamikazeAuction_{ie} \cdot Post_{et} + u_{iet}$$

where the dependent variable y_{iet} is the ratio between deaths and number of inpatients in hospital i, cohort e and year t. The main independent variable $KamikazeAuction_{ie}$ is equal to 1 if the purchase of essential medicine for hospital i in cohort e was made via a kamikaze auction and 0, otherwise. Post$_{et}$ is a dummy equal to one after the contracts were awarded and 0, otherwise. Columns I-IV present results for all causes, while columns V-VI focus on the top 3 causes. Odd-numbered columns use a 2-year window around each event, and even-numbered columns use a 3-year window. All regressions control for Hospital-Cohort-Cause and Cause-Cohort-Year fixed effects, with columns III and IV also include Hospital-Cohort-Year fixed effects. Standard errors clustered at the cohort level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

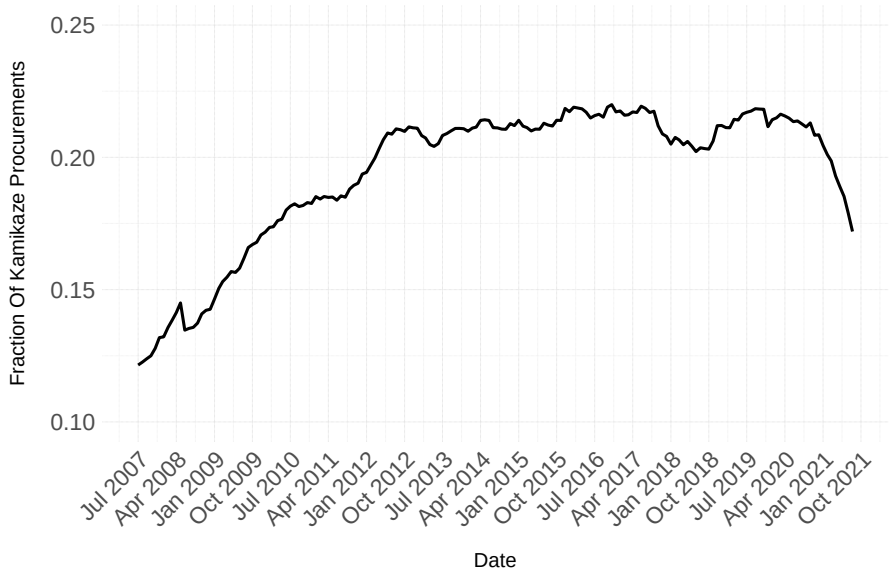
Table 11: *Kamikaze Road Repair Procurements and Road Accidents*

Panel A: Recontract Time				
	$\log(\text{years})_{ie}$	years_{ie}	p(recontr.)_{ie}	$\text{p}(< 3 \text{ years})_{ie}$
	I	II	III	IV
$\text{KamikazeAuction}_{ie}$	-0.2582**	-0.9292***	0.1067***	0.2098**
	(0.0917)	(0.2352)	(0.0273)	(0.0670)
Obs	2,133	2,133	6,777	2,133
R^2	0.531	0.479	0.476	0.585
Road Extension*Cohort	Yes	Yes	Yes	Yes

Panel B: Accidents by Fault Type				
	$\log(\text{accidents})_{iet}$		$\log(\text{victims})_{iet}$	
	Road	Non-Road	Road	Non-Road
	I	II	III	IV
$\text{KamikazeAuction}_{ie} \cdot \text{Post}_{et}$	0.1370**	0.0088	0.0962^{+}	-0.0108
	(0.0469)	(0.0425)	(0.0507)	(0.0382)
Obs	28,207	31,250	27,035	30,880
R^2	0.927	0.973	0.893	0.971
Cohort*Road	Yes	Yes	Yes	Yes
Road Extension*Cohort*Year	Yes	Yes	Yes	Yes

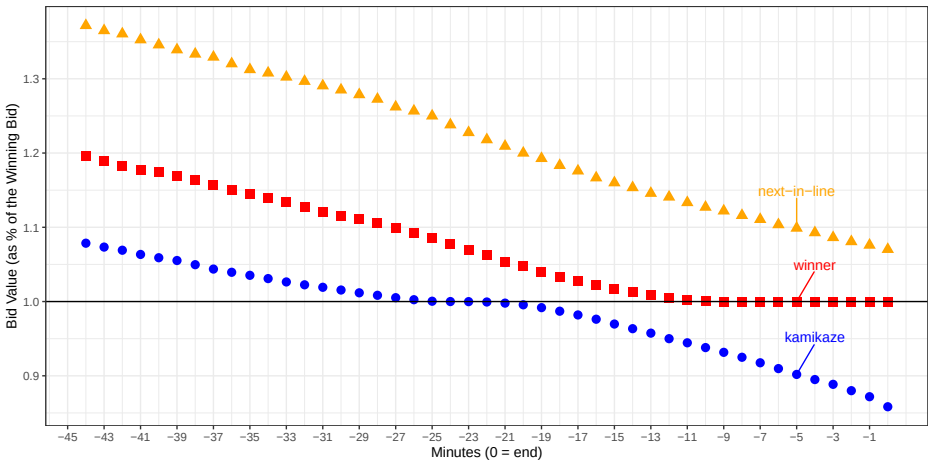
This table compares outcomes between road repair contracts awarded via kamikaze vs non-kamikaze auctions. Kamikaze auctions are defined to be those auctions in which a kamikaze firm participated. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The specification is similar as the one from Table 10: For each road maintenance contract awarded through a kamikaze auction (where the original lowest bidder withdrew), we select as controls road maintenance contracts awarded through standard competitive auctions (where the lowest bidder successfully won) that occurred in the same quarter in a "stacked" DID design. The main independent variable $\textit{KamikazeAuction}_{ie}$ is equal to 1 if the road repair was awarded in a kamikaze auction and 0, otherwise. Panel A presents a cross-sectional analysis of recontract timing. The dependent variables are logarithm of years until next recontract (column I); years until next recontract (column II); probability of being recontracted (column III); and probability of being recontracted within 3 years, i.e., the median in the sample (column IV). Panel B examines the effect of kamikazes on road accidents using a stacked DID design comparing outcomes by fault type. The dependent variable y_{iet} is either the logarithm of the number of accidents in road repair i, cohort e and year t (columns I and II) or the logarithm of the number of victims (columns III and IV). Results are presented separately for road-fault accidents (columns I and III) and non-road-fault accidents (columns II and IV). Post_{et} is equal to 1 after the contracts were awarded and 0, otherwise. Road Extension refers to quintiles based on the length of the road, allowing us to control for road size. Standard errors clustered at the cohort level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 10 for further details of the specifications.

Figure 1: *Evolution of Kamikaze Bidding in Public Procurement Auctions*



This figure shows the average fraction of auctions with kamikazes in Brazil between 2007 and 2021. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner by, for instance, withdrawing, not submitting the required documents, or providing inadequate documentation.

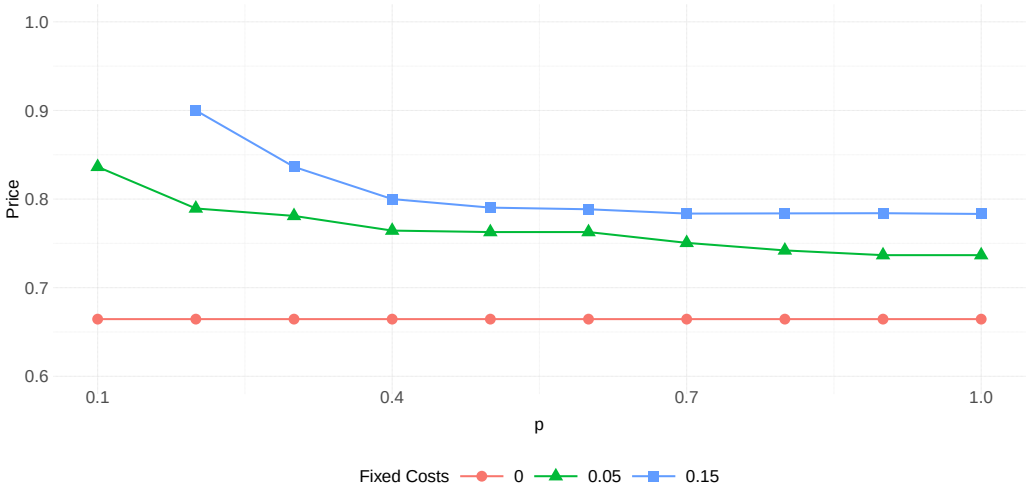
Figure 2: *Bid Dynamics for Kamikaze, Winner, and Next in Line Bidders*



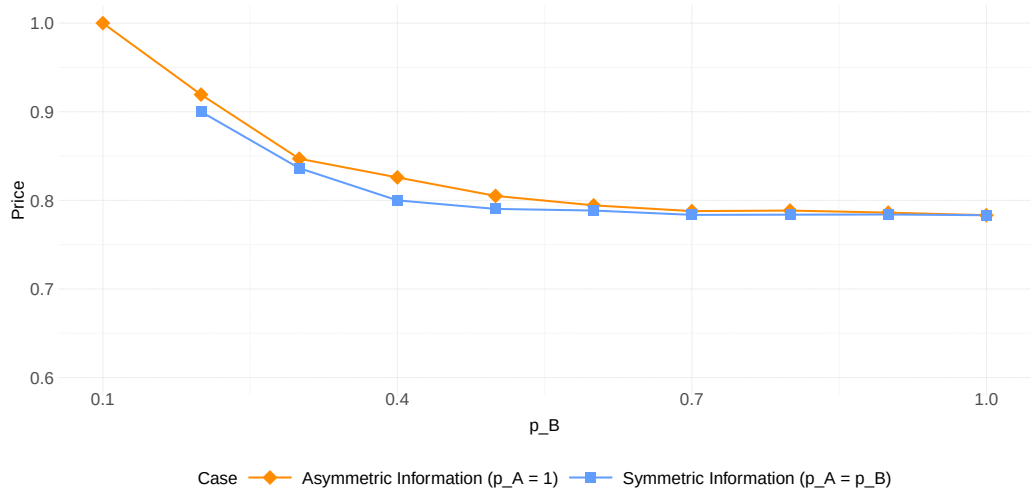
This figure plots the dynamic development of the median bid price in the minutes leading up to the end of the auction for three types of bidders: kamikaze participants (blue circles), eventual winning bidders (red squares), and next-in-line bidders (orange triangles). The bid prices are expressed as a percentage of the winning bid. To construct this plot, we first gather the bids for each auction and each minute before the end. If a bidder does not make a new bid within a given minute, we carry forward the value of their bid from the previous minute. We then plot the median bids for each type of bidder.

