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

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Abstract

Bid-rigging in public procurements has severe implications for public service quality. We take one ex-post observable bid-rigging strategy to document its effects on Brazil's public services. In a 'kamikaze' strategy in procurement auctions, the lowest bidder withdraws after the auction concludes, allowing the second-lowest bidder to win at higher prices. This pattern occurs in 17 percent of auctions, increasing prices by 18 percent. Shared ownership ties between kamikaze and winning firms suggest coordination of bids. Ultimately, this behavior correlates with negative real non-price outcomes: higher mortality rates in public hospitals and increased road accidents after maintenance contracts. Our findings reveal how bid-rigging extends beyond fiscal costs and endangers public well-being.

Keywords: public procurement, bid-rigging, shared ownership, non-market outcomes, financially-constrained governments

JEL Classification: G34, G38, L22, L41

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Governments spend significant resources purchasing goods and services from private companies, with public procurements constituting 12 percent 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 percent (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 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 approximately 15 million distinct item purchases between 2005 and 2021. Government institutions conduct these purchases via first-price electronic reverse auctions, a format commonly employed in public procurement worldwide,[1] where bidders compete in real-time by offering successively lower prices. Using this rich dataset, we identify a specific and prevalent form of bid-rigging: in 17 percent of the auctions, the lowest bidder ("kamikaze") withdraws post-auction, allowing the second-lowest bidder to win.[2] 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 leads to significant overpricing compared to similar auctions where it is not present. Procurement prices are 16 to 18 percent higher in auctions with kamikaze firms, when the lowest bidder drops out from the auction and the second-lowest bidder wins. Such pricing outcomes come together with non-kamikaze firms submitting 1.1 to 1.3 fewer bids (a 23-28 percent reduction from the average of 4.7 bids per bidder) and 19-21 percent lower dispersion in bid values, suggesting less aggressive competitive strategies. The effect is robust when comparing auctions for the same item, year, number of bidders, purchasing institution, and even for the same winning firm.

To understand this behavior, we develop a theoretical framework that highlights how

[1] According to the World Bank Procurement Database, electronic reverse auctions are used in countries such as the United States, the United Kingdom, France, Russia, India, and Mexico, albeit to varying degrees.

[2] 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."*

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 before submitting their own 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 by kamikaze, some competitors may opt out of bidding. Anticipating reduced competition, other bidders submit less aggressive bids, leading to higher prices.

The empirical evidence supports these theoretical predictions. 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. 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.

Our interpretation of coordination is further reinforced by ownership patterns. Kamikaze and winning firms are often owned by the same ultimate owner, with kamikaze firms being smaller and younger than the winners. Moreover, firms repeatedly act as kamikazes across multiple auctions. Combined with their shared ownership patterns, this suggests that kamikaze firms are likely special-purpose entities created specifically to support bidding strategies. In the end, in auctions where kamikazes and winners share the same owner, we observe higher overpricing than in kamikaze auctions where they do not share owners.

These ownership patterns also allow us to address a key concern that our results might be driven by unobserved factors that explain why certain firms choose to participate as kamikazes. We address this concern by studying a 2014 transparency reform in the procurement system. This reform allowed auctioneers to observe shared ownership between auction participants. 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 pre-trends in procurement prices before the reform. In contrast, prices dropped significantly after 2014 for firms that previously engaged in coordination through shared ownership. These findings indicate that kamikaze bidding represents deliberate coordination facilitated through ownership ties rather than coincidental bidding patterns.

Having established that kamikaze behavior is associated with overpricing and can be explained by bid-rigging, we examine how the resulting inefficiencies affect public service provision. Such an effect can occur through at least two channels. First, bid-rigging places financial strains on government institutions, as overspending can negatively impact future public budgeting. 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. 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 percent 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.

We also investigate how kamikaze bidding affects road safety after the award of maintenance contracts. Roads maintained through contracts awarded to firms in kamikaze auctions experience 15 to 25 percent more accidents and casualties, even when comparing road repairs with similar complexity. Unlike for specific medicine procured by 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.

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 showing how bid-rigging leads to negative real effects in public service provision. More generally, the literature on bid-rigging 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). Instead, we use an observed bid-rigging behavior 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 firm growth (Ferraz et al., 2022), productivity (di Giovanni et al., 2022), healthcare access (Barkley, 2023), infrastructure (Liscow et al., 2023), and the environment (Alé-Chilet et al., 2024). Our analysis also reveals *how* bid-rigging harms 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, 2011; Decarolis, 2014).[3] 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. The distinction is crucial because it highlights a more covert form of bid-rigging that drives up prices, placing 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.[4] In addition, related to the broader corporate ownership implications, we provide new evidence of how firm ownership can affect patient

[3]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."*

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

health outcomes (e.g., 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.

1 Data

The main dataset comes from the ComprasNet portal, 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. 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. Internet Appendix Table A1 provides an example list with selected products and services, while Internet Appendix Table A2 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 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. The dataset covers about 15 million procurement auctions from 2005 to 2021. The average auction had 6.84 participants, with each non-kamikaze firm submitting an average of 4.26 bids. 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. The data also reveals that in 2% of the auctions, participating firms had shared owners, while in 23% of the cases, the winning firm and the kamikaze firm were located in the same municipality.

[5] Internet Appendix Figures A1 and A2 illustrate the geographical spread of government institutions and bidding firms, respectively.

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. In these 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 (Best et al., 2023), Israel, India (Lewis-Faupel et al., 2016), and Mexico. In contrast, countries like Germany, Italy, Canada, South Korea, and Singapore tend to use first-price sealed bid auctions. Evidence suggests these auctions can generate substantial savings: U.S. federal agencies reported 12-14% cost reductions (United States Government Accountability Office, 2013), while the UK public sector achieved savings between 20-39% across various commodities (Office of Government Commerce, 2010).

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 to see if they meet the minimal criteria. Approved bidders are then 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 each other's lowest bids but not the history of the bids, nor the identities of other bidders.[6] On the other hand, 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

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

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. While this may result from honest mistakes or cost misestimations, e.g., as a result of a "winner's curse" realization,[7] 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,[8] and these bidders have been coined "kamikazes",[9] 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 dollar value of 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), the winners (red, square), and "runner-up" bidders (orange, triangle). We express all bid prices as a percentage of the winning bid. To construct this plot, we gather bids for each auction at one-minute intervals. 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 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, confirming the aggressive bid behavior of these to-be-forfeited bids. Second, winners stop reducing the bid around 12 minutes before the end of the auction, suggesting that they might be aware of the kamikaze's intentions to remove itself from the auction. Third, kamikaze firms continue to reduce the bids until the end of the auction, potentially targeting the runner-up bidder who might assign a non-zero probability that the kamikaze firm is a legitimate bidder.

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

[7]Note that, compared to closed-bid auctions, in open-bid auctions the "winner's curse" is less likely as bidders observe the dynamic evolution of bids.

[8]*Tribunal de Contas da União* (TCU)'s sentence no. 1793/2011 argues that *"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."*

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

as a surety bond, or the imposition of fines, the enforcement against kamikaze behavior is limited in Brazil. Federal Law No. 10,250/2022 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.[10] 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.[11] Moreover, corporate lawyers argue against severe punishment for potential good-faith mistakes, citing the risk of overpricing in future auctions by reducing the number of potential competitors. In the Internet Appendix B, we highlight the difficulty in prosecuting kamikaze firms via a case study of two firms that may have acted as kamikaze firms in a 2016 public auction conducted by Brazil's National Institute for Colonization and Agrarian Reform (INCRA).

3 Kamikaze Firms

Before we discuss the real non-market outcomes, we establish the relevance of kamikaze behavior as a bid-rigging indicator. This section first investigates whether auctions with kamikaze firms are associated with higher prices of goods and services than similar auctions. Then, it discusses the reasons why the kamikaze strategy is successful. Lastly, we study the characteristics of the kamikaze firms and the dynamics of the kamikaze behavior.

3.1 Overpricing

We first study whether auctions that present kamikaze behavior have different outcomes 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. While this behavior could indicate strategic coordination with other participants, it may also result from honest mistakes or a cost misestimation. In this section, we document that kamikaze bidding is indeed associated with higher eventual prices, and we analyze the reasons in Section 3.2.

[10] See https://compras.dados.gov.br/docs/fornecedores/ocorrencia_fornecedor.html.

[11] See TCU's sentence no. 1793/2011, paragraph 90.

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 log of the price of 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 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 log of the procured price. Column I reveals that auctions with kamikaze firms have 18.4% higher prices than other similar auctions for the same items, the same number of bidders, and occurring in the same year. To address concerns 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 these controls, the kamikaze behavior is still associated with a 16.6% price increase, suggesting that the presence of kamikaze firms significantly drives up costs, regardless of the procuring institution's efficiency.

We further study other public procurement outcomes associated with kamikaze behavior to document whether the presence of kamikaze firms is indeed associated with lower competition. We estimate equation (1) for two additional outcome variables: the number of bids per non-kamikaze firm and the standard deviation across all the bids by non-kamikaze firms within an auction normalized by the average bid. Lower values for these measures would suggest less aggressive competition from the non-kamikaze firms. Columns III to VI of Table 2 show the findings: on average, 1.127 to 1.329 fewer bids per non-kamikaze firms in the presence of kamikaze firms (columns III and IV), and 19-21 lower relative variability of bids in kamikaze auctions (columns V and VI). All in all, these findings suggest that the kamikaze auctions have lower competition, which is consistent with the higher prices.

To further support this interpretation, we analyze the bidding behavior of runner-up firms (genuine second-place winners after kamikaze firms drop out). Internet Appendix Figure A4 demonstrates that in kamikaze auctions, runner-ups converge more slowly to eventually-winning bids, thus suggesting less aggressive bidding. The runner-ups' bids are also consistently larger than the second-place bids in the auctions without kamikazes. Internet Appendix Table A3 confirms this with the econometric evidence of a larger gap between runner-up and winning bids in the kamikaze auctions as compared to non-kamikaze auctions. Collectively, these findings indicate that the presence of kamikaze firms is associated with lower competition, consistent with the higher prices observed in kamikaze auctions.

We address two potential explanations for the observed overpricing in kamikaze auctions that are alternative to the coordinated bidding. 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, and thus consistently charging higher prices for their items than winners in non-kamikaze auctions. We address this concern 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 by half to about 7-8% (columns I to III), 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.[12]

Second, in column IV of Table 3, we report the findings with which we address a potential concern about the correlation between the incidence of kamikazes and the auctioneer's efficiency, corruptibility, or other incentives. When we compare procurements that had the same auctioneer, we see that the coefficients' magnitude is similar to our main specifications in Table 2, suggesting that that the observed overpricing in kamikaze auctions is not driven by potential differences in auctioneers' characteristics.[13]

3.2 Strategy Stability

This section provides theoretical and empirical evidence explaining how and why the kamikaze strategy may be successful in driving up prices in procurement auctions. While one might assume that non-kamikaze firms could bid the same price regardless of kamikaze firms, effectively neutralizing their strategy, the framework outlined below shows an argument why this is not necessarily the case. In particular, non-cartel bidders bid less aggressively if three necessary conditions hold: (a) uncertainty on whether excessively low bids are legitimate, (b) bidders have a fixed cost of bidding, and (c) one or more regular bidder has inside knowledge about the kamikaze firm (akin to coordination between them). Such cases generate the overpricing that we document in Section 3.1 above.

[12]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.

[13]We further show in Internet Appendix Table A4 that the overpricing does not vary significantly across institutions with higher versus lower incidence of kamikaze firms. In addition, we show that while the effect is stronger for goods than services, it is significant in both. These findings reinforce the notion that institution-specific characteristics or item types do not drive the overpricing effect.

