Road Construction, Bargaining, and Bribes: Spatial Allocation of Checkpoints and Highway Corruption in West Africa

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Abstract

Petty corruption in the developing world impedes citizens from receiving public services and operating their businesses. In this paper, we show the importance of market structure in determining a corruption equilibrium. We do this in the context of highway merchandise transportation in West Africa, where checkpoint officials frequently stop truck drivers for petty bribes. We exploit a road system with two alternative corridors to develop a model which predicts that checkpoints in the two competing corridors follow a Bertrand game as they set price equal to the marginal cost. Moreover, when costs to pass through one corridor increase due to road construction, checkpoints in the other corridor raise prices and keep drivers waiting for longer. We estimate a difference-in-differences model to confirm that road construction did increase both bribes and enforced delays for stops in the unaffected corridor. This work demonstrates the importance of competition among corrupted officials to facilitate public services for drivers and suggests that the effectiveness of a local intervention can be offset by reallocating bargaining power towards officials who are not targeted by it.

1 Introduction

In the developing world, corruption among public officials, politicians, and state-owned companies is pervasive (Svensson, 2005). Despite the potential for distortion caused by ill-functioning institutions to generate a "grease the wheel" effect (Leff, 1964; Méon & Sekkat, 2005), the prevalence of corruption can cause large dead weight loss as profit is spent bidding on licenses to do business rather than raising productivity (Tullock, 2001; Shleifer & Vishny, 1993). Beyond the grand corruption found in large public projects, there is widespread petty corruption that affects citizens and the private sector on a daily basis. Such corruption usually involves small bribes to low level officials to expedite public services, such as connections to utilities, passports, and admissions to school (Carr & Jago, 2014). Despite its effects on citizen's daily lives and economic efficiency, petty corruption remains relatively understudied compared to the grand corruption.

In West Africa, policymakers are particularly concerned with rampant petty corruption in the transport sector. Along inter-state highway corridors, long-haul drivers frequently encounter checkpoint stations where officials force them to pay bribes to proceed. Such costs negatively affect regional trade (Nayo & Egoumé-Bossogo, 2011), international exports (Freund & Rocha, 2011), and even local investment in agricultural assets (Foltz & Bromley, 2013). Traditional interventions, including monitoring and rewarding good behavior, have been largely unsuccessful in mitigating or even eliminating highway bribery (Foltz & Opoku-Agyemang, 2015; Cooper, 2018). This resilient pattern of corruption behavior calls for researchers to look beyond the individual utility effects of bribes and instead explore strategic interactions among officials.

Competition among officials is an important factor in corruption outcomes. Burgess et al. (2012) find that competition among Indonesian forestry officials increases deforestation by facilitating illegal logging. In our setting, spatial allocation of checkpoints would also create competition for checkpoint officials, potentially facilitating long-haul merchandise transportation by driving down bribes. We study how a corruption equilibrium on West Africa's highway corridors is determined by spatial competition among checkpoints. We dual road corridors between Bamako (the capital of Mali) and Ouagadougou (the capital of Burkina Faso) for our analysis. The two corridors share a single route starting from Ouagadougou. Past the city of Bobo-Dioulaso (Bobo), the roads then separate into two parallel roads, and eventually re-merge in the destination city of Bamako. The northern corridor crosses the national border at Koury, while the southern corridor crosses the national border at Hérémakono (Héré).[1] This road structure makes checkpoints on the two parallel segments between Bamako and Bobo real-time competitors with each other for long-haul

[1] The shared segment of two corridors is 377km long. The distance from Bobo to Bamako through Koury is 624km, and the distance from Bobo to Bamako through Héré is 557 km. There is 67km difference between two non-shared segments, or 48 min difference in driving times. Throughout the paper, we will call the corridor crossing Koury the *Koury*, and the corridor crossing Héré the *Héré*.

driver-customers.

We further study how strategic interactions among checkpoints change the market structure by exploiting an exogenous shock to one non-shared segment. From November 2009 to March 2012, the Malian government launched a road construction project that completely rebuilt the non-shared *Héré* segment, changing road conditions on that route. We hypothesize that the extra cost to pass through one route will push more drivers to choose the alternative road. As a result, checkpoints on the other road gain extra bargaining power against drivers and therefore extort more from them.

We demonstrate the ideas above through a model of oligopolistic competition with a time-consuming bargaining process between officials and drivers. In the model, each checkpoint posts a package of prices and times to "attract" drivers who have idiosyncratic reference points to pay for a stop. A driver can immediately pass the checkpoint by agreeing to pay the posted price. Otherwise, he has to wait for the posted time. The bargaining process ends after the enforced delay with a payment of the driver's reference point to the official. The flow of drivers on the road is negatively dependent on the aggregated price and delay on the road.

The model predicts a unique Nash equilibrium where checkpoints on the two non-shared segments both set price and waiting time as 0. On the other hand, the checkpoint on the shared segment behaves as a monopolist as it is the only player charging positive bribes. When there is an extra cost to pass through one segment, both the posted bribes and time on the competing segment increase, indicating an increase in the bargaining power of that segment. Moreover, the total cost (cash plus time) on the shared segment decreases. In summary, the model predicts that after checkpoints adapt to the market's changed structure, there will be a redistribution of corruption benefits from those deterred by the road construction to those who are not affected.

We then implement a difference-in-differences estimation to test the model's predictions. Specifically, we evaluate how illegal payments and delays change in other segments relative to the segment under construction. We use data collected by USAID's West Africa Trade Hub which surveyed drivers on six main corridors crossing West Africa. Consistent with the model's predictions, we find that both bribes and minutes delayed on the unaffected non-shared segment (i.e. the non-shared *Koury*) increased during the period of road construction, relative to those on the affected non-shared segment (i.e. the non-shared *Héré*). Meanwhile, we find that the total cost