Figure 3: *Expected Prices in First-Price Auctions with Fixed Costs and a Kamikaze Firm*

Panel A: Symmetric Information

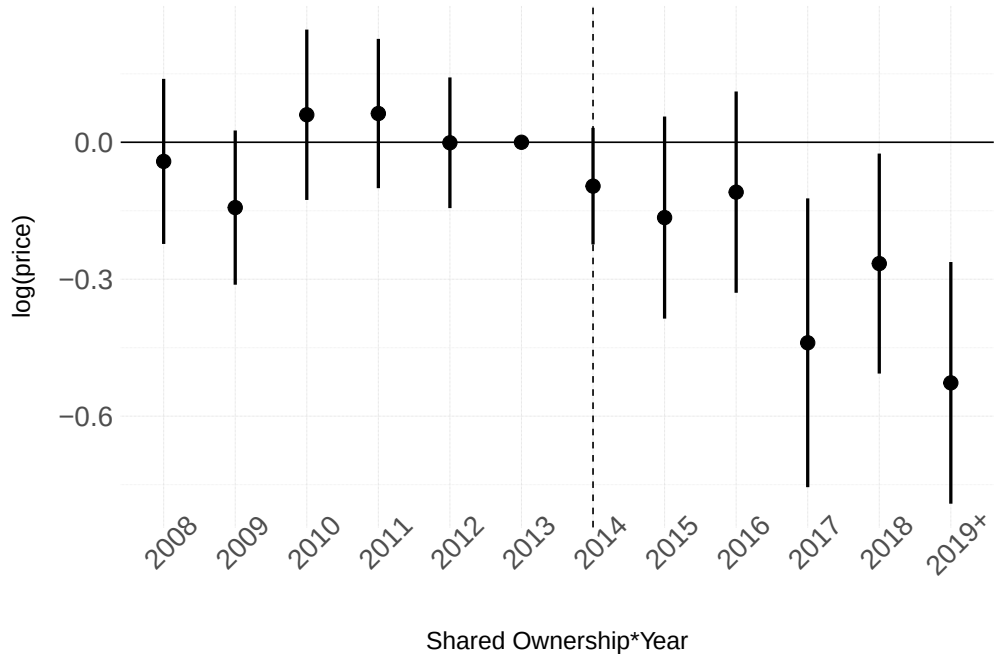


Panel B: Symmetric vs. Asymmetric Information



The figure plots expected prices (y-axis) obtained from numerically solving a first-price auction model with 2 regular bidders (A and B) and one kamikaze bidder (K) who always bids zero. In Panel A, bidders A and B are assumed to believe that K forfeits with probability p (x-axis). Regular bidders face a cost $F \geq 0$ associated with submitting a bid. The bottom line (red circles) represents zero fixed costs ($F = 0$), showing stable prices around 0.67 regardless of the kamikaze's forfeiture probability p as shown in Section 3. The middle line (green triangles) shows moderate fixed costs ($F = 0.05$): prices start to increase significantly compared to the benchmark case, especially for low p. The top line (blue squares) shows high fixed costs ($F = 0.15$): prices are higher than in the previous two cases, especially for lower p. Panel B shows expected prices in a first-price auction with fixed costs $F = 0.15$ under two scenarios. In the first scenario (orange diamonds), bidder A believes that the kamikaze bidder forfeits with probability 1, while bidder B believes the kamikaze bidder forfeits with probability p_B (x-axis). In the second scenario (blue squares), both bidders believe the kamikaze bidder forfeits with probability $p = pA = p_B$.

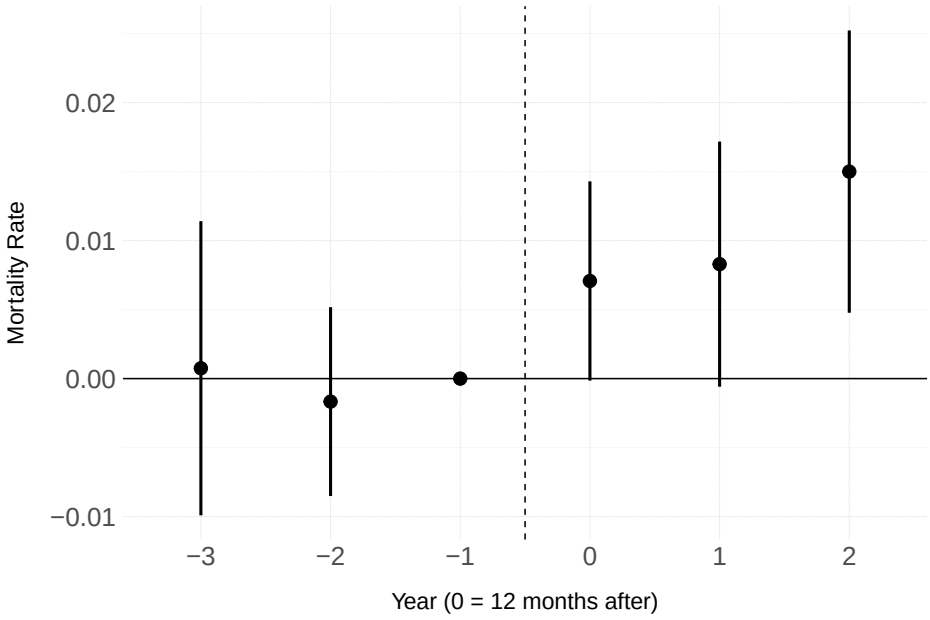
Figure 4: *The Effect of the Transparency Reform on Prices*



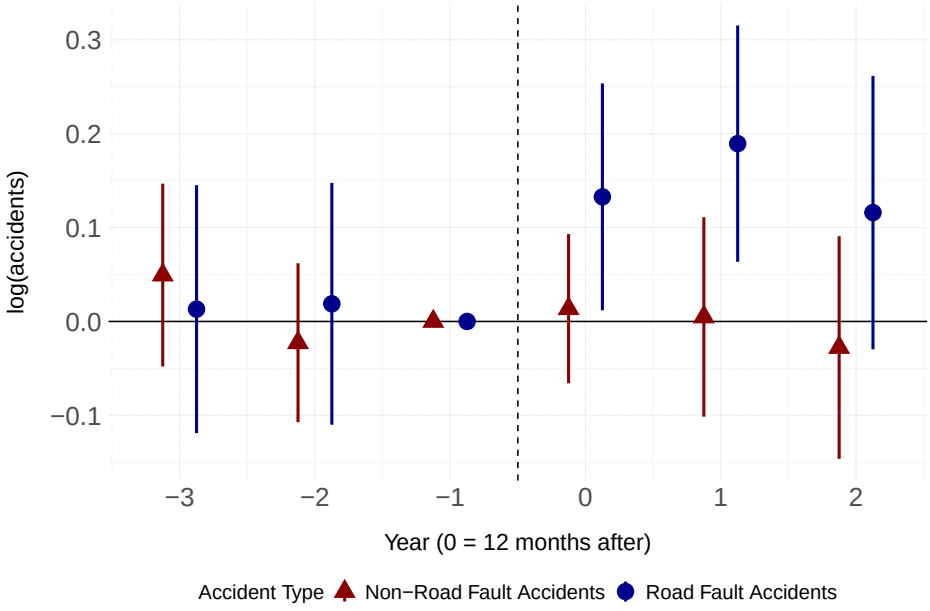
This figure plots the dynamic effects obtained from a DID analysis that examines the impact of enforcing a shared ownership alert feature in the ComprasNet system in 2014 on procurement prices. The treatment variable, Shared Ownership, represents the proportion of procurement contracts awarded before 2014, in which the winning firms in kamikaze auctions also shared ownership with the kamikaze companies. The year 2013 serves as the reference point in the plot. All regressions include Firm and Item-by-Year fixed effects.

Figure 5: *Excess Deaths in Public Hospitals and Number of Road Accidents*

Panel A: Excess Deaths in Public Hospitals



Panel B: Number of Road Accidents



This figure plots the dynamic effects of kamikaze versus non-kamikaze auctions, along with the corresponding 95% confidence intervals. Panel A shows the effects on hospital mortality rates for essential medicine purchases, while Panel B shows the effects on the number of road accidents due to road fault conditions (blue circles) and non-road fault accidents (red triangles) for road repair contracts. In both panels, the x-axis denotes the year relative to event 0 (the 12 months after the occurrence of kamikaze). The y-axis indicates the changes in mortality rate (Panel A) and the number of accidents (Panel B).