Our framework provides insights into why non-collusive firms might struggle to adapt to and counteract these strategies effectively over time. We further document empirical evidence that underscores the importance of the three key conditions outlined above. First, overpricing increases with uncertainty about kamikaze bids, especially when the kamikaze bid is more aggressive or when multiple kamikaze firms create the appearance of competition. Second, higher costs required to continue bidding amplify overpricing, particularly in scenarios when simultaneous auctions for similar items divert bidders' attention and resources. Third, we present evidence suggesting coordination between kamikaze firms and eventual winners, as they are more likely to share common owners.

3.2.1 Simplified Framework and Effective Competition

We develop a formal framework of procurement auctions with kamikaze bidding to justify informal arguments on the kamikaze strategy stability. Consider a first-price procurement auction with $N = 3$ bidders: $N - N_K = 2$ regular bidders (A and B) and $N_K = 1$ potential kamikaze bidder (K). In this auction, the lowest bid wins, and the winner gets awarded the contract in the value of their bid. Each regular bidder has a private cost of providing the procured good c_i, independently drawn from a uniform distribution on $[0, 1]$. Regular bidders know the distribution of each other's costs but not the specific realizations. Regular bidders are risk-neutral and seek to maximize expected profit. We normalize the kamikaze bid to be at $b_K = 0$, regardless of its actual costs.

Regular bidders simultaneously observe the kamikaze bidder's bid before submitting their own bids.[14] The regular bidders face uncertainty whether the kamikaze bidder's bid is genuine and thus will be fulfilled or whether it is a kamikaze bid and it will be withdrawn post-auction. That is, while we later relax this assumption, for now we assume that both regular bidders hold the same information and do not know the kamikaze bidder's cost distribution. So, they both believe the kamikaze bid will be forfeited with probability $p \in [0, 1]$.

In this scenario, regular bidders will choose a bidding strategy that maximizes their expected profit:

$$E[\pi] = p \cdot P(b_i < b_j) \cdot (b_i - c_i)$$

where $p \cdot P(b_i < b_j)$ is the effective probability that bidder i will win the auction, namely the probability that the kamikaze firm will forfeit and bidder i's bid is lower than bidder j.

[14] While our empirical analysis is based on an open bid auction, as a simplification, we model the behavior of regular bidders A and B as if in a sealed bid framework. Specifically, after observing the kamikaze bid, we assume A and B submit their bids simultaneously without further interaction.

The solution to this problem will be that 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. Thus, the outcomes will be equivalent to an auction with only two "actual" bidders. Propositions 1 and 2 show the optimal bidding strategy and the expected price under these assumptions. For a full proof of the propositions below, see Internet Appendix C.1 and C.2.

Proposition 1 (Equilibrium Bidding Strategy)**.** *In the unique symmetric Nash Equilibrium, the optimal bidding strategy for regular bidders is:*

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

Proposition 2 (Expected Price)**.** *Because the kamikaze firm always retracts its bid, the expected price in this scenario is the same as if the auction only had bidders A and B:*

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

Proposition 2 demonstrates that in an auction with three bidders – two regular bidders (A and B) and one kamikaze bidder (K) – the expected price is 2/3. This price is higher than 1/2, which would be the expected price in a scenario with three regular bidders. The intuition behind this result is that with the kamikaze bidder always forfeiting, the auction effectively becomes a two-bidder auction between A and B. In such a setting, non-kamikaze bidders end up competing for second place, knowing that the lowest (kamikaze) bid will likely be withdrawn. This scenario is equivalent to an auction with $N - N_K$ bidders, where N_K is the number of kamikaze bidders. Thus, part of the overpricing observed in kamikaze auctions can be attributed to this reduction in the number of genuine bidders actively competing for the contract.

Empirical Evidence: Actual Number of Competitors If the reduction of genuine competitors is the sole cause of overpricing documented in Section 3.1, we would expect to see no difference in pricing between kamikaze and non-kamikaze auctions when comparing auctions with the same number of effective competitors ($N - N_K$ bidders). That is, if the kamikaze bidder is (expected to be) forfeiting the bid due to, say, the "winner's curse" reason, we should not observe any overpricing once we control for the effective number of competitors if other bidders have the same information about the kamikaze bidder. However, our findings in column V of Table 3 contradict this interpretation. While the coefficients decrease, indicating that this direct effect partially contributes to explaining our results, a larger share of overpricing remains unexplained. This residual excess overpricing points to the potential role of asymmetric information about the kamikaze bidder contributing to the overpricing observed in kamikaze auctions.

3.2.2 Extended Framework: Explaining Excess Overpricing

We now extend the framework to consider a scenario where there are fixed costs $F > 0$ associated with submitting a bid. These costs represent, for example, the opportunity cost of time spent monitoring the auction or the expense of maintaining a team on standby during the auction period. In this extended model, bidders will only choose to participate if their expected profit is non-negative, which depends not only on their own strategies but also on their beliefs about the other bidders' participation and bidding decisions.

The expected profit for bidder i with cost c_i is given by:

$$E[\pi_i] = p \cdot P_j \cdot P(b_i < b_j | \text{ both participate}) \cdot (b_i - c_i) + p \cdot (1 - P_j) \cdot (b_i - c_i) - F$$

where P_j is the probability that the other bidder j participates.

The introduction of fixed costs complicates the bidding and participation strategies. First, a bidder will only choose to participate if their expected profit is non-negative. This expected profit depends not only on the participation cost F but also on the probability that the other bidder participates (P_j). This, in turn, depends on the bidder's j expected profit and their beliefs about the bidder's i participation decision. Second, similar reasoning applies to the optimal bid as it depends on the probability of winning and is now affected by the probability that the other bidder will participate or not. Third, the participation decision depends on the expected profit, which depends on the optimal bid. However, the optimal bid itself depends on the probability of winning, which is influenced by the other bidder's participation and bidding decisions.

Due to this circular dependence, closed-form solutions for the bidding strategies and participation decisions are not tractable. Instead, we resort to numerical methods to approximate the equilibrium. For each cost level between $[0, 1]$, we simulate the bidders' decisions by iteratively updating their bidding strategies and participation decisions based on their expected profits until achieving convergence. Each bidder seeks to maximize their expected profit by choosing an optimal bid, considering the probability of winning and the cost of participating. The participation decision is made by comparing the expected profit (which depends on the bid) to the fixed cost F. The bidder only participates if the expected profit exceeds F.

Panel A of Figure 4 illustrates these patterns by plotting expected prices obtained from numerically solving the model. With zero fixed costs ($F = 0$), prices remain stable around 0.67 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. These trends reveal how both higher fixed costs and a lower probability of kamikaze firm forfeiture influence bidding behavior in reverse auctions. 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 in the competitive landscape 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 both increase profit margins, making participation worthwhile despite elevated risks, and compensate for the reduced winning probability due to potential kamikaze participation. Thus, the model predicts that higher fixed costs combined with lower forfeiture probabilities lead to less aggressive bidding as bidders adapt to the changing auction environment.

Empirical Evidence: Simultaneous Auctions and Capacity Constraints Our argument relies on regular bidders experiencing fixed costs of bidding after entering into an auction and observing the bid of a kamikaze firm. One source of such fixed costs in the institutional context of Brazilian public procurements is that open-bid procurements via electronic auctions often involve simultaneous auctions, which might affect the allocation of resources each bidder spends on each auction. In fact, half of the firms in each procurement auction participate in other auctions within the same procurement batch. We observe that 23 other auctions are happening at the same time as an average procurement auction with 9 sourcing items in the same family of goods and services (e.g., agricultural supplies) and 3 sourcing the same item (e.g., a particular fertilizer). The open nature of electronic procurement auctions allows bidders to see each other's bids, though not the identity of the bidders, in real-time. This enables bidders to learn about their competitors' valuation of the item within the same auction. As a result, losing bidders might choose to refrain from spending further resources bidding in a particular auction, even before it concludes and instead to focus on other auctions. Effectively, the limited bandwidth in the presence of simultaneous auctions generates the fixed cost of bidding.

Moreover, the presence of capacity constraints provides another, more nuanced, argument on how simultaneous auctions introduce fixed costs. Unlike in traditional single-item auctions, where bidders can focus on optimizing their outcomes in a singular context, the nature of simultaneous bidding encourages bidders to not only decide how much to bid in each auction, but also where to bid more aggressively and where to be more conservative.

Engelbrecht-Wiggans and Weber (1979) highlight these different strategies by noting that "under equilibrium bidding in simultaneous auctions, bidders may bid more aggressively for some objects than for other objects of equal value; although a bidder may be able to use only a certain number of objects, he is willing to take additional objects if they come at bargain prices". The bidder may decide to sell goods across multiple auctions only if they can secure a substantially better price in at least one of them. 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.

In column VI of Table 3, we report findings where we interact the presence of kamikaze firms with a dummy variable indicating a higher-than-median number of simultaneous auctions, which are auctions conducted at the same time by the same buyer for similar goods or services. Indeed, the kamikaze behavior is successful in creating overpricing, particularly in procurements with more simultaneous auctions. These findings are consistent with the simultaneous auctions introducing fixed bidding costs due to limited bandwidth, bidding resources, or capacity constraints.

Empirical Evidence: Aggressiveness of the Kamikaze Behavior The argument of bidders switching to simultaneous auctions when they perceive that the probability of winning is low is reinforced with further evidence that the impact varies with the intensity of observed kamikaze behavior. We consider that higher intensity is more likely to induce the other bidders to shift their attention to other simultaneous auctions, in particular when the kamikaze bids are exceptionally low or when there is a higher number of firms placing low bids and subsequently withdrawing upon winning the contract, i.e., more kamikaze firms.

We start with the degree to which kamikaze firms bid lower than the winning bid. We re-estimate equation (1) by adding the interaction term of the *Has Kamikaze* dummy with dummies based on how much lower the kamikaze bid was relative to the winning bid ("discount"). Panel A of Table 4 presents these estimates that show that the lower the kamikaze bid compared to the winning bid (i.e., the higher the discount), the higher the resulting overpricing of the procurement. This finding is consistent with intimidation by kamikaze firms: potential competitors are less likely to continue bidding if they observe an excessively low bid by the lowest bidder. As a result, the second lowest bid is going to be higher than what it should be in the absence of kamikaze firms.

Another way to intimidate and give the appearance of competition is to have more than one kamikaze firm participating in an auction. We add interaction terms to equation (1), interacting the *Has Kamikaze* dummy with the number of kamikaze firms in the particular auction, grouped into buckets. Indeed, about 40% of the auctions with kamikazes have multiple kamikaze firms that do not submit the required documents after the auction. Panel B of Table 4 presents the results that paint a similar picture to the magnitude of the kamikaze firms' bids results seen in Panel A. We see that more kamikaze firms in the same auction correspond to more overpriced winning bids, as compared to similar auctions.

3.3 Coordination

Coordination among bidders, specifically collusion between a regular bidder and the kamikaze firm, can lead to overpricing through asymmetric information. This scenario extends the model outlined in Section 3.2.2 by allowing bidder A to collude with the kamikaze firm, giving this bidder the certainty that the kamikaze firm will always be withdrawn (i.e., $p_A = 1$). In contrast, bidder B, unaware of this collusion, believes forfeiture is less certain (i.e., $p_B < 1$). 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 4 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.

We then turn to examine the linkages between kamikaze firms and eventual winners empirically that help us ascertain their roles in the strategic bidding rings. We provide the general trends of these relationships and then study the transparency reform that made these linkages, in particular the ownership between the firms, more salient. We conclude by studying whether these relationships repeat themselves across different auctions.