Internet Appendix

Kamikazes and Public Procurements
Bid-Rigging and Real Non-Market Outcomes

For Online Publication Only

A Additional Tables and Figures

Table A1: *Examples of Products, Services and Government Agencies*

Panel A: Examples of Products and Services	
Description	Unit
Ballpoint Pen	1 unit
Flexible Eletric Cable	1 meter
Battery	1 unit
Ethyl Alcohol	1 liter
Coffee	500 grams
External HD	1 unit
Sugar	1 kilogram
Mineral Water	20 liters
Detergent	500 mililiters
HP Printer Toner Cartridge	1 unit
White Board Pen	1 unit
Insulin	3 mililiters
Microscope	1 unit
Petrol	1 liter
Security Services	1 month
Landline	1 minute

Panel B: Government Agencies	
Name of Government Agency	Classification
Universidade Federal do Rio Grande do Sul	Education
Universidade Federal do Pará	Education
Universidade Federal de Pernambuco	Education
Hospital Universitario UFSC	Hospitals
Hospital Universitario Antonio Pedro (UFF/RJ)	Hospitals
Hospital Universitario Gaffree e Guinele (UNIRIO)	Hospitals
Grupamento de Apoio de São José dos Campos	Armed Forces
Grupamento de Apoio de Brasilia	Armed Forces
14 Grupo de Artilharia de Campanha	Armed Forces
Comissao Nacional de Energia Nuclear	Other
Governo do Estado do Ceara	Other
Departamento de Logistica em Saude	Other

Panel A shows examples of products and services from CADMAT and CADSER, while Panel B provides examples of government institutions in the procurement dataset.

Table A2: *Kamikaze Firms and Procurement Outcomes: Controlling for the Same Kamikaze Firm*

	$\log(\text{price})_{ipjt}$		
	I	II	III
Has Kamikaze$_{ipt}$	0.1545***	0.1306***	0.1034***
	(0.0072)	(0.0058)	(0.0124)
Obs	10,918,266	10,918,266	10,918,266
R^2	0.911	0.914	0.939
Firm*Item*Year FEs	Yes	Yes	
# Genuine Part*Year FEs	Yes	Yes	Yes
Gov Institution*Year FEs		Yes	
Firm*Gov Institution*Item*Year FEs			Yes

This table compares outcomes of procurement auctions with and without the presence of kamikaze firms. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The analysis compares auctions where the same firm submits the lowest bid but has different outcomes: either the firm withdraws (kamikaze behavior, Has Kamikaze = 1) or the firm successfully completes the formalities and wins the contract (Has Kamikaze = 0). The dependent variable is the logarithm of the price for item p purchased in procurement i where firm j participated at time t. Has Kamikaze$_{ipt}$ is equal to 1 if procurement i for item p at time t has a kamikaze firm and 0, otherwise. The sample includes all auctions where a firm submitted the lowest bid, restricting to firms that acted as kamikaze (withdrew after winning) at least once for the same item-year combination. In columns I to III, we progressively add fixed effects. Column I includes Kamikaze Firm-by-Item-by-Year fixed effects (comparing auctions with the same lowest-bidding firm for the same item and year), item and year, and # Genuine Bidders-by-Year fixed effects comparing procurements with the same number of genuine participants and year. Column II adds Government Institution-by-Year fixed effects. Column III includes Kamikaze Firm-Government Institution-Item-Year fixed effects while maintaining # Genuine Bidders-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 2 for further details of the specifications.

Table A3: *Kamikaze Firms and Difference Between Winning and Next-in-Line Bids*

	Winning Bid - Next-In-Line Bid$_{ipt}$ (as a % of winning bid)	
	I	II
Has Kamikaze$_{ipt}$	0.1987***	0.2011***
	(0.0036)	(0.0034)
Obs	13,540,521	13,540,521
R^2	0.161	0.186
Item*Year FEs	Yes	Yes
# Genuine Bidders*Year FEs	Yes	Yes
Gov Institution*Year FEs		Yes

This table examines how kamikaze firms affect the gap between winning and next-in-line bids in procurement auctions. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The dependent variable is the difference between the eventually winning bid and the next bid as a percentage of the winning bid. Has Kamikaze$_{ipt}$ is equal to 1 if procurement i for item p at time t has a kamikaze firm and 0, otherwise. Column I controls for Item-by-Year and # Genuine Bidders-by-Year fixed effects. Column II also includes Government Institution-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. The specification is the same as in Table 2. See caption of Table 2 for further details of the specifications.

Table A4: *Kamikaze Firms and Procurement Outcomes: Effects by Kamikaze Intensity*

	$\log(\text{price})_{ipt}$	
	I	II
1 Kamikaze Firm$_{ipt}$	0.0653***	0.0525***
	(0.0034)	(0.0030)
2 Kamikaze Firms$_{ipt}$	0.1389***	0.1188***
	(0.0062)	(0.0051)
3 Kamikaze Firms$_{ipt}$	0.1982***	0.1756***
	(0.0093)	(0.0071)
4 Kamikaze Firms$_{ipt}$	0.2597***	0.2245***
	(0.0115)	(0.0101)
5+ Kamikaze Firms$_{ipt}$	0.3566***	0.3247***
	(0.0180)	(0.0154)
Obs	14,967,462	14,967,462
R^2	0.865	0.870
Item*Year FEs	Yes	Yes
# of Actual Competitors*Year FEs	Yes	Yes
Gov Institution*Year FEs		Yes

This table extends the analysis of procurement auctions with and without the presence of kamikaze firms presented in Table 2 and focuses on how the effect of kamikaze firms on pricing varies with the number of kamikaze firms. Kamikaze firms are defined as those firms that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The main independent variables are indicators based on the number of kamikaze firms in procurement i for item p at year t, i.e., 1, 2, 3, 4, or 5+ kamikaze firms. The dependent variable is the logarithm of the price for item p purchased in procurement i at time t. Column I controls for Item-by-Year and # of Actual Competitors-by-Year fixed effects. Column II also includes Government Institution-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 2 for further details of the specifications.

Table A5: *Heterogeneous Effects*

	$\log(\text{price})_{ipt}$				
	I	II	III	IV	V
Has Kamikaze$_{ipt}$	0.1669***	0.1423***	0.1667***	0.1039***	0.1262***
	(0.0060)	(0.0060)	(0.0057)	(0.0139)	(0.0105)
Has Kamikaze$_{ipt}$ · High Kamikaze$_a$	-0.0009				
	(0.0054)				
Has Kamikaze$_{ipt}$ · High Kamikaze$_p$		0.0319***			
		(0.0074)			
Has Kamikaze$_{ipt}$ · Local$_a$			-0.0028		
			(0.0089)		
Has Kamikaze$_{ipt}$ · Product$_p$				0.0700***	
				(0.0142)	
Has Kamikaze$_{ipt}$ · High # Sim. Auct.$_{it}$					0.0425***
					(0.0088)
Obs	14,967,462	14,967,462	14,967,462	14,967,462	13,574,911
R^2	0.870	0.870	0.870	0.870	0.872
Item*Year FEs	Yes	Yes	Yes	Yes	Yes
# Genuine Bidders*Year FEs	Yes	Yes	Yes	Yes	Yes
Gov Institution*Year FEs	Yes	Yes	Yes	Yes	Yes

This table examines the heterogeneous effects of kamikaze firms on procurement outcomes with and without the presence of kamikaze firms. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. The dependent variable y_{ipt} is the logarithm of the price for item p purchased in procurement i at time t. Has Kamikaze$_{ipt}$ is equal to 1 if procurement i for item p at time t has a kamikaze firm and 0, otherwise. In column I, High Kamikaze$_a$ equals to 1 if government institution a is in the upper median in the incidence of kamikaze auctions and 0, otherwise. In column II, High Kamikaze$_p$ equals to 1 if item p is in the upper median in the incidence of kamikaze auctions and 0, otherwise. In column III, Local$_a$ equals to 1 if the government institution a is either a municipality or state government agency and 0, otherwise. In column IV, Product$_p$ equals to 1 for products and to 0 for services. In column V, High # Sim. Auct.$_{it}$ is a dummy equal to 1 if procurement i has an above-median number of simultaneous auctions and 0 otherwise. All specifications control for Item-by-Year, Government Institution-by-Year, and # Genuine Bidders-by-Year fixed effects. Standard errors clustered at the item level are presented in parentheses. $^+$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively. See caption of Table 2 for further details of the specifications.

Table A6: *Organizations by Prevalence of Kamikaze Bidding*

Organization	Kamikaze Fraction
High Kamikaze Prevalence	
Base Aérea de Brasília/DF (Maer-Babr)	0.633
Superintendência de Administração em São Paulo	0.537
Estação Naval do Rio Negro	0.502
Base de Apoio Logístico do Exército	0.490
Fundação de Atendimento Socioeducativo do Pará	0.490
Departamento de Educação e Cultura do Exército	0.475
Batalhão de Suprimento (Mex-9)/MS	0.468
3° Centro Integrado de Defesa Aérea e Controle de Tráfego Aéreo	0.467
Gerência Regional em São Paulo	0.456
Base Aérea dos Afonsos	0.448
Lowest Kamikaze Prevalence	
Biblioteca Central da UFPB	0.022
3° Regimento de Carros de Combate	0.031
Centro Federal de Educação Tecnológica de Urutaí	0.035
CEFET/BA	0.035
Faculdade de Filosofia e Ciências Humanas/UFMG	0.036
Instituto Federal de Rondônia/Campus Ariquemes	0.041
22° Grupo de Artilharia de Campanha/RS	0.047
5ª Brigada de Cavalaria Blindada	0.048
Fundação Diamantinense de Apoio ao Ensino e Pesquisa	0.050
Hospital da Guarnição de Alegrete/RS	0.050

This table shows examples of organizations across the spectrum of kamikaze bidding prevalence. Kamikaze Fraction represents the proportion of auctions for each organization that featured kamikaze bidders.

Table A7: *Products/Services by Prevalence of Kamikaze Bidding*

Description	Kamikaze Fraction
High Kamikaze Prevalence	
Government Administrative Services	0.601
Personnel Services	0.511
Engineering Services	0.503
General Cleaning Services	0.495
Printer Toner Cartridge	0.494
Office Workstation/Partitions	0.440
Notebook Computer	0.435
Cleaning Services	0.429
IT Support Services	0.427
Led Lamp	0.315
Low Kamikaze Prevalence	
Tool Parts	0.110
Construction Stone	0.118
Gas (Fuel)	0.089
Insurance Services	0.077
Veterinary Equipment	0.075
Glass Fuse	0.068
Compressed Gas	0.064
Landline Services	0.049
Books	0.052
Technical Publications	0.014

This table shows examples of products and services across the spectrum of kamikaze bidding prevalence. Kamikaze Fraction represents the proportion of auctions for each product/service that featured kamikaze bidders.