3.3.1 Firm Linkages and Shared Ownership

We start with the correlations. We obtain information on firm characteristics from the Brazilian firm registry *Receita Federal*. While we can extract only limited information, we are able to consider firms' geographic location and ownership structures. We are particularly interested in whether they share the same geographic environment and ownership.

We only focus on the non-kamikaze participants in auctions with kamikazes. We then estimate the following specification:

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

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} are firm characteristics at the procurement i, item p, and firm j level—the dummies indicating whether firm j is from the same municipality, is from the same zip code, and has the same owner as the kamikaze firm in procurement i and item p. This specification adds procurement-by-item fixed effects, which effectively compares the characteristics of firms participating in the same auction.

Table 5 presents the findings. Column I reports the correlations between being the winner and being from the same municipality as the kamikaze firm, column II reports the correlations between being the winner and being from the same zip code as the kamikaze firm, and column III reports the correlations between being the winner and having the same owner as the kamikaze firm in procurement i and item p. Winning firms are indeed more likely to be connected to kamikaze firms than the other participants in the same procurement.[15]

More importantly, we observe shared ownership structures between kamikazes and winning firms. Those participants that have at least one owner in common with the kamikaze firm are 6.7% more likely to win the procurements. This finding provides the most direct evidence of the possible *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 share ownership, 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.

We further expand on this observation of the shared ownership between the kamikaze and winning firms. Since kamikaze firms are more likely to share owners with potential winners, we investigate the interactive effect on prices if kamikaze firms share common owners with the winner. That is, we re-estimate the equation (1) by interacting the *Has Kamikaze* dummy with the dummy on whether kamikaze firms and winner firms shared ownership. Table 6 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 103% of the unconditional effect of having a kamikaze firm in an auction. These findings that overpricing is larger in those cases when kamikaze and winning firms are linked via shared ownership give the most direct evidence of the potential coordination in actions between these sets of firms.

[15] 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.

3.3.2 Transparency Reform and Kamikaze Behavior

High-dimensional fixed effects in our previous estimates 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 A5, the fraction of public procurements with participants that shared ownership with other participants in the same auction dropped after 2014. 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 approach. The regression specification is as follows:

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

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.

Table 7 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 percentage point 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 $SharedOwnership_j$.

Finally, to validate the use of this transparency reform for identification, we look at the pre-trends in price behavior for treated versus control firms. Figure 5 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 $SharedOwnership_j$.

Overall, this provides 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.

3.3.3 Firm Roles

Finally, we document the characteristics of kamikaze firms and their relationships with winners in repeated auctions. The analysis reveals that kamikaze firms are consistently smaller and younger than the winners, suggesting that they are likely special-purpose entities. Their opaqueness could contribute to their success in facilitating collusive bidding arrangements, as it makes detection and prosecution more challenging.

Moreover, we find that kamikaze and winning firms tend to maintain stable roles across auctions. Firms that acted as kamikaze firms in the past 12 months have a 4.3% probability of repeating this role in current procurements, compared to 3.7% for firms without recent kamikaze history. Similarly, firms that won in kamikaze auctions in the last 12 months are 14.9% more likely to win current procurements, compared to 11.5% for firms without such wins. This stability in roles supports the notion that kamikaze firms serve as special-purpose entities to enable collusion while evading detection. A detailed discussion of this analysis is provided in Internet Appendix Section D.

4 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 proper public services. We study this by examining service quality in terms of the cost overruns and the days of contract completion. We then again zoom into one particular sector and investigate the real effects of road accidents that are likely to occur due to lower-quality road maintenance by the winners of kamikaze auctions.

4.1 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 across all government institutions in our sample:

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

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

where in specification (4) 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 (5), $Kamikaze\ Share_{apt}$ 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 log 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 leads 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 budget constraints of government institutions.

Back-of-the-envelope calculations on the cross-item effects in Panel B suggest consistent effects. The average purchase of institution a for all items $p^* \neq p$ at year t is 277 million Brazilian Reais (BRL), so if kamikaze auctions rise by 1 percentage point and they are on average 17% overpriced, that would result in an average 470.9 thousand BRL (86.5 thousand USD) extra expenditures due to kamikaze bid-rigging. As the average purchased item p is 277 thousand BRL and on average there are 50 items purchased, the elasticity in Column III of Panel B suggests that a 1 percentage point increase in kamikazes and 471 thousand BRL overpricing would be associated with lower 277 thousand BRL expenditures in the following period.

4.2 Contract Quality

Next, we study the budget and contract execution of these procurements. 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 study whether contracts that follow the kamikaze auctions are associated with lower quality: that is, whether they are more often canceled, associated with higher cost overruns, and extended delays.

We estimate the following regression:

$$y_{ijt} = \alpha_{at} + \beta \cdot HasKamikaze_{ijt} + e_{ijt}, \quad (6)$$

where y_{ijt} are the contract quality outcome variables 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 strategy and 0, otherwise. We add government institution-by-year fixed effects (α_{at}) to take into account any time-varying shock to contract quality and incidence of kamikaze firms that are related to the institution.

We then compare these outcomes for procurement i that had a kamikaze bid against those procurements that did not, and report our estimates 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, marking a significant 16.7% increase compared to the average rate of cancellations. Furthermore, we find a 0.6% greater chance of experiencing cost overruns, meaning expenses that exceed the initial budget projections. Additionally, the comparison of actual payments to predicted costs reveals a 1 percentage point higher ratio in instances of kamikaze bidding. Lastly, these procurements commonly encounter extended delays, with the delivery timeline almost 16% longer than that of comparable procurements without kamikaze bids. All in all, it seems that the winners in kamikaze auctions may not initially be the most efficient. Such effects add additional strains on government agencies on top of 18% overpricing for the same products and services.

4.3 Hospital Mortality

We analyze data on hospital mortality for 61 federal hospitals in Brazil obtained from Data-SUS. 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.[16] 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 date of purchase in a "stacked" difference-in-differences method (e.g., Gormley and Matsa, 2011; Cengiz et al., 2019; Deshpande and Li, 2019) approach as follows:

$$y_{iet} = \alpha_{ie} + \alpha_{et} + \beta \cdot Kamikaze_{ie} \cdot Post_{et} + u_{iet} \tag{7}$$

where y_{iet} refers to the mortality rate of hospital i in cohort e at time t. $Kamikaze_{ie}$ 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 hospital mortality.

Table 10 shows the estimates for this specification. In columns I and II, we can see that kamikaze auctions of essential medicines are associated with a 0.78-0.79 percentage point higher mortality rate for the particular cause, looking at 2- and 3-years windows around the event, respectively. This increase corresponds to an approximately 19% increase from the unconditional average mortality rate.[17] These initial estimates are robust to time-invariant

[16] We classify hospital-disease pairs as "treated" when at least 90% of their purchases in the same quarter are made in kamikaze auctions.

[17] The increase in mortality rate is comparable to that found in the literature for other hospital policies.

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, we introduce additional controls in the form of hospital-event-year fixed effects, as shown in columns III and IV. 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 percentage points, reinforcing our initial findings. In the 3-year window (column IV), the effect decreases to 0.53 percentage points.

To further explore the impact of kamikaze auctions, we focus on the top three causes of mortality in columns V and VI. We find even larger estimates, ranging from 0.93 to 1.09 percentage points. 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, potentially exacerbating their negative effects on patient outcomes.

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 6, we provide a visual representation of the effect of kamikaze auctions on hospital mortality. 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. Moreover, the effect of kamikaze auctions emerges only after the purchase.

To 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 percentage point 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)

For instance, Nelly et al. (2010) finds a decrease of 18% in the mortality rate after a hospital training program by the Veterans Health Association.

(-1.2 for low birth weight infants),[18] suggesting our mortality effects are within reasonable bounds.

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.

4.4 Road Accidents

In addition to hospital mortality, we also look at road quality as another real outcome of bid-rigging in kamikaze auctions. We take information from 952 road repair contracts. Of these, 360 were awarded in kamikaze auctions and 592 in non-kamikaze 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 month. We then estimate a regression in a "stacked" difference-in-differences approach similarly as in the specification (7) above.

Table 11 shows the estimates. In columns I and III, we can see that road repair contracts awarded in kamikaze auctions are associated with a 25.7% higher number of accidents and a 26% higher number of victims, respectively, in the two years around the procurement.[19] As the auction design could be correlated with the complexity of road repairs, we further control for the differences in the extension of these road repairs in terms of the number of kilometers. As seen in columns II and IV, the coefficients are almost identical. Panel B of Figure 6 shows that the effect on accidents only comes after the purchase and that there are no clear diverging trends before the procurement.

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. This suggests another channel through which bid-

[18]This elasticity is backed out from the increase in 11% in hospital charges for infants below 1,500 grams and the decrease in mortality by 0.7 percentage points (or 13% of the unconditional average). See more details in Almond et al. (2010).

[19]This increase in accidents and victims is comparable with evidence in the literature. For instance, Faccio and McConnell (2020) find an increase of 48% in the number of accidents and 27% increase in injuries due to the introduction of Pokémon GO in the US. Moreover, Grundy et al. (2009) argue that the mandatory introduction of 20 mph (32 km an hour) zones in London reduced road casualties by 42%.

rigging in public procurements can affect real outcomes — via lower quality of the procured services themselves.

5 Conclusion

This study documents that bid-rigging in public procurement auctions leads to capital misallocation and ultimately affects the quality of public service provision. 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 18% and often involves firms that share common owners. The consequences of this behavior go beyond fiscal costs. It affects real outcomes through two channels: 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 results 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 (Pessendorfer, 2000), or complementary bidding (Porter and Zona, 1993; Bajari and Ye, 2003; Clark et al., 2018). Like our 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, while maintaining the cartel requires favoring members 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 the connections between the winning firms can raise the costs of implementing bid-rigging strategies. This finding strongly 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 should 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
No. Kamikaze firms_{ipt}	14,967,464	0.357	1.095	0.000	0.000	54.000
# 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
Auction-Participant Variables						
Has Shared Owners_{ipt}	14,967,474	0.020	0.139	0.000	0.000	1.000
Same $\text{Municipality}_{ipj}$	18,836,250	0.227	0.419	0.000	0.000	1.000
Same ZIP Code_{ipj}	18,836,250	0.006	0.077	0.000	0.000	1.000
Same Owners_{ipj}	18,836,250	0.001	0.030	0.000	0.000	1.000
p(winner)_{ipj}	18,836,250	0.130	0.337	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
$\left(\frac{Payment\$}{Predicted\$}\right)_{ijt}$	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-Event Variables						
mortality $(\text{all})_{iet}$	997,503	0.041	0.058	0.000	0.021	0.308
mortality $(\text{main})_{iet}$	168,186	0.095	0.070	0.000	0.078	0.333
Road-Event Variables						
log(no. $\text{accidents})_{iet}$	22,616	4.245	1.469	0.000	4.522	6.941
log(no. $\text{victims})_{iet}$	22,360	3.809	1.323	0.000	4.060	6.213

This table presents the summary statistics of the main variables used in the analysis for the period from 2005 to 2021. The subscripts i, p, t, and j refer to the procurement, item, time, and participating firm, respectively. Log(price)_{ipt} is the natural logarithm of the procurement purchase price. Has Kamikaze_{ipt} is a binary variable indicating whether the procurement has at least one kamikaze firm, defined as a firm that submits the lowest bid but does not win the procurement. # $\text{Participants}_{ipt}$ represents the number of bidders participating in the auction, while No. Kamikaze firms_{ipt} is the number of kamikaze firms in the auction. # bids per bidder_{ipt} shows the average number of bids per bidder submitted by non-kamikaze firms in the auction. $\sigma(bid)/\overline{bid}_{ipt}$ is the ratio of the standard deviation of the bid values to the average bid value for non-kamikaze firms within an auction. Has Shared Owners_{ipt} is a binary variable indicating whether any of the participating firms in the auction have shared owners. Same $\text{Municipality}_{ipj}$, Same ZIP Code_{ipj}, and Same Owners_{ipj} are binary variables indicating whether a bidder and the kamikaze firm are located in the same municipality, have the same ZIP code, or have the same owners, respectively. Finally, p(winner)_{ipj} is the probability of a bidder winning the auction. For procurement-winning firm variables, p(canceled)_{ijt} represents the probability of cancellation, $\text{p(cost overrun)}_{ijt}$ indicates the probability of cost overrun, $\left(\frac{\text{Payment \$}}{\text{Predicted \$}}\right)_{ijt}$ is the ratio of actual payment to predicted payment, and $\log(\text{days})_{ijt}$ is the logarithm of days taken for completion. Hospital-cause-event variables include mortality rates for different categories: mortality $(\text{all})_{iet}$, mortality $(\text{non-terminal})_{iet}$, mortality $(\text{terminal})_{iet}$, and mortality $(\text{main})_{iet}$. Road-event variables comprise log(no. $\text{accidents})_{iet}$, which is the logarithm of the number of accidents, and log(no. $\text{victims})_{iet}$, representing the logarithm of the number of victims.

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
Has Kamikaze$_{ipt}$	0.1843***	0.1664***	-1.329***	-1.127***	-0.2074***	-0.1896***
	(0.0068)	(0.0052)	(0.0258)	(0.0202)	(0.0061)	(0.0049)
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	0.184	0.232	0.364	0.429
Item*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
# of Participants*Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Gov Institution*Year FEs		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:

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

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 either the logarithm 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 procurement i for item p at time t (columns III and IV), or the ratio between the standard deviation of the bid value to the average bid value for procurement i for item p at time t (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} are item-by-year fixed effects; $\alpha_{X_i t}$ are interactions of procurement i characteristics (X_i) and year fixed effects such as # of Participants-by-Year fixed effects and Government Institution-by-Year fixed effects. Column I adds Item-by-Year and # of Participants-by-Year fixed effects, effectively comparing procurements for the same item purchased with the same number of participants in the same year. Column II also includes Government Institution-by-Year fixed effects. Standard errors are clustered at the item level and are presented in parentheses. $^+$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

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

	$\log(\text{price})_{ipjt}$					
	Same Winner			Same Auctioneer	Actual Competitors	Simult Auctions
	I	II	III	IV	V	VI
Has Kamikaze$_{ipt}$	0.0814***	0.0789***	0.0712***	0.1636***	0.0970***	0.1262***
	(0.0041)	(0.0039)	(0.0049)	(0.0048)	(0.0043)	(0.0105)
Has Kamikaze$_{ipt}$ · High Nr Simultaneous Auctions$_{it}$						0.0425***
						(0.0088)
Obs	14,965,838	14,965,838	14,965,838	14,765,552	14,967,462	13,574,911
R^2	0.928	0.930	0.946	0.873	0.870	0.872
Winner*Item*Year FEs	Yes	Yes				
# of Participants*Year FEs	Yes	Yes	Yes	Yes		
Gov Institution*Year FEs		Yes			Yes	Yes
Winner*Gov Institution*Item*Year FEs			Yes			
Item*Year FEs				Yes	Yes	Yes
Auctioneer*Year FEs				Yes		
# of Actual Competitors*Year FEs					Yes	Yes

This table compares outcomes of procurement auctions with and without the presence of kamikaze firms. The main independent variable Has Kamikaze$_{ipt}$ is a dummy equal to 1 if procurement i for item p at year t had a Kamikaze firm and zero otherwise. 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 log of the price for item p purchased in procurement i with winner firm j at time t. In columns I to III, we control for the same winner of the procurement. Column I includes add Winner-by-Item-by-Year — comparing procurements with the same winner, item and year — and # Participants-by-Year fixed effects comparing procurements with the same number of participants, items, and year. Column II also adds Government Institution-by-Year fixed effects. Finally, column III includes Winner-Government Institution-Item-Year fixed effects as well as Participants-by-Year fixed effects. In column IV, we compare procurements with the same auctioneer. In columns V and VI, we compare procurements with the same item purchased, the same number of actual competitors, and the same government institution in the same year. In column VI, High # Simultaneous Auctions$_{it}$ is a dummy equal to 1 if procurement i has an above-median number of simultaneous auctions and 0 otherwise. Standard errors clustered at the item level are presented in parentheses. Actual competitors is defined as the number of total participants minus the number of kamikaze firms in procurement p for item i. Column IV includes Item-by-Year, # of Participants-by-Year, and Auctioneer-by-Year fixed effects. Column V includes Item-by-Year, # of Actual Competitors-by-Year, and Government Institution-by-Year fixed effects. $^+$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

Table 4: *Kamikaze Firms and Procurement Outcomes: Effects by Kamikaze Intensity*

	$\log(\text{price})_{ipt}$	
	I	II
Panel A: Kamikaze Intensity		
Has Kamikaze_{ipt} (0% to 10% Discount)	0.0431***	0.0265***
	(0.0038)	(0.0030)
Has Kamikaze_{ipt} (10% to 25% Discount)	0.0917***	0.0665***
	(0.0074)	(0.0057)
Has Kamikaze_{ipt} (25% to 50% Discount)	0.2534***	0.2235***
	(0.0109)	(0.0097)
Has Kamikaze_{ipt} (50%+ Discount)	0.3689***	0.3515***
	(0.0107)	(0.0098)
Obs	14,967,462	14,967,462
R^2	0.866	0.870
Item*Year FEs	Yes	Yes
# of Actual Competitors*Year FEs	Yes	Yes
Gov Institution*Year FEs		Yes
Panel B: Number of Kamikaze Firms		
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 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. n Panel A, the main independent variables are dummies equal to 1 if the procurement i for item p at year t had between 0% to 10%, 10% to 25%, 25% to 50%, or 50%+ discount relative to the winning bid, and zero otherwise. In Panel B, we divide an indicator variable for the presence of kamikaze firms into five indicator variables 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 log of the price for item p purchased in procurement i at time t. Column I adds Item-by-Year and # of Actual Competitors-by-Year fixed effects, effectively comparing procurements for the same item purchased with the same number of participants in the same year. 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 5: *Relationships between Kamikaze Firms and Winners*

	p(winner)$_{ipj}$		
	I	II	III
Same Municipality$_{ipj}$	0.0350***		
	(0.0019)		
Same ZIP Code$_{ipj}$		0.0920***	
		(0.0143)	
Same Owners$_{ipj}$			0.0671***
			(0.0202)
Obs	18,836,250	18,836,250	18,836,250
R^2	0.160	0.159	0.158
Procurement*Item FEs	Yes	Yes	Yes

This table shows the characteristics of kamikaze firms. The dependent variable is p(winner)$_{ipj}$ — a dummy equal to 1 if bidder j at procurement i for item p is the winner and zero otherwise. 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 independent variables are the probability that firm j is from the same municipality or zip code as the kamikaze firms (columns I and II, respectively), and the probability that firm j has the same owner as the kamikaze firm (column III). All columns add Procurement*Item fixed effects and drop kamikaze firms from the sample. 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 6: *Kamikaze Firms and Procurement Outcomes: Shared Ownership*

	$\log(\text{price})_{ipt}$	
	I	II
Has Shared Owners$_{ipt}$	0.0959***	0.0702***
	(0.0200)	(0.0158)
Has Kamikaze$_{ipt}$	0.1163***	0.0964***
	(0.0054)	(0.0043)
Has Shared Owners & Kamikaze$_{ipt}$	0.0993^{+}	0.0725^{+}
	(0.0537)	(0.0384)
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 compares outcomes of procurement auctions with and without the presence of kamikaze and shared-owned firms. Has Kamikaze$_{ipt}$ is a dummy equal to 1 if procurement i for item p in year t had a kamikaze firm and zero otherwise. 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. 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 a firm is both a kamikaze firm and shares ownership with the winning firm in the same procurement i for item p at year t. The dependent variable is the log of the price of item p purchased in procurement i at time t. Column I adds Item-by-Year and # of Actual Competitors-by-Year fixed effects, effectively comparing procurements for the same item purchased with the same number of participants in the same year. 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 7: *Transparency Reform and Procurement Outcomes*

	$\log(\text{price})_{ipt}$		p(win & kamikaze)$_{ijpt}$		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
# of Actual Competitors*Year FE		Yes		Yes		Yes

This table presents the difference-in-differences effect of the introduction of a shared ownership alert in the electronic procurement system in 2014. The treatment variable, Shared Ownership$_j$, represents the fraction of procurements pre-2014 in which firm j won a kamikaze auction (i.e., a procurement in which a kamikaze firm participated) and also shared ownership with the kamikaze firm in that procurement. The dependent variables are the log of the price of item p purchased in procurement i at time t, the probability of a firm being both a winner and a kamikaze firm 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 number of Actual Competitors-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 8: *Effect of Kamikaze Auctions on Future Purchases*

	$\log(q)_{ap,t+1:t+4}$	$q_{ap,t+1:t+4}/q_{ap,t}$	$\log(\text{value})_{ap,t+1:t+4}$
	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
Institution*Item FEs	Yes	Yes	Yes
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
Institution*Item FEs	Yes	Yes	Yes
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. Panel A uses the fraction of the total quantity purchased in kamikaze procurements by institution a for item p at quarter t as the independent variable, while Panel B uses the fraction of total value purchased in kamikaze procurements by institution a for other items $p^* \neq p$ at quarter t. The dependent variables are the log 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 log 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 include Government Institution-by-Item and Item-by-Quarter 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. The dependent variables are the probability that the contract is canceled for procurement i, with winner firm j at time t (Column I), the probability that the contract has cost overruns for procurement i, with winner firm j at time t (Column II), the fraction of actual payment over predicted one for procurement i, with winner firm j at time t (Column III), and the log days for completion of contracts for procurement i, with winner firm j at time t (Column IV). All specifications include Government Institution-by-Year fixed effects. 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
$\text{kamikaze}_{ie} \cdot \text{post}_{et}$	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*Event*Cause	Yes	Yes	Yes	Yes	Yes	Yes
Cause*Event*Year	Yes	Yes	Yes	Yes	Yes	Yes
Hospital*Event*Year			Yes	Yes		

This table compares hospital excess death outcomes between essential medicine purchased via kamikaze vs non-kamikaze auctions. For each kamikaze auction, we select non-kamikaze auctions that happened in the same month. We stack these events in a "stacked" DID design as in the following equation:

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

where the dependent variable yiet is the ratio between deaths and number of inpatients in hospital i, event e and year t. The main independent variable kamikaze_{ie} is a dummy equal to one if the purchase of essential medicine for hospital i in event e was made via a kamikaze auction and zero otherwise. Post_{et} is a dummy equal to one after the contracts were awarded and zero 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 include hospital-event-cause and cause-event-year fixed effects, with columns III and IV also incorporating hospital-event-year fixed effects. Standard errors clustered at the event 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*