Table A8: *Characteristics of Kamikaze Firms*

	p(kamikaze)$_{ipj}$		p(winner)$_{ipj}$	
	I	II	III	IV
Young Firm$_{ipj}$	0.0324***		-0.0168***	
	(0.0031)		(0.0015)	
Small Firm$_{ipj}$		0.0389***		-0.0532***
		(0.0046)		(0.0033)
Obs	24,989,145	24,989,145	24,989,830	24,989,830
R^2	0.176	0.175	0.086	0.088
Procurement*Item FEs	Yes	Yes	Yes	Yes

This table shows the characteristics of kamikaze and winning firms. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner. This table follows the same specification as in Table 4, but with diferent dependent and independent variables. The dependent variables are p(kamikaze)$_{ipj}$ — a dummy equal to 1 if bidder j at procurement i for item p is a kamikaze firm and zero otherwise — in columns I and II, and p(winner)$_{ipj}$ — a dummy equal to 1 if bidder j at procurement i for item p is the winner and zero otherwise in columns III to IV. The independent variables are the probability that firm j was created less than 3 years ago (columns I and III), and the probability that firm j is small, as defined by the official government classification (columns II and IV). All columns control for Procurement-by-Item fixed effects. Standard errors clustered at the firm level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table A9: *Switching Across Procurements*

	p(kamikaze)$_{ipjt}$		p(win)$_{ipjt}$		
	I	II	III	IV	V
Was Kamikaze$_{j,t-1:t-12}$	0.0028***		-0.0108***		
	(0.0005)		(0.0015)		
Was Winner in Kamikaze Procur$_{j,t-1:t-12}$		-0.0069***		0.0156***	0.0126***
		(0.0005)		(0.0014)	(0.0016)
Was Winner$_{j,t-1:t-12}$					0.0053***
					(0.0015)
Obs	86,165,835	86,165,835	86,169,148	86,169,148	86,169,148
R^2	0.298	0.298	0.140	0.140	0.140
Procurement*Item FEs	Yes	Yes	Yes	Yes	Yes

This table examines role persistence by testing whether firms that previously acted as kamikazes or won kamikaze auctions are more likely to repeat these roles in subsequent procurements. We estimate the following specification:

$$y_{ipjt} = \alpha_{ip} + \beta_1 \cdot X_{jt} + e_{ipjt}$$

clawhere y_{ipjt} is the probability that firm j is a kamikaze (columns I-II) or winner (columns III-V) in procurement i for item p at time t. The key explanatory variables are: Was Kamikaze$_{j,t-1:t-12}$, a dummy equal to 1 if firm j acted as a kamikaze in any procurement within the past year; and Was Winner in Kamikaze Procur$_{j,t-1:t-12}$, a dummy equal to 1 if firm j won any procurement with kamikaze presence during the past within the past year. Column V includes Was Winner$_{j,t-1:t-12}$, indicating whether firm j won any procurement (regardless of kamikaze presence) within the past year. All columns include Procurement-by-Item fixed effects, comparing firms within the same auction. The sample includes all participating firms. Standard errors clustered at the firm level are presented in parentheses. $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table A10: *Switching Within Procurements*

	p(kamikaze)$_{ipjt}$		p(win)$_{ipjt}$		
	I	II	III	IV	V
Was Kamikaze$_{ip^*jt}$	0.0775***		-0.0240***		
	(0.0011)		(0.0013)		
Was Winner in Kamikaze Procur$_{ip^*jt}$		-0.0380***		0.1703***	0.0480***
		(0.0007)		(0.0018)	(0.0014)
Was Winner$_{ip^*jt}$					0.2135***
					(0.0019)
Obs	86,165,835	86,165,835	86,169,148	86,169,148	85,115,139
R^2	0.319	0.303	0.140	0.174	0.238
Procurement*Item FEs	Yes	Yes	Yes	Yes	Yes

This table examines role persistence by testing whether firms that acted as kamikazes or won kamikaze auctions in other auctions of the same procurement. That is, within a procurement i, we compare the probability that a firm is a kamikaze or a winner for a product p based on its participation in other auctions within the same procurement. We implement the following specification:

$$y_{ipjt} = \alpha_{ip} + \beta_1 \cdot X_{ip^*jt} + e_{ipjt}$$

where y_{ipjt} is the probability that firm j is a kamikaze (columns I-II) or winner (columns III-V) in procurement i for item p at time t. The key explanatory variables are: Was Kamikaze$_{ip^*jt}$, a dummy equal to 1 if firm j was a Kamikaze firm in procurement i purchasing item $p^* \neq p$; and Was Winner in Kamikaze Procur$_{ip^*jt}$, a dummy equal to 1 if firm j was a winner in procurement i purchasing item $p^* \neq p$ with kamikaze presence. Column V includes Was Winner$_{ip^*jt}$, indicating whether firm j won any item $p^* \neq p$ in procurement i (regardless of kamikaze presence). All columns include Procurement-by-Item fixed effects, comparing firms within the same auction. The sample includes all participating firms. Standard errors clustered at the firm level are presented in parentheses. $^+$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table A11: *DataSUS: International Classification of Diseases*

Certain infectious and parasitic diseases
Neoplasms
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism
Endocrine, nutritional and metabolic diseases
Mental and behavioural disorders
Diseases of the nervous system
Diseases of the eye and adnexa
Diseases of the ear and mastoid process
Diseases of the circulatory system
Diseases of the respiratory system
Diseases of the digestive system
Diseases of the skin and subcutaneous tissue
Diseases of the musculoskeletal system and connective tissue
Diseases of the genitourinary system
Pregnancy, childbirth and the puerperium
Certain conditions originating in the perinatal period
Congenital malformations, deformations and chromosomal abnormalities
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
Injury, poisoning and certain other consequences of external causes
External causes of morbidity and mortality
Factors influencing health status and contact with health services
Codes for special purposes

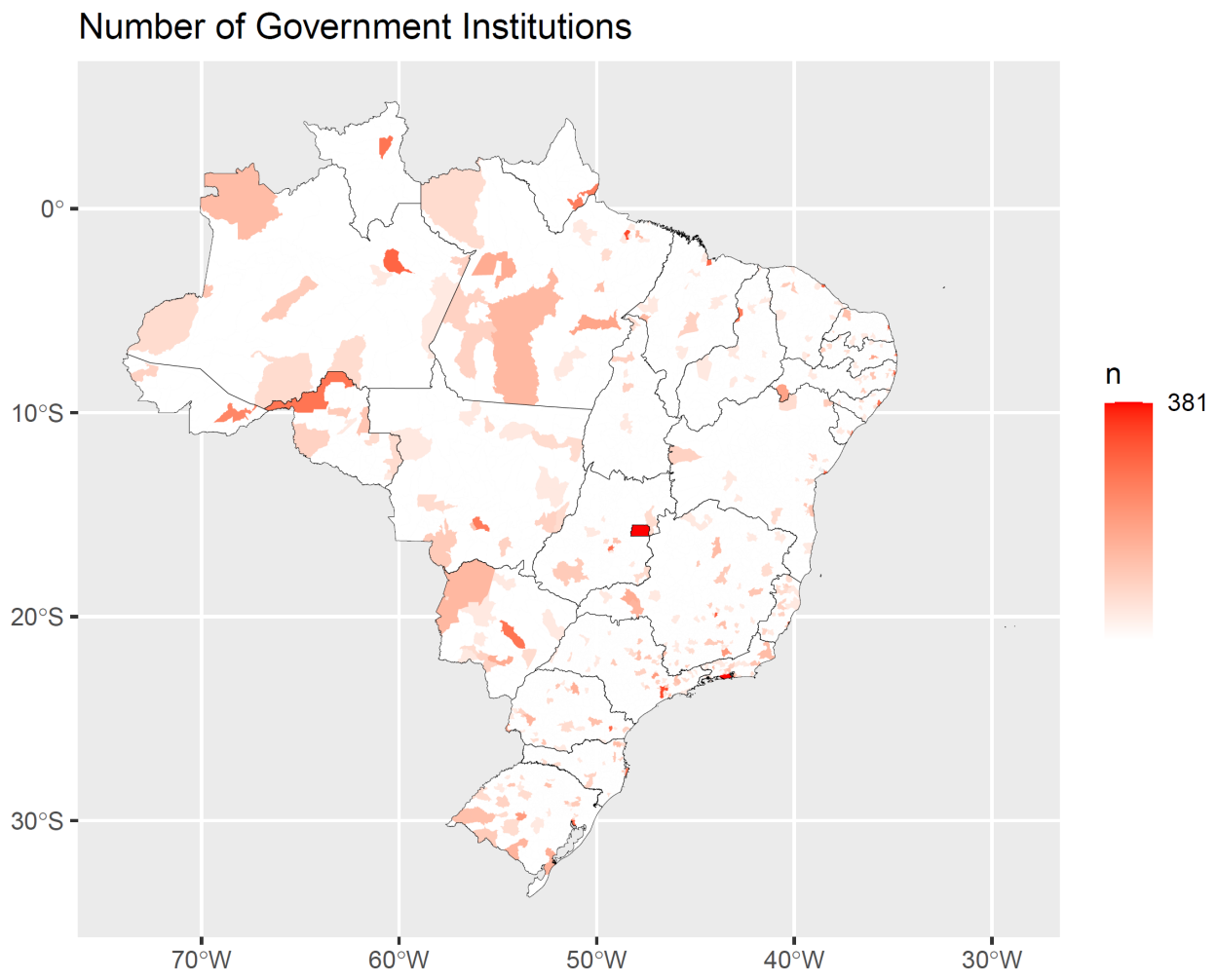
This table lists different diseases classifications from the World Health Organization's International Classification of Diseases. These categories correspond to how DataSUS records diseases in their hospital mortality dataset.