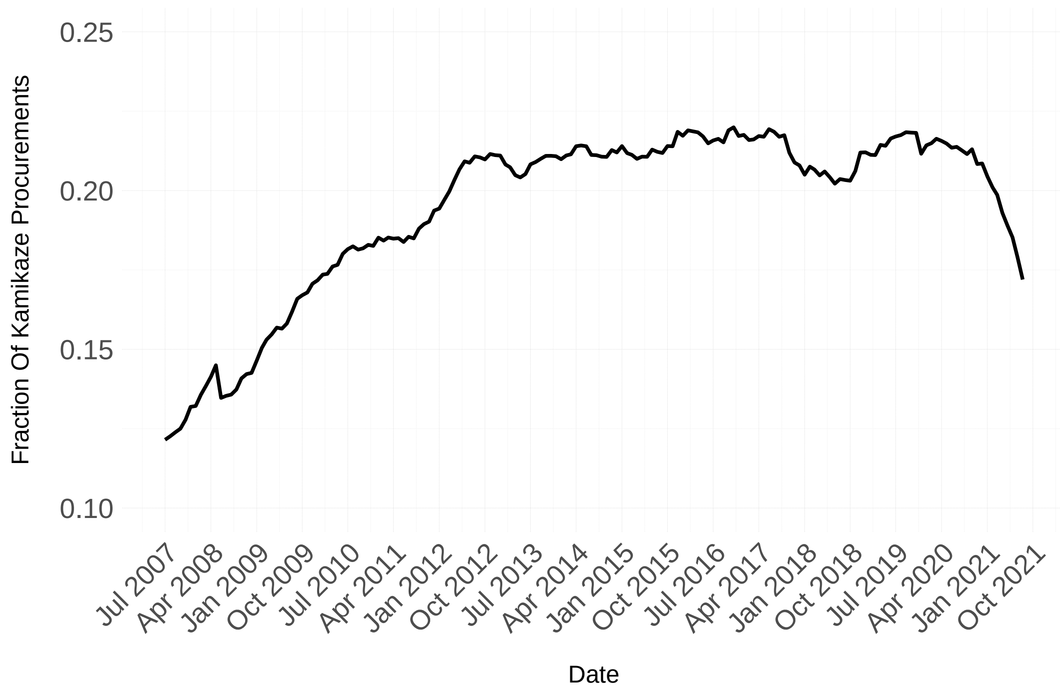
	$\log(\text{No. Accidents})_{iet}$		$\log(\text{No. Victims})_{iet}$	
	I	II	III	IV
Kamikaze_{ie} x Post_{et}	0.2568*	0.1794^{+}	0.2599*	0.1545
	(0.1074)	(0.0951)	(0.1220)	(0.1035)
Window	2y	3y	2y	3y
Obs	15,555	22,616	15,362	22,360
R^2	0.859	0.851	0.852	0.842
Event*Road	Yes	Yes	Yes	Yes
Road Extension*Event*Year	Yes	Yes	Yes	Yes
State*Event*Year	Yes	Yes	Yes	Yes

This table compares outcomes between road repair contracts awarded via kamikaze vs non-kamikaze auctions. For each kamikaze auction, we select non-kamikaze auctions that happened in the same month. We stack these events in a "stacked" DID design as in the following equation:

$$y_{iet} = \alpha_{ie} + \alpha_{et} + \beta Kamikaze_{ie} \cdot Post_{et} + e_{iet}$$

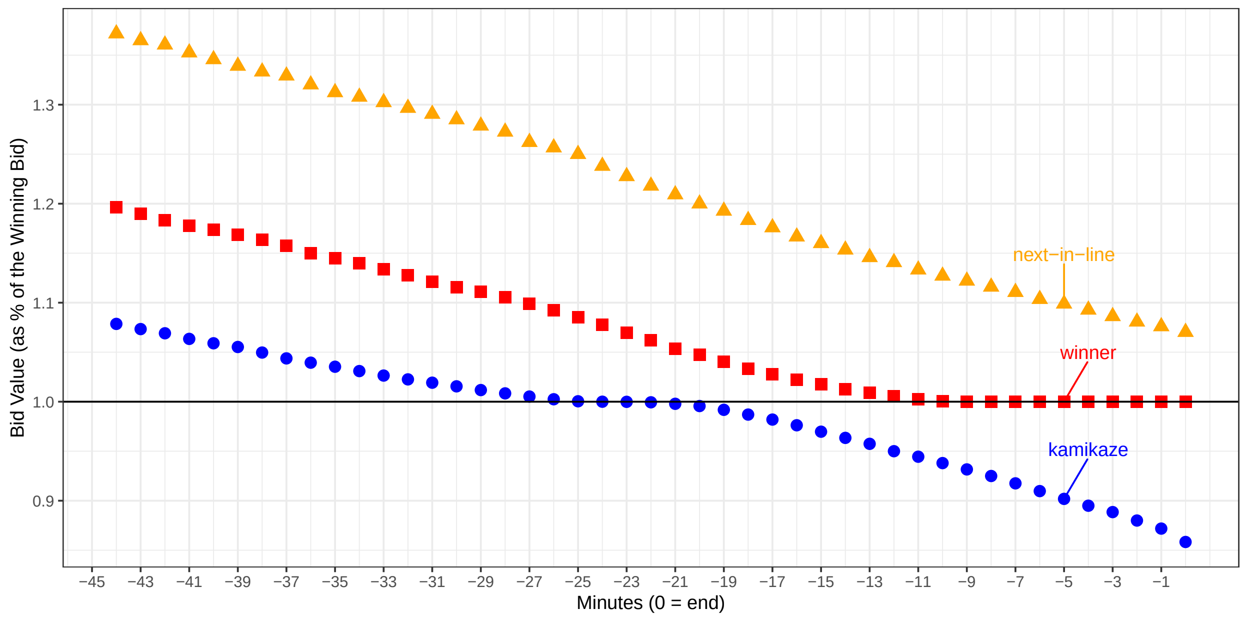
where the dependent variable y_{iet} is either the logarithm of the number of accidents in road repair i, event e and year t (columns I and II) or the log of the number of victims in road repair i, event e and year t (columns III and IV). The main independent variable kamikaze_{ie} is a dummy equal to one if road repair i of event e was awarded in a kamikaze auction and zero otherwise. Post_{et} is a dummy equal to one after the contracts were awarded and zero otherwise. All specifications control for event-road, road extension quintile-event-year and state-event-year fixed effects. Standard errors clustered at the event level are presented in parentheses $^{+}$, *, **, and *** denote significance at the 10%, 5%, 1%, and 0.1% levels, respectively.

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



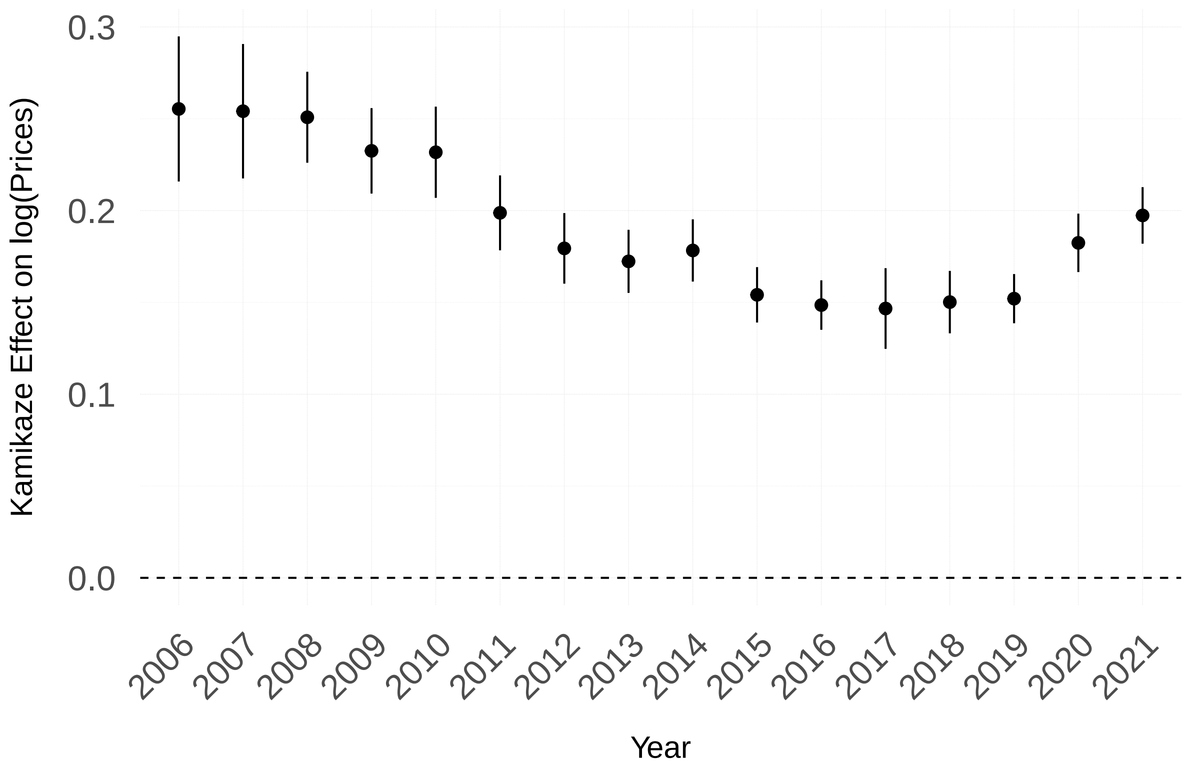
This figure shows the average fraction of auctions with kamikazes in Brazil between 2007 and 2021. Kamikaze firms are those that have the lowest bid but do not win the procurement because they do not satisfy the final formalities required to be declared the winner.

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), eventual winning bidders (red), and next-in-line bidders (orange). 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 calculate the median of these bid dynamics across all bids in the sample for each type of bidder and plot the results.

Figure 3: *Kamikaze Firms and Overpricing Across Years*



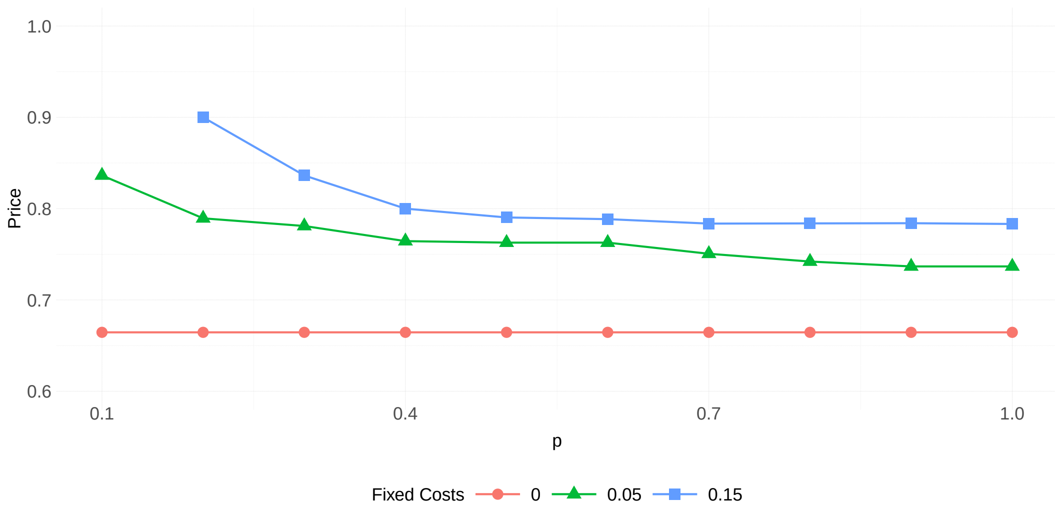
This figure plots the impact of kamikaze bidding on procurement prices over time. We estimate the following regression specification:

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

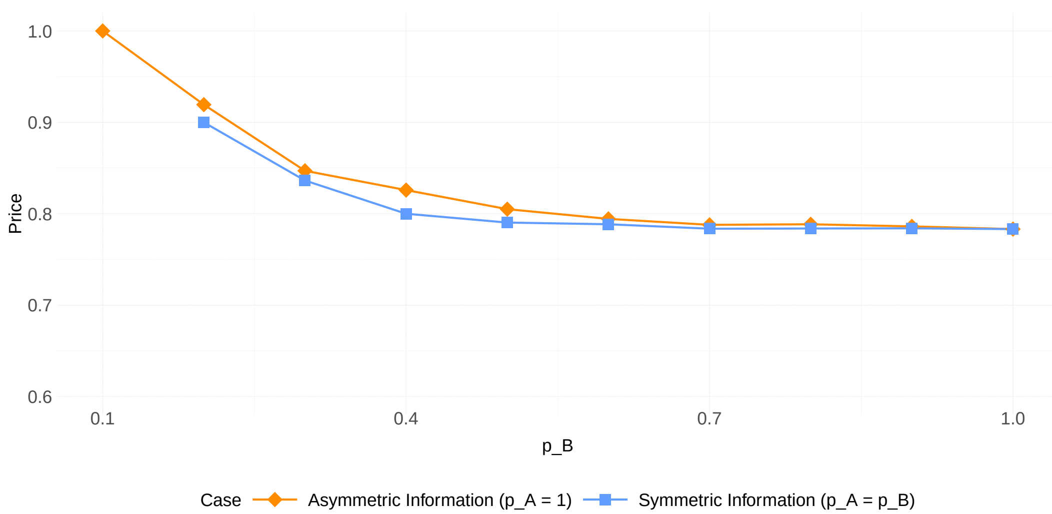
where Has Kamikaze equals 1 if a firm submits the lowest bid but fails to win procurement i for item p in year t due to not satisfying final formalities. The specification includes item-by-year fixed effects (α_{pt}) and interactions of procurement characteristics with year fixed effects ($\alpha_{X_i t}$), such as number of participants and government institution fixed effects. The figure plots the estimated β_t coefficients, which capture the difference in log prices in procurements with kamikaze bidding relative to those without for each year. The vertical lines show 95% confidence intervals with standard errors clustered at the item level.

Figure 4: *Expected Prices in First-Price Auctions with Fixed Costs and a Kamikaze Firm*

Panel A: Symmetric Information

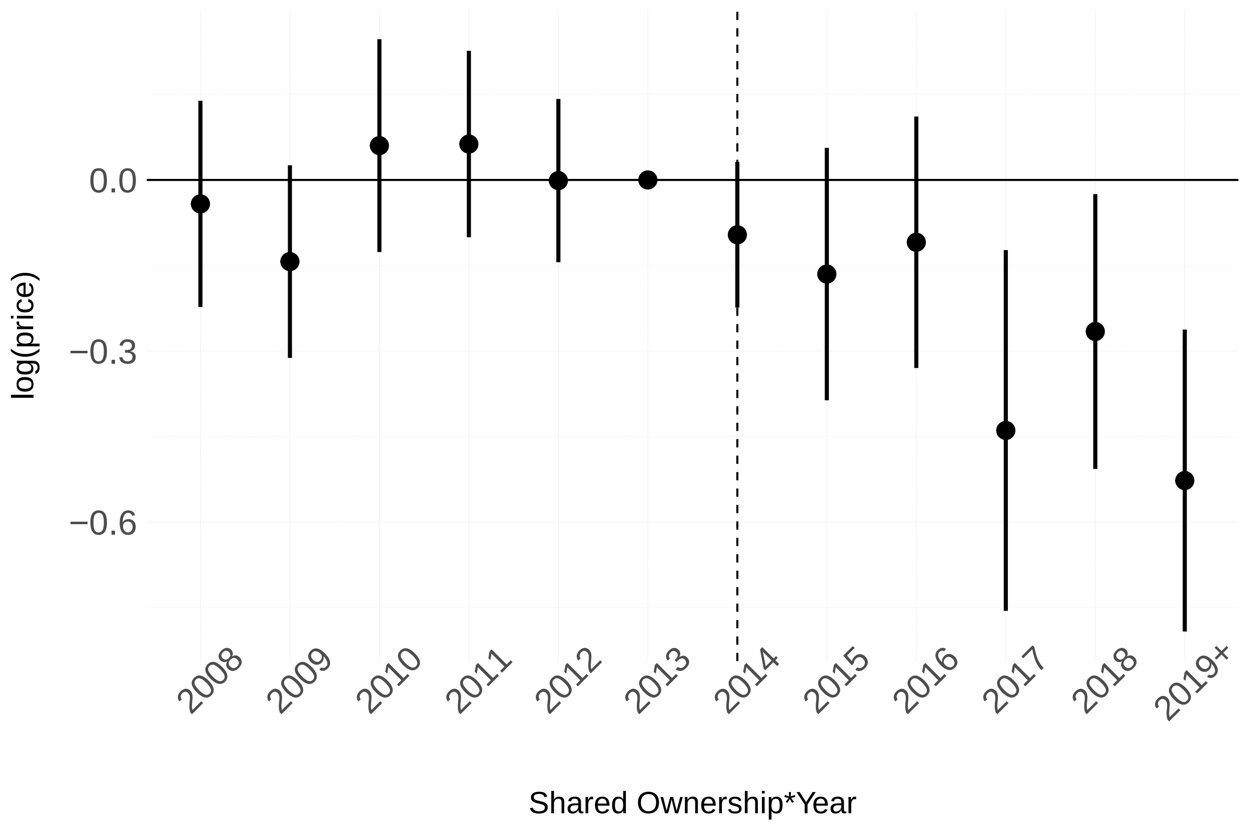


Panel B: Symmetric vs. Asymmetric Information



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 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 3.2.1. 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 $p = pA = p_B$.

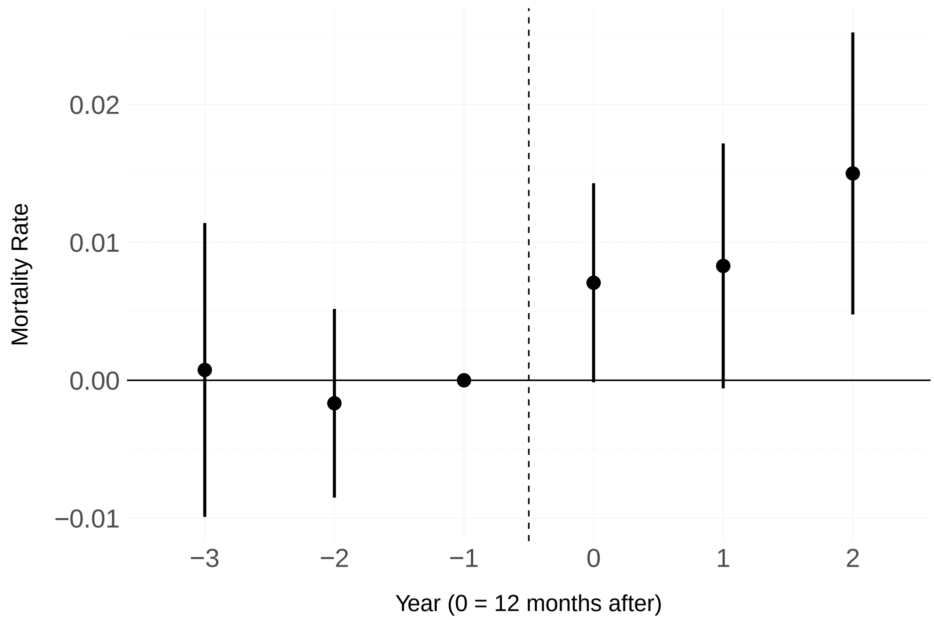
Figure 5: *The Effect of the Transparency Reform on Prices*



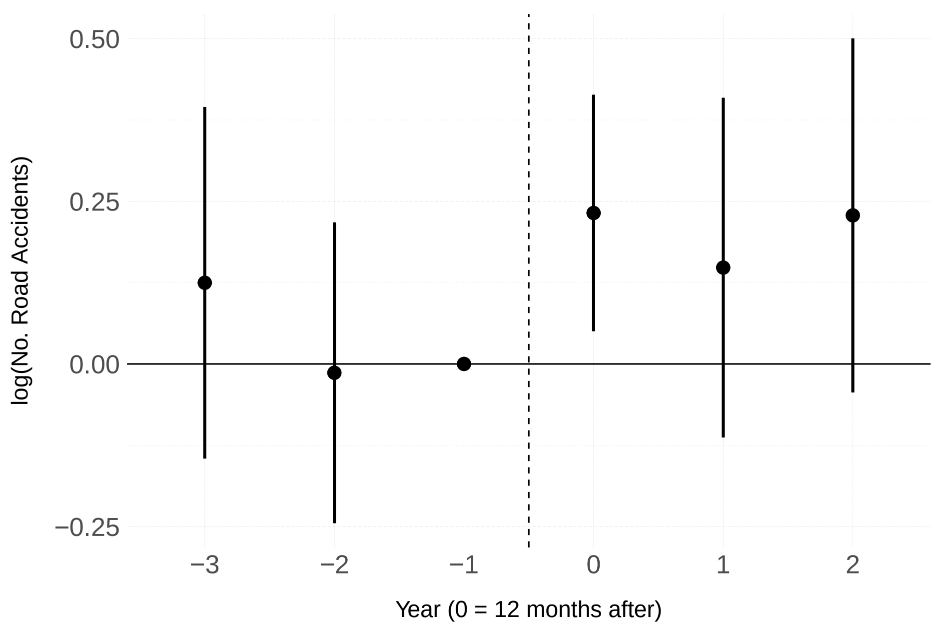
This figure plots the dynamic effects obtained from a difference-in-differences analysis that examines the impact of introducing a shared ownership alert feature in the ComprasNet system in 2014 on procurement prices. The treatment variable, Shared Ownership, represents the proportion of procurement 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-time fixed effects.

Figure 6: *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 vs non-kamikaze auctions, along with the corresponding 95 percent 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 for road repair contracts. In both panels, the x-axis denotes the ith year relative to event 0 (the 12 months after the occurrence of kamikaze). The y-axis indicates the changes in mortality rate (Panel A) or the number of accidents (Panel B).

Internet Appendix

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

For Online Publication Only

Dimas Fazio Alminas Žaldokas

December 2, 2024

A Additional Tables and Figures

Table A1: *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

This table shows examples of products and services from CADMAT and CADSER.

Table A2: *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

This table provides examples of government institutions in the procurement dataset.