Table A12: *Road-Related and Non-Road-Related Accident Causes*

Road-Related Causes	Non-Road-Related Causes
Slippery road	Lack of attention
Water accumulation on pavement	Not maintaining safe distance
Oil accumulation on pavement	Incompatible speed
Potholed road	Improper overtaking
Sand or debris on pavement	Disobeying traffic signs
Uneven road surfaces	Sleeping/drowsy driving
Depressions or undulations in pavement	Alcohol ingestion
Road in disrepair	Use of psychoactive substances
Sharp curves	Using mobile phone while driving
Steep slopes	Failure to react or inefficient reaction
Insufficient lane width	Abrupt braking
Uneven shoulder	Disregarding right of way at intersections
Lack of shoulder	Driving in the wrong direction
Temporary detours	Changing lanes improperly
Irregular access	Prohibited turns or returns
Road in different levels	Accessing road without observing other vehicles
Limited visibility at horizontal curves	Parking or stopping in prohibited locations
Limited visibility at vertical curves	Driving on the sidewalk
Reduced visibility (general)	Driving on the shoulder
Insufficient or inadequate road signaling	Participating in street racing
Absence of signaling	Motorcycling between lanes
Poorly positioned signaling	Disregarding red traffic light
Covered signaling	Pedestrian inattention
Defective traffic light	Pedestrian improper use of the road
Lack of containment elements	Sudden pedestrian entry
Urban area without pedestrian crossing	Pedestrian disobeying traffic rules
Static object on the roadway	Alcohol/substance use by pedestrian
Works on the road	Mechanical or electrical failures
Roadway obstruction	Tire damage or excessive wear
Animals on the road	Brake/Suspension problems
Inefficient drainage system	Vehicle mechanical defects
Non-compliant speed reducer	Modified vehicle (prohibited modifications)
Poor lighting	Misaligned headlights
	Deficiency in vehicle lighting/signaling systems
	Excessive and/or poorly conditioned load
	Driver sudden illness
	External aggression
	Environmental factors
	Other unspecified causes

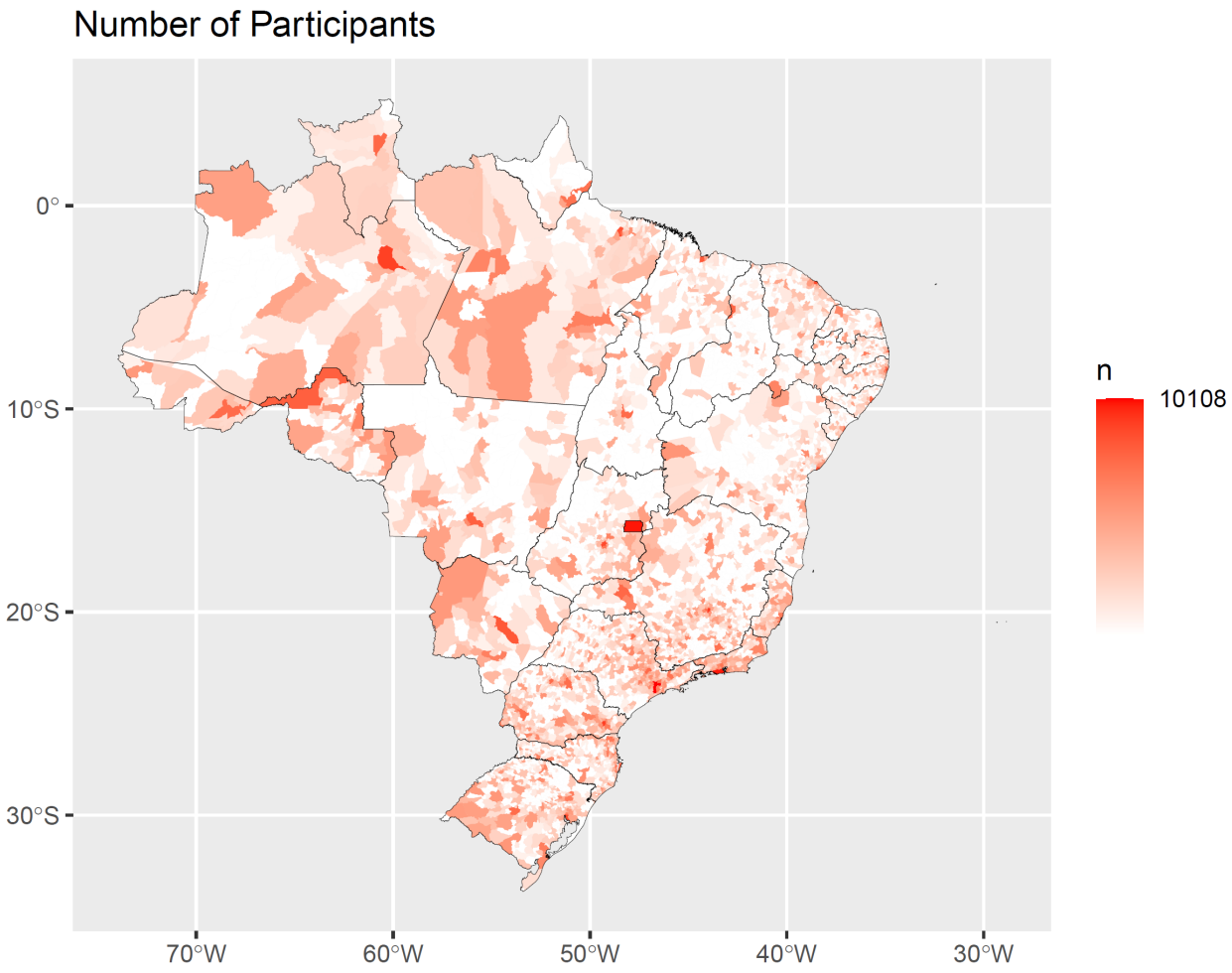
This table categorizes accident causes from the Federal Highway Patrol dataset into road-related and non-road-related factors.

Figure A1



This figure shows the geographical distribution of the average number of government institutions from 2005 to 2021 for a sample of 1,049 municipalities with government agencies.

Figure A2



This figure shows the geographical distribution of the average number of unique bidders from 2005 to 2021.

Figure A3

COMPRASNET Pregão Eletrônico

UASG: 200999 - MIN. DO PLANEJAMENTO ORCAMENTO E GESTAO/DF
Pregão nº: 672014
Login: fornec2

Abertos/Suspensos | Fechados | Encerrados | Cancelados | Ajuda

Itens com situação Aberto — Horário de Brasília: 22/05/2014 15:51

Item		Descrição	Situação	Seu Último Lance	Melhor Lance	Lance		
	1	PAPEL BOBINADO	Aviso de Iminência	R$ 131.345,0000	R$ 131.345,0000		(R$)	Enviar
	2	GRAXA	Aviso de Iminência	R$ 9,5400	R$ 5,1200		(R$)	Enviar
	3	AÇÚCAR	Aviso de Iminência	R$ 9,3400	R$ 4,9200		(R$)	Enviar
	5	TINTA ESMALTE	Aviso de Iminência	R$ 301,5400	R$ 297,1200		(R$)	Enviar
	6	APARELHO SOM	Aviso de Iminência	R$ 1.207,5400	R$ 1.203,1200		(R$)	Enviar
	4	CAPA CORTE CABELO	Aviso de Iminência	R$ 153.600,0000	R$ 153.600,0000		(R$)	Enviar

Seu lance é o vencedor. Seu lance NÃO é o vencedor. Seu lance está EMPATADO. Voltar

Panel A: Original Figure

COMPRASNET Electronic Bidding

UASG: 200999 - MIN. OF PLANNING BUDGET AND MANAGEMENT/DF
Auction No.: 672014
Login: fornec2

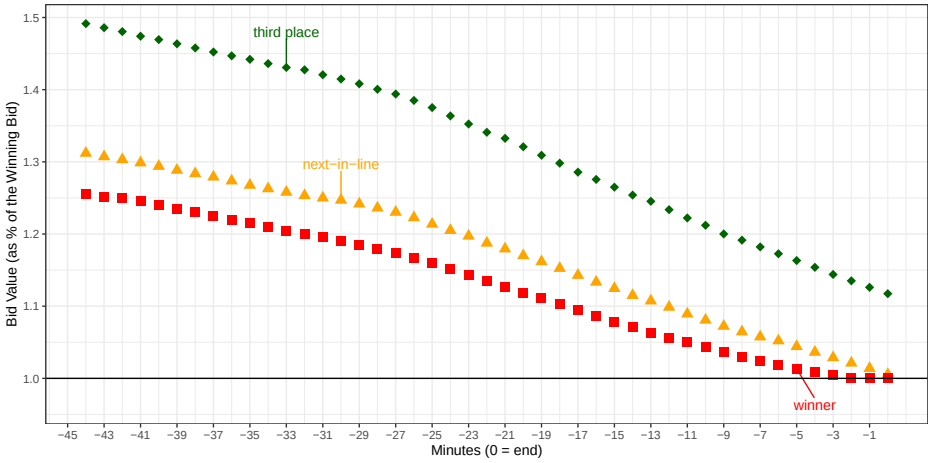
Items with Open status			Brasilia Time: 22/05/2014 15:51			
Item	Description	Status	Your Last Bid	Best Bid	Bid	
1	ROLLED PAPER	Impending Notice	R$ 131,345.0000	R$ 131,345.0000		Send
2	GREASE	Impending Notice	R$ 9.5400	R$ 5.1200		Send
3	SUGAR	Impending Notice	R$ 9.3400	R$ 4.9200		Send
5	ENAMEL PAINT	Impending Notice	R$ 301.5400	R$ 297.1200		Send
6	SOUND SYSTEM	Impending Notice	R$ 1,207.5400	R$ 1,203.1200		Send
4	HAIR CUTTING CAPE	Impending Notice	R$ 153,600.0000	R$ 153,600.0000		Send

• Your bid is the winner. • Your bid is NOT the winner. • Your bid is TIED.

Panel B: English Translation

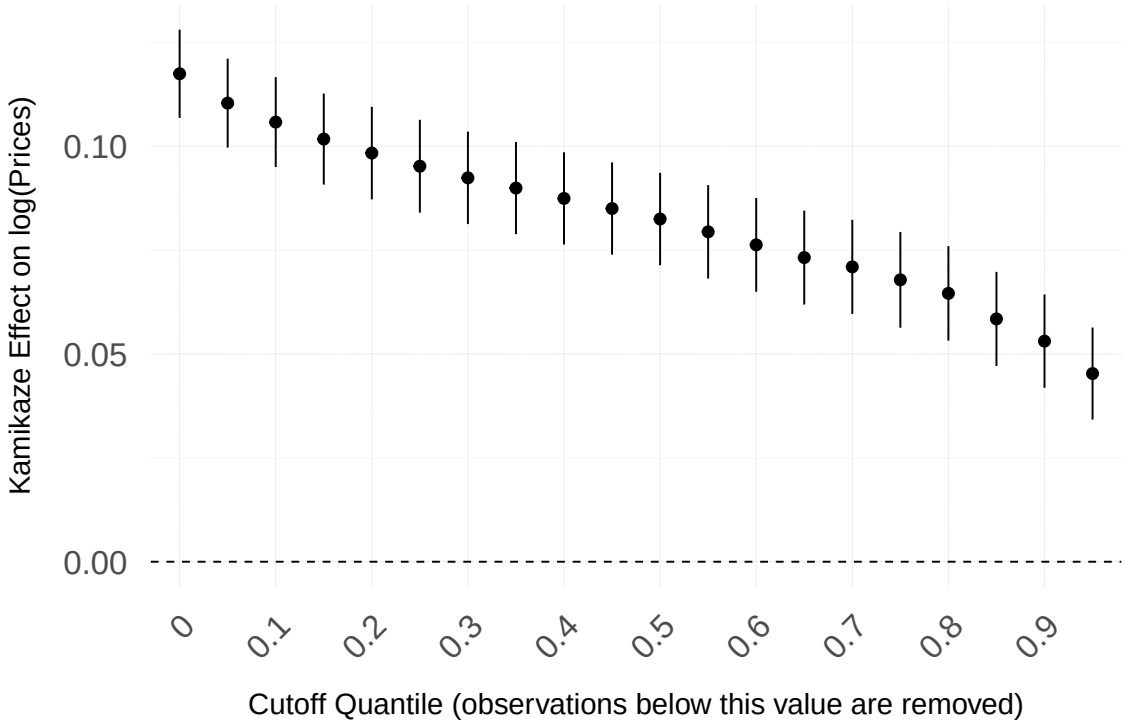
This figure plots an image of the ComprasNet portal during the procurement from the perspective of the bidder. The bidders can see information about their bid, the minimum bid, and details about the auction they participate.

Figure A4: *Bid Dynamics for Winner, Next in Line, and Third Place Bidders in Non-Kamikaze Auctions*



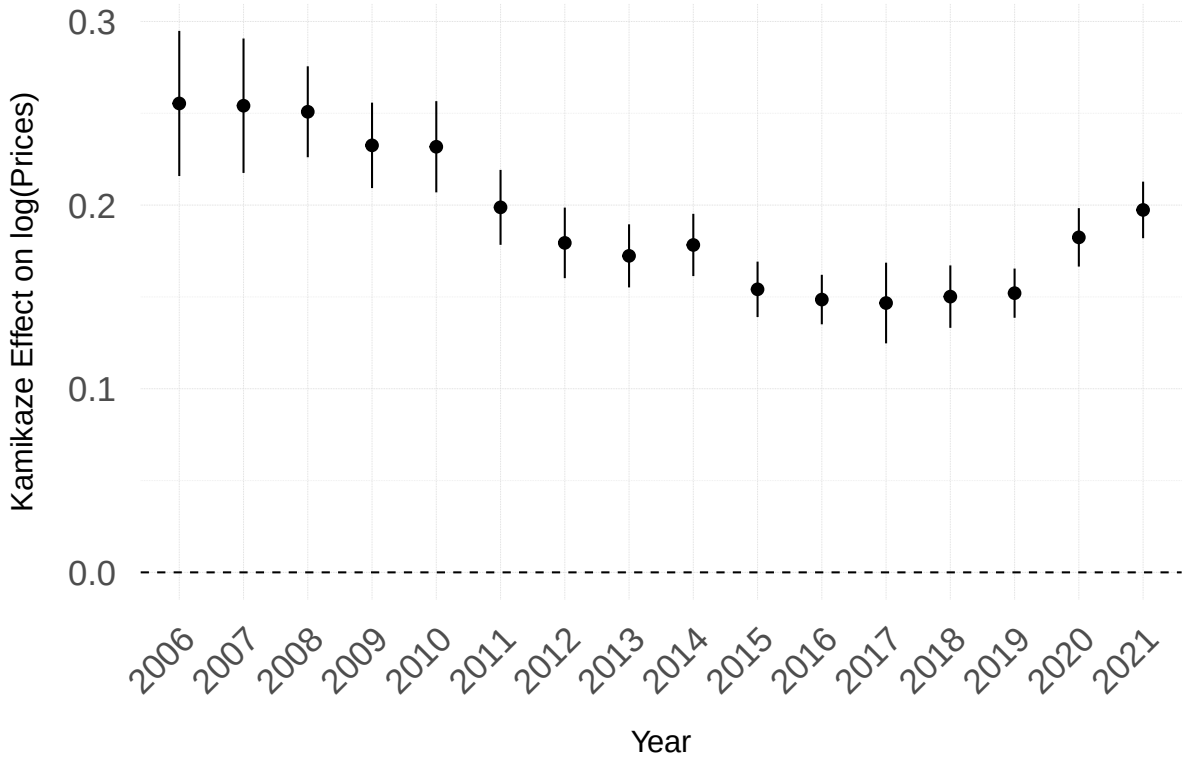
This figure plots the dynamic development of the median bid price in the minutes leading up to the end of the auction for three types of bidders: winners (red squares), next-in-line bidders (orange triangles), and third-place bidders (green diamonds). The bid prices are expressed as a percentage of the winning bid. To construct this plot, we first gather the bids for each auction and each minute before the end. If a bidder does not make a new bid within a given minute, we carry forward the value of their bid from the previous minute. We then plot the median bids for each type of bidder.

Figure A5: *Effect of Kamikaze Rounds on Procurement Prices Across Value Distribution*



The figure plots the estimated effect of kamikaze firms on the winning prices as reported in Table 2 as we progressively remove observations below each quantile cutoff of the procurement value distribution. For example, when the x-axis equals 0.2, all observations below the 20th percentile of contract value have been removed from the estimation. When the x-axis is zero this is the benchmark specification in Table 2, column I. The vertical lines show 95% confidence intervals with standard errors clustered at the item level.

Figure A6: *Kamikaze Firms and Overpricing Across Years*

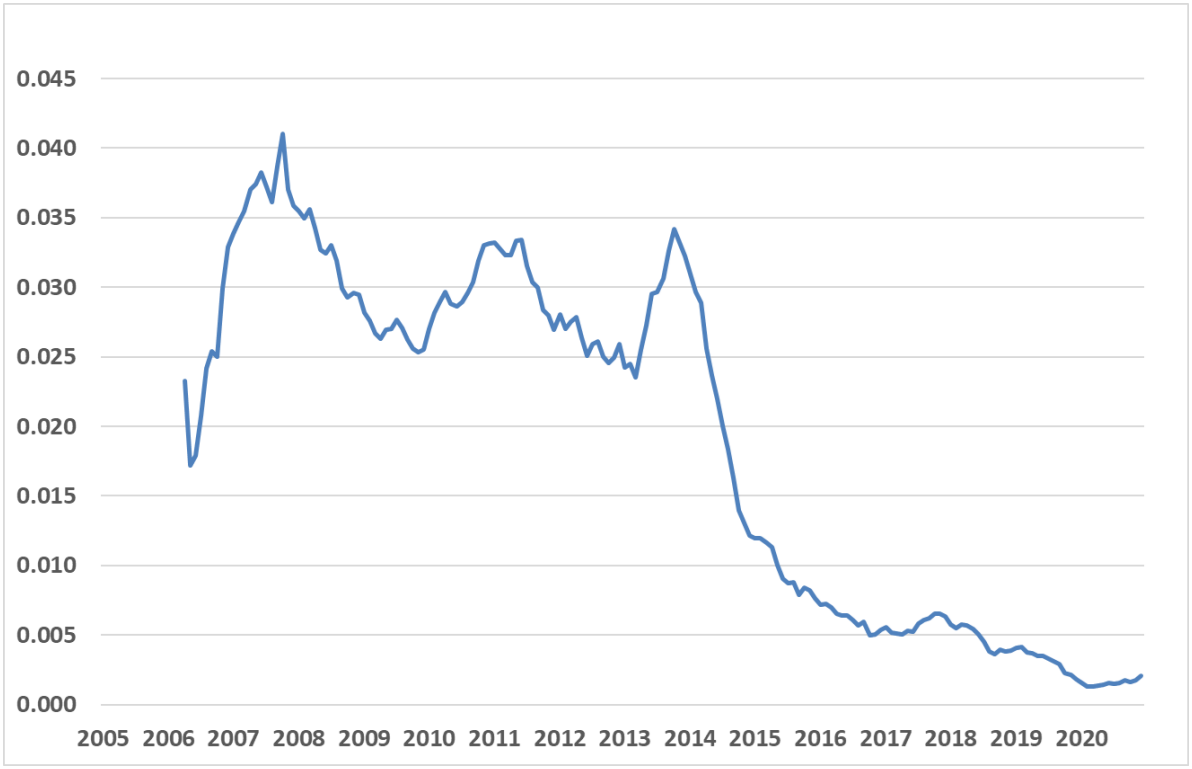


The figure plots the estimated effect of kamikaze firms on the winning prices as reported in Table 2 for different years. We estimate the baseline regression separately for each year:

$$log(price)_{ipt} = \alpha_{pt} + \alpha_{X_i,t} + \beta_t \cdot HasKamikaze_{ipt} + e_{ipt}$$

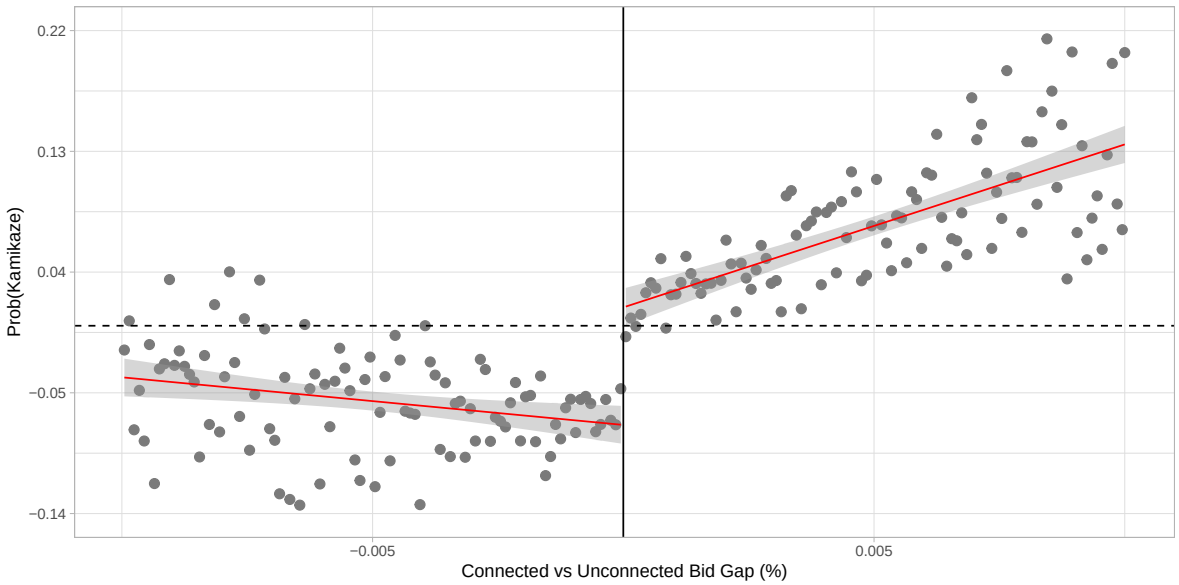
where Has Kamikaze equals 1 if a firm submits the lowest bid but fails to win procurement i for item p in year t due to not satisfying final formalities. The specification includes Item fixed effects (α_p) and interactions of procurement characteristics with year fixed effects (α_{X_i}), such as # Genuine Bidders and Government Institution fixed effects. The figure plots the estimated β_t coefficients for each year t, which capture the difference in logarithm prices in procurements with kamikaze bidding relative to those without it. The vertical lines show 95% confidence intervals with standard errors clustered at the item level.

Figure A7: *Proportion of Procurements with Shared Owners*



This figure plots the proportion of the procurement with shared owner participants over time.

Figure A8: *Regression Discontinuity Evidence of Strategic Coordination*



This figure presents regression discontinuity plots examining whether kamikaze firms are more likely to withdraw when connected firms would benefit from the withdrawal. The horizontal axis shows the normalized bid difference between connected and unconnected firms competing for second place: (Connected firm's bid - Unconnected firm's bid). Positive values indicate that connected firms have lower bids (are in second place), while negative values indicate unconnected firms have lower bids. The vertical axis shows the kamikaze withdrawal rate. The vertical line at zero represents the threshold where connected and unconnected firms are essentially tied for second place. The fitted lines on either side of the threshold show the local linear regression estimates, and the confidence intervals are displayed in gray.

B Case Study of the Kamikaze Strategy

The report TC-035.967/2016-1 from the Brazilian Federal Court of Accounts (or *Tribunal de Contas da União*, TCU) provides a detailed case study of the "kamikaze" bidding tactic (locally known as "*coelho*" or "rabbit") being used in a public electronic auction conducted by the National Institute for Colonization and Agrarian Reform (INCRA) in 2016.

INCRA was looking to hire seven secretaries and ten receptionists through this procurement process. During the auction, two companies - *Semog Construtora e Serviços Terceirizados - Eireli - ME (Semog)* and *M. Burmann Varanda - ME (M. Burmann)* - submitted unusually low bids which raised suspicions.

According to the TCU report, the practice is described as: "*the action of a bidder who presents an excessively low proposal in a bidding process so that other companies give up competing, because they believe that the other competitor would have a price that would not allow them to continue in the dispute. Subsequently, a company that is in collusion with the 'rabbit' offers the second best bid and, with the intentional disqualification of the first, ends up being contracted for a value that could possibly be higher than that which would be obtained without the influence of the 'rabbit'.*" (p. 3)

The report notes that after presenting the lowest bids, both companies quickly withdrew: "*After the companies Semog and M. Burmann took the initiative to withdraw from the dispute and request the disqualification of their last bids*" (p. 5). These withdrawals were made with vague justifications described as "*simple and vague allegations of 'spreadsheet rounding problems' and 'for technical reasons'*" (p. 4).

The TCU report shows that GA Serviços ultimately won the contract with bids significantly higher than those initially offered: "*the final prices and those that came to be contracted were invariably higher than the best bids of the initial phase*" (p. 6). The report includes a table showing that GA's winning bids were between 10-23% higher than the initial low bids by the suspected kamikaze firms:

Comparison of Bids in INCRA Auction

Item	**Initial Low Bids**	**Final GA Bid**	**Difference**
7 Secretaries	R$ 294,000.00 (Semog)	R$ 326,499.60	+11.1%
8 Receptionists	R$ 239,800.00 (Semog)	R$ 258,997.44	+8.0%
1 Receptionist (Araguaína)	R$ 26,700.00 (M. Burmann)	R$ 33,199.92	+24.3%
1 Receptionist (Araguatins)	R$ 27,400.00 (Semog)	R$ 33,199.80	+21.2%

An INCRA employee, Flávio da Silva Mota, identified the suspicious pattern and alerted the auction officials. The report states: "*Having perceived the indications of such a scheme,*

[the whistleblower] notified his hierarchical superior, the auctioneer, support team, as well as the head of the SR-TO/Incra about the indications of the practice of 'rabbit'" (p. 1). Despite these warnings, the auction administrators failed to take appropriate action to investigate or penalize the companies involved.

Regarding the outcome of the case, the TCU determined that INCRA must complete its internal investigation and report back: "*9.4. determine that the Superintendence of Incra in the State of Tocantins, based on art. 250, item II, of the Internal Rules of the TCU, send to this Court, within thirty days, a conclusive report on the investigations regarding the conduct of bidders in PE 11/2016 and the measures adopted as a result of such results, having as guiding parameters the provisions of art. 7 of Law 10.520/2002*" (p. 32).

Regarding the difficulty in sanctioning companies suspected of kamikaze bidding, it is important to note that the TCU did not share the view presented by the Regional Superintendent. The Superintendent Carlos Alberto da Costa said: "*in view of the absence of elements essential to the verification of the 'rabbit' tactic, of other companies not having given up participating, of not becoming winners the companies pointed to as suspects of the illicit practice, nor of disadvantage occurring for the Administration, such circumstances did not enable the opening of administrative procedure*" (p. 18).

In contrast, the TCU's position was more assertive. The report states: "*In our assessment, there was indeed the practice of the 'rabbit' strategy in Electronic Auction 11/2016, reinforced by other indications of proximity between the companies, in addition to atypical procedures that were decisive in directing the object bid, a situation aggravated by the fact that the companies that most contributed to this environment were not admonished by the INCRA's regional office according to the governing regulations.*" (p. 20). This demonstrates that the Court firmly believed that kamikaze bidding had occurred, despite the challenges in providing definitive legal proof of collusion.