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
# of Participants*Year FEs	Yes	Yes
Gov Institution*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 to be declared the winner. We implement the following specification:

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

Has Kamikaze_{ipt} equals to 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 is either the logarithm of the price for item p purchased in procurement i at time t (columns I and II), the average number of bids per bidder in procurement i for item p at time t (columns III and IV), or the ratio between 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-by-year fixed effects; $\alpha_{X_i t}$ are interactions of procurement i characteristics (X_i) and year fixed effects such as # of participants-by-year fixed effects and government institution-by-year fixed effects. Column I adds Item-by-Year and # of Participants-by-Year fixed effects, effectively comparing procurements for the same item purchased with the same number of participants in the same year. Column II also includes Gov Institution-Year fixed effects. Finally, column III includes Government Institution-by-Year and # of Participants-item-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 A4: *Heterogeneous Effects*

	log(price)$_{ipt}$	
	I	II
Has Kamikaze$_{ipt}$	0.1669***	0.1039***
	(0.0060)	(0.0139)
Has Kamikaze$_{ipt}$ · High Kamikaze$_a$	-0.0009	
	(0.0054)	
Has Kamikaze$_{ipt}$ · Product$_p$		0.0700***
		(0.0142)
Obs	14,967,462	14,967,462
R^2	0.870	0.870
Item*Year FEs	Yes	Yes
# of Participants*Year FEs	Yes	Yes
Gov Institution*Year FEs	Yes	Yes

”

This table compares the 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. 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. The dependent variable *yipt* is the log of the price for item p purchased in procurement i at time t. In column I, High Kamikaze$_a$ equals 1 if the government institution a is in the upper median in the incidence of kamikaze auctions, and 0 otherwise. Product$_p$ in column II is a dummy equal to 1 for products and 0 for services. We estimate the following specification:

$$y_{ipt} = \alpha_{pt} + \alpha_{X_it} + \beta \cdot HasKamikaze_{ipt} + \gamma \cdot HasKamikaze_{ipt} \times Z_{ipt} + e_{ipt}$$

where Z_{ipt} represents the interaction variables in each column. α_{pt} are item-by-year fixed effects; α_{X_it} are interactions of procurement i characteristics (X_i) and year fixed effects such as government institution-by-year, and number of participants-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 A5: *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 firms. 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. 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 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 add 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 A6: *Switching Across Procurements*

	p(kamikaze)$_{ipjt}$		p(winner)$_{ipjt}$				
	I	II	III	IV	V	VI	VII
Was Kamikaze$_{j,t-1:t-12}$	0.0074***		-0.0013				
	(0.0003)		(0.0014)				
Was Winner in Kamikaze Procur$_{j,t-1:t-12}$		-0.0020***		0.0326***	0.0339***	0.0206***	0.0199***
		(0.0005)		(0.0013)	(0.0016)	(0.0015)	(0.0017)
Was Winner in Kamikaze Procur$_{j,t-1:t-12}$ · Has Kamikase$_{ipt}$					-0.0050***		0.0032*
					(0.0013)		(0.0015)
Obs	83,086,792	83,086,800	83,086,792	83,089,393	83,089,382	76,836,196	76,836,185
R^2	0.341	0.304	0.341	0.148	0.148	0.158	0.158
Sample	All	All	All	All	All	Previous Winners	Previous Winners
Procurement*Item FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table shows whether kamikaze firms and procurement winners switch positions across procurements. That is, within a procurement-product pair, we compare the probability that a firm j is a kamikaze or a winner in the current procurement auction i based on its past participation in other procurements over the last 12 months. We implement the following specification:

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

where y_{ipjt} is an outcome for procurement i, item p, firm j and time t: the probability that firm j is a kamikaze firm in procurement i to purchase item p at year t and 0, otherwise (columns I to III), and the probability that firm j was a winner of procurement i, item p at year t, and 0 otherwise (columns IV to VII). 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. All columns add Procurement*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 A7: *Switching Within Procurements*

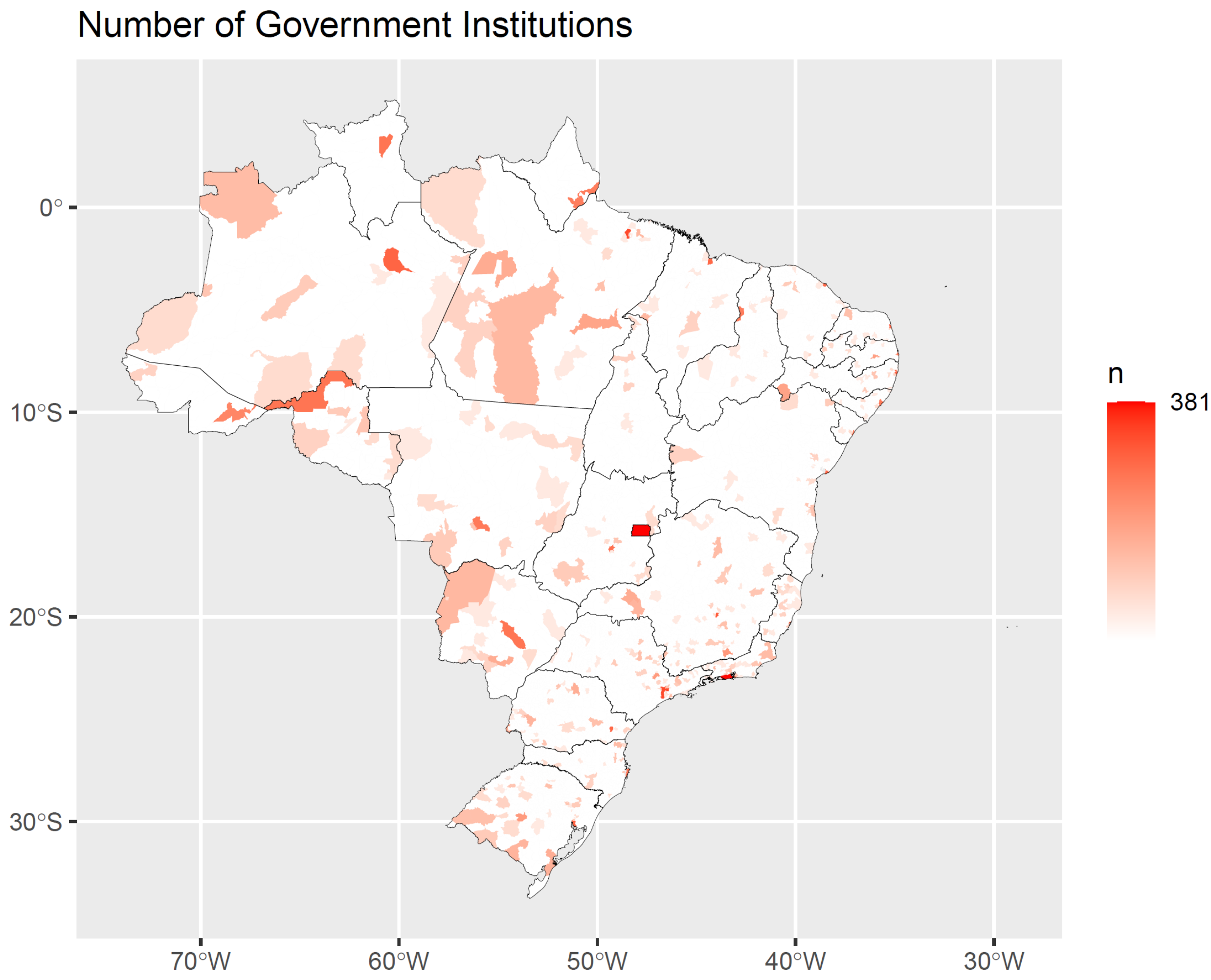
	p(kamikaze)$_{ipjt}$		p(winner)$_{ipjt}$				
	I	II	III	IV	V	VI	VII
Was Kamikaze$_{ip^*jt}$	0.0480***		-0.0226***				
	(0.0008)		(0.0013)				
Was Winner in Kamikaze Procur$_{ip^*jt}$		-0.0377***		0.1712***	0.1456***	0.0571***	0.0375***
		(0.0007)		(0.0018)	(0.0020)	(0.0017)	(0.0020)
Was Winner in Kamikaze Procur$_{ip^*jt}$ · Has Kamikase$_{ipt}$					0.1091***		0.1420***
					(0.0019)		(0.0022)
Obs	82,695,885	82,695,950	82,698,357	82,698,462	82,698,453	48,499,901	48,499,893
R^2	0.35112	0.30637	0.14330	0.17834	0.18095	0.20511	0.20696
Sample	All	All	All	All	All	Previous Winners	Previous Winners
Procurement*Item FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table shows whether kamikaze firms and procurement winners switch positions within procurements. 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:

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

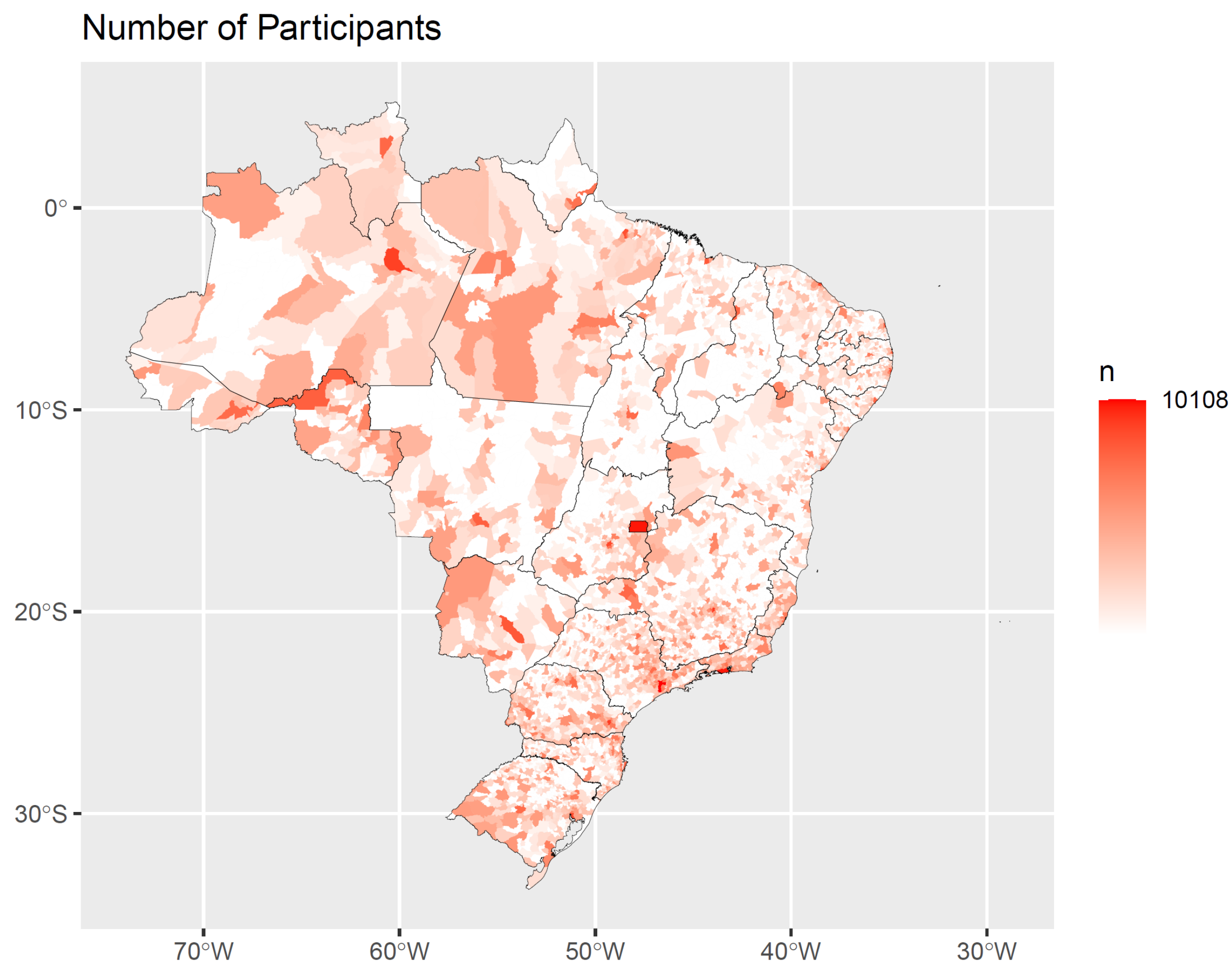
where y_{ipjt} is an outcome for procurement i, item p, firm j and time t: the probability that firm j is a kamikaze firm in procurement i to purchase item p at year t and 0, otherwise (columns I to III), and the probability that firm j was a winner of procurement i, item p at year t, and 0 otherwise (columns IV to VII). X_{ip^*jt} is either *Was Kamikaze*$_{ip^*jt}$ or *Was Winner in Kamikaze Procur*$_{ip^*jt}$. Was Kamikaze$_{jp^*j}$ is a dummy equal to 1 if firm j was a Kamikaze firm in procurement i purchasing item $p^* \neq p$. Was Winner in Kamikaze Procur$_{ip^*jt}$ is a dummy equal to 1 if firm j was a winner in procurement i purchasing item $p^* \neq p$. All columns add Procurement*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.