C Detailed Analysis of Illustrative Model

C.1 Proof of Proposition 1: Equilibrium Bidding Strategy

To find the equilibrium bidding strategy, consider a regular bidder with cost c bidding b. Their expected profit is:

$$E[\pi_i] = p(b_i - c_i)Pr(b_i < b_j) + (1-p) \cdot 0$$

where $(1-b)$ is the probability of winning against the other regular bidder, given the uniform cost distribution.

$$Pr(b_i < b_j) = Pr(b(c_j) > b_i) = Pr(c_j > b^{-}1(b_i)) = 1 - b^{-}1(b_i)$$

So the maximization problem is:

$$maxE[\pi_i] = p(b_i - c_i)(1 - b^{-1}(b_i))$$

Assume $b_i = \alpha + \beta c_i$. Then

$$maxE[\pi_i] = p(b_i - c_i)\left(1 - \frac{b_i - \alpha}{\beta}\right)$$

Conditional on bidding, the first order condition is

$$p(1 - \frac{b_i - \alpha}{\beta}) - \frac{1}{\beta}p(b_i - c_i) = 0$$

Or simplifying

$$(\beta - b_i + \alpha) - (b_i - c_i) = 0$$

$$b_i = \frac{\alpha + \beta}{2} + \frac{1}{2}c_i$$

So $\alpha = \beta = 1/2$ and the solution to this equation yields the optimal bidding strategy:

$$b_i = \frac{1 + c_i}{2}$$

□

C.2 Proof of Proposition 2: Expected Price

To calculate the expected price, we first condition on the event that the kamikaze bidder disqualifies. Given the equilibrium bidding strategy $b(c) = \frac{1+c}{2}$, the expected price conditional on the kamikaze bidder disqualifying is:

$$\begin{aligned} E[\text{price}] &= E[\min(b(c_1), b(c_2))] \\ &= E[\min(\frac{1+c_1}{2}, \frac{1+c_2}{2})] \\ &= \frac{1}{2} + \frac{1}{2}E[\min(c_1, c_2)] \\ &= \frac{1}{2} + \frac{1}{2} \cdot \frac{1}{3} = \frac{2}{3} \end{aligned}$$

To understand why $E[\min(c_A, c_B)] = 1/3$ for two bidders with costs uniformly distributed on $[0, 1]$:

1. The cumulative distribution function (CDF) for $\min(c_A, c_B)$ is:

$$F(x) = 1 - Pr(\text{both costs} > x) = 1 - (1 - x)^2$$

2. The probability density function (PDF) is the derivative of the CDF:

$$f(x) = 2(1 - x)$$

3. The expected value is then:

$$E[\min(c_A, c_B)] = \int_0^1 x \cdot 2(1 - x)dx = \frac{1}{3}$$

This result, combined with the bidding strategy $b(c) = (1 + c)/2$, leads to the expected price of $2/3$.

Since the price is only determined by the bids of the two regular bidders, and the kamikaze bidder always forfeits, the unconditional expected price is equal to the conditional expected price:

$$E[\text{price}] = E[\text{price}] = \frac{2}{3}$$

□

D Empirical Support for Model's Assumptions

Our theoretical framework predicts that kamikaze strategies become more effective under specific conditions that amplify their impact on genuine bidders' behavior. We examine two key factors that determine when these strategies are most successful.

Fixed Costs: Simultaneous Auctions Our model shows that fixed bidding costs amplify kamikaze effectiveness by making participation less attractive for genuine bidders when they face uncertainty about kamikaze withdrawals. Brazilian electronic procurement provides a natural setting to test this mechanism, as these auctions often involve simultaneous bidding across multiple items. Half of firms in each procurement auction participate in other auctions within the same batch, with an average of 23 simultaneous auctions occurring for related goods and services during each procurement event.

Unlike in traditional single-item auctions where bidders can focus on optimizing outcomes in a singular context, simultaneous bidding forces bidders to make strategic allocation decisions across multiple auctions. Engelbrecht-Wiggans and Weber (1979) highlight that capacity-constrained bidders strategically vary their bid aggressiveness, offering competitive bids for some contracts while submitting less competitive bids for others they are willing to win only at premium rates. The presence of kamikaze bidding in some auctions introduces a layer of risk for bidders constrained by capacity, making it risky for them to significantly lower their prices in response to such tactics. Instead, they may opt to be more aggressive in other simultaneous auctions.

Column V of Internet Appendix Table A5 tests this by interacting kamikaze presence with above-median simultaneous auctions. The results show significantly stronger kamikaze effects when more simultaneous auctions compete for bidders' resources, consistent with resource constraints amplifying the strategic deterrence effects of kamikaze bidding.

Uncertainty: Multiple Kamikaze Firms Our model predicts that when regular bidders perceive a lower probability of kamikaze bid forfeiture (lower p), they submit less aggressive bids. This effect can be amplified when there are multiple kamikaze firms in the same auction. With K kamikaze firms, assuming independence, the probability that all kamikaze bids will be forfeited is p^K, which is lower than p for $p < 1$.[22] This lower probability reduces regular bidders' perceived chances of winning and the incentives of continuing in the auction.

To test this implication, we interact the *Has Kamikaze* dummy in equation (1) with the

[22] From the perspective of genuine bidders who cannot distinguish coordinated from independent behavior, multiple kamikaze firms appear as independent threats.

number of kamikaze firms in the particular auction, grouped into buckets. Indeed, about 40% of the auctions with kamikazes have more than one kamikaze firm that do not submit the required documents after the auction. The findings in Internet Appendix Table A4 strongly support our model's predictions. Column II shows that auctions with a single kamikaze firm exhibit a 5.25% higher price compared to similar auctions without kamikaze firms. This effect monotonically increases with the number of kamikaze firms, reaching 32.5% for auctions with five or more kamikaze firms. This pattern is consistent with the framework where multiple kamikaze firms give an appearance of competition, leading to less competitive bidding behavior of genuine firms and higher procurement prices.

These findings demonstrate that kamikaze strategies are most effective when genuine bidders face resource constraints and heightened uncertainty about withdrawal probabilities, supporting our theoretical framework's predictions about the conditions that enable sustained kamikaze success.

E Firm Roles

In this section, we report the analysis of the characteristics of kamikaze firms. Brazilian firm registry *Receita Federal* allows us to observe a few firm characteristics such as firm age and size.[23] We thus study if the kamikaze firms are consistently smaller and younger than the winning firms, i.e., they are likely to be special-purpose entities, and whether they take stable roles with the winning firms in the repeated auctions.

We first estimate the following specification as we focus on individual characteristics:

$$y_{ipj} = \alpha_{ip} + \beta X_{ipj} + e_{ipj} \tag{9}$$

where y_{ipj} is either the $p(kamikaze)_{ipj}$—a dummy equal to 1 if bidder j at procurement i for item p is a kamikaze firm and zero otherwise—or $p(winner)_{ipj}$—a dummy equal to 1 if bidder j at procurement i for item p is the winner and zero otherwise. The main explanatory variables, X_{ipj} are firm characteristics at the procurement i, item p, and firm j level—firm age and size. This specification controls for procurement-by-item fixed effects, which effectively compares the characteristics of firms participating in the same auction.

Internet Appendix Table A8 presents the findings. Columns I and II show that relative to the other participants in the same auction, smaller and younger firms, i.e., those that are more opaque, are more likely to be kamikazes. In particular, firms that were created less

[23]Small firms are defined as per official Brazilian government classification. These are firms that have at most BRL 4.8 million in yearly revenue (USD 1 million) and no more than 99 employees.

than 3 years ago (young firms) are 3.24% more likely to engage in the kamikaze strategy than other auction participants. Also, small firms are 3.89% more likely to be kamikaze firms. Columns III and IV look at the corresponding characteristics of winners in kamikaze auctions. We see that young and small firms are 1.68% and 5.32% less likely to be winners, as compared to other participants in the same auction.

To study the dynamics of the roles that kamikaze and winning firms take and thus to understand whether the kamikaze and winning firms engage in bid rotation or have stable roles (especially if they are likely related through ownership), we investigate whether firms that engage in kamikaze strategies in some auctions are likely to continue following the same strategy in the other auctions.

We initially consider whether firms switch across different procurements. To do that, we estimate the following regression:

$$y_{ipjt} = \alpha_{ip} + \beta_1 \cdot X_{jt} + e_{ipjt} \tag{10}$$

where y_{ipjt} is a role in the procurement i, item p, firm j and time t: either whether the firm j is a kamikaze firm in procurement i to purchase item p at year t, or whether the firm j was a winner of procurement i, item p at year t. Similarly, X_{jt} is either *Was Kamikaze*$_{j,t-1:t-12}$, or *Was Winner in Kamikaze Procur*$_{j,t-1:t-12}$. *Was Kamikaze*$_{j,t-1:t-12}$ is a dummy equal to 1 if firm j was a kamikaze firm in another procurement in the past 12 months. *Was Winner in Kamikaze Procur*$_{j,t-1:t-12}$ is a dummy equal to 1 if firm j was a winner in procurement in the past 12 months with the presence of a kamikaze firm.

Internet Appendix Table A9 presents the findings. In columns I and II, y_{ipjt} is a dummy equal to one if a firm j is a kamikaze firm in procurement i to purchase item p at year t and 0 otherwise. Column I shows that firms that were engaging in a kamikaze strategy in the previous year are more likely to continue doing so in the focal procurement. In addition, as per column II, winning firms in kamikaze auctions in the previous year are less likely to engage in kamikaze themselves in the focal procurement. These results suggest that kamikaze firms adopt constant roles in their coordinating strategies. Similarly, in columns III-V, y_{ipjt} is a dummy equal to one if a firm j is a winner firm in procurement i to purchase item p at year t and 0 otherwise. Column III shows that previous kamikazes are less likely to be winner, while columns IV and V show that previous winners in kamikaze auctions are more likely to continue winning. Column V includes a control for general winning experience (Was Winner) to show that the effect is specific to winning in kamikaze auctions rather than general firm quality.

We also test switching *within the same procurement* but across different items purchased

in the same procurement. We implement the following specification:

$$y_{ipjt} = \alpha_{ip} + \beta_1 \cdot X_{ip^*jt} + e_{ipjt} \tag{11}$$

where y_{ipjt} is a role in the procurement i, item p, firm j and time t: either whether the firm j is a kamikaze firm in procurement i to purchase item p at year t, or whether firm j was a winner of procurement i, item p at year t. Similarly, X_{ip^*jt} is either $\textit{Was Kamikaze}_{ip^*jt}$ or $\textit{Was Winner in Kamikaze Procur}_{ip^*jt}$. $\textit{Was Kamikaze}_{jp^*j}$ is a dummy equal to 1 if firm j was a kamikaze firm in procurement i purchasing item $p^* \neq p$. $\textit{Was Winner in Kamikaze Procur}_{ip^*jt}$ is a dummy equal to 1 if firm j was a winner in procurement i purchasing item $p^* \neq p$.

Internet Appendix Table A10 shows the findings that are very similar to the ones found across procurements as reported in Internet Appendix Table A9: kamikaze firms are less likely to win other auctions of the same procurement, and winners of auctions with kamikaze firms are more likely to win other auctions, especially when these other auctions also have a kamikaze firm.