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

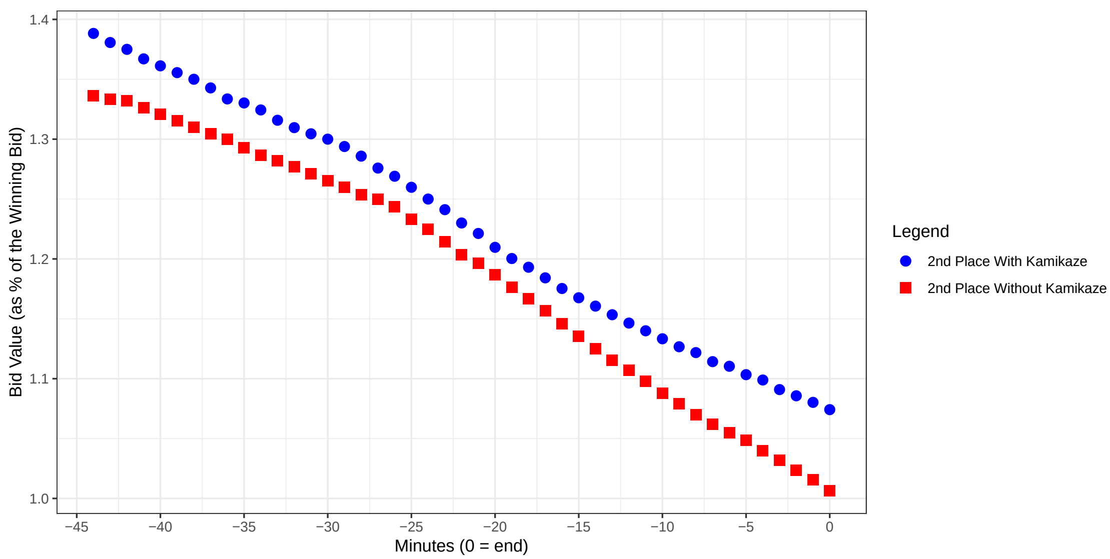
Items with Open status			Brasilia Time: 22/05/2014 15:51			
Item	Description	Status	Your Last Bid	Best Bid	Bid	
1	ROLLED PAPER	Impending Notice	R$ 131,345.0000	R$ 131,345.0000		Send
2	GREASE	Impending Notice	R$ 9.5400	R$ 5.1200		Send
3	SUGAR	Impending Notice	R$ 9.3400	R$ 4.9200		Send
5	ENAMEL PAINT	Impending 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.

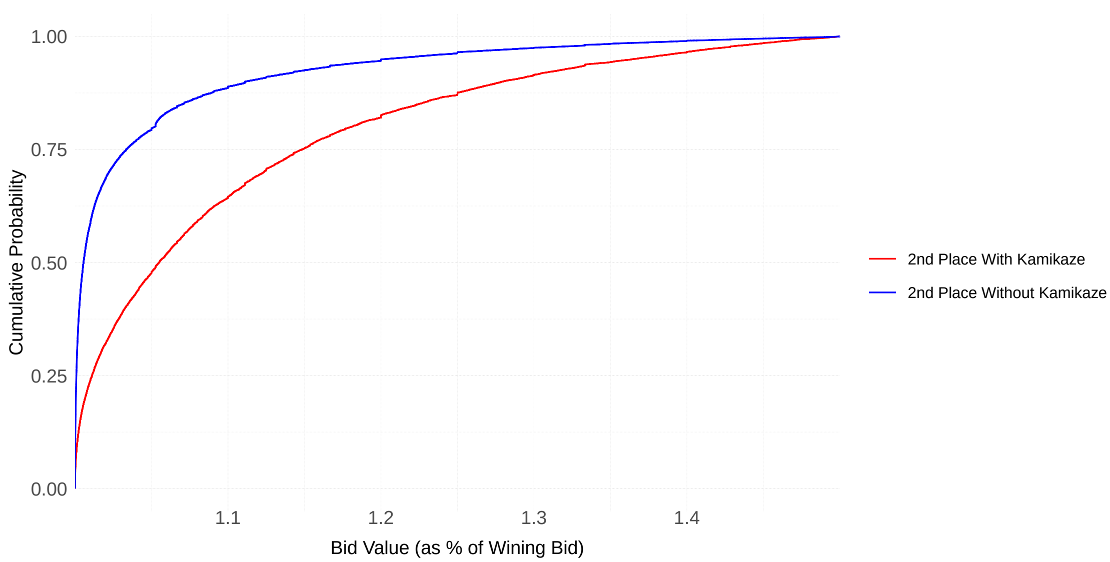
Panel B: English Translation

This figure plots an image of the ComprasNet portal during the procurement. It shows what bidders can see information about their bid, the minimum bid, and details about the auction they participate.

Figure A4: *Bid Dynamics of Next-in-Line Bidders in Kamikaze vs Non-Kamikaze Auctions*



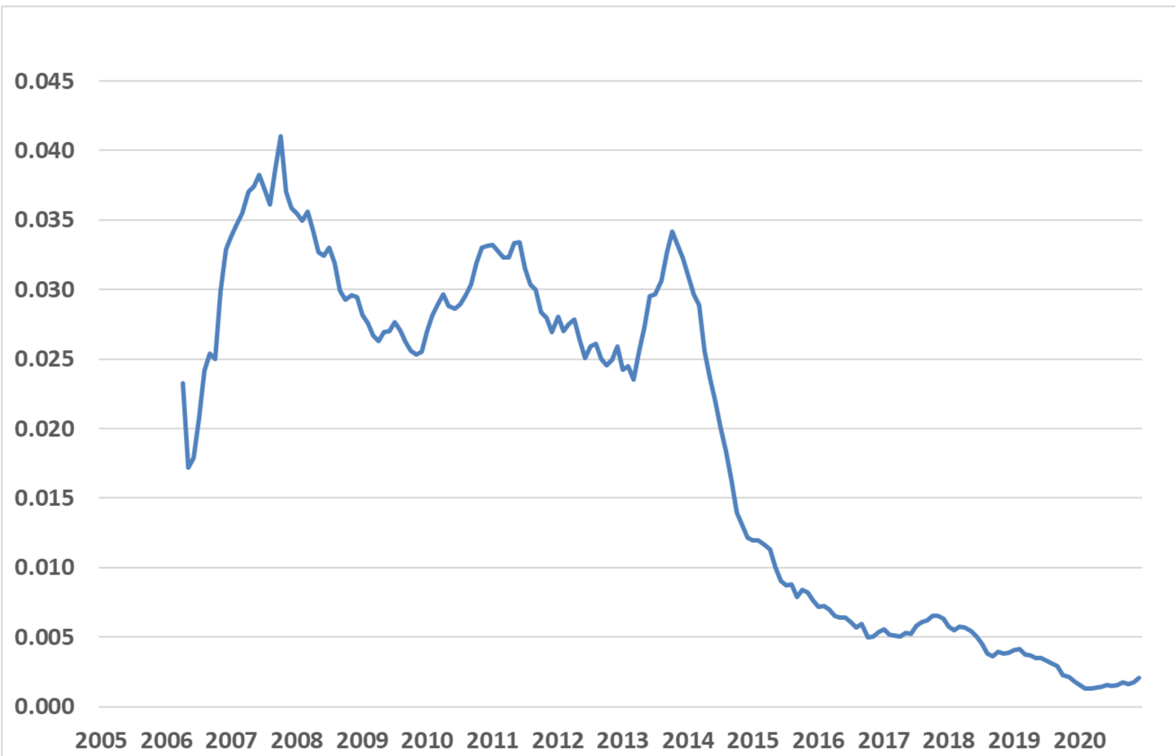
Panel A



Panel B

These figures plot the bid dynamics of second-place bidders in kamikaze auctions (blue) and non-kamikaze auctions (red), with bid prices normalized to the winning bid. Panel A shows the bid dynamics over time before the auction end, while panel B presents the cumulative distribution functions of bids. The second-place bids represented here are those that came in second after a genuine winner was declared and fulfilled the formal requirements.

Figure A5: Proportion of Procurements with Shared Owners



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

B Case Study of the Kamikaze Strategy

The report TC-035.967/2016-1 from the Brazilian Federal Court of Accounts (TCU) provides a detailed case study of the "kamikaze" bidding tactic 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. These low bids may have been used to intimidate and discourage other legitimate bidders from competing further.

Subsequently, Semog and M. Burmann withdrew from the auction citing vague reasons like "spreadsheet rounding errors" and "technical issues". This suggested that their participation may have been insincere and they never truly intended to win or fulfill the contract.

After Semog and Burmann dropped out, INCRA ended up accepting significantly higher bids from another company called *GA Serviços de Apoio Administrativos para Terceiros Ltda (GA)*. GA's winning bids were 10-23% higher than the initial low bids placed by Semog and M. Burmann.

This sequence of events and bidding pattern matches the kamikaze tactic, where certain bidders place very low bids only to withdraw later, allowing a pre-selected bidder to win at an inflated price. It is suspected that Semog and M. Burmann acted as kamikaze firms to enable GA to win at a higher price.

Despite the suspicious activity, TCU found that there wasn't sufficient evidence to legally prove that the companies colluded to commit fraud. However, the TCU still deemed the behavior of Semog and M. Burmann as improper and mischievous.

As a result, TCU sanctioned the auctioneers from INCRA who allowed this to happen with monetary fines. The contract awarded to GA was also ultimately canceled by TCU on grounds of mismanagement by INCRA.

This case demonstrates how the kamikaze strategy can be used by colluding bidders to manipulate public auctions and inflate prices. It also highlights the challenges in detecting and proving such collusive behavior even when there are strong suspicions.

C Detailed Proofs

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

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

Thus, the first order condition is:

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:

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

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 Discussing Firm Roles

In this section, we report the analysis of the characteristics of kamikaze firms. Brazilian firm registry *Receita Federal* also allows us to observe a few firm characteristics such as firm age and size.[20] 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, where we now also include kamikaze firms as we focus on individual characteristics rather than the firm-pair relationships:

$$y_{ipj} = \alpha_{ip} + \beta X_{ipj} + e_{ipj} \tag{8}$$

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. As before, this specification controls for procurement-by-item fixed effects, which effectively compares the characteristics of firms participating in the same auction.

Internet Appendix Table A5 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 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

[20] 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.

estimate the following regression:

$$y_{ipjt} = \alpha_{ip} + \beta_1 \cdot X_{jt} + e_{ipjt} \tag{9}$$

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 $\textit{Was Kamikaze}_{j,t-1:t-12}$, or $\textit{Was Winner in Kamikaze Procur}_{j,t-1:t-12}$. $\textit{Was Kamikaze}_{j,t-1:t-12}$ is a dummy equal to 1 if firm j was a kamikaze firm in another procurement in the past 12 months. $\textit{Was Winner in Kamikaze Procur}_{j,t-1:t-12}$ 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 A6 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-VII, 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. Columns III and IV show that previous winners in kamikaze auctions are more likely to continue winning. This, however, could be explained by the fact that these firms are indeed the best providers of goods and services and thus have a higher unconditional probability of winning. Columns VI and VII remove those firms from the control group that did not win in any procurement in the past year. We document consistent findings. Column VII reports that past winners in kamikaze auctions are more likely to win in those procurements that also have the observed kamikaze behavior.

We also test switching *within the same procurement* but across different items purchased in the same procurement. We implement the following specification:

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

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 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 $p^* \neq p$. *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 A7 shows the findings that are very similar to the ones found across procurements: 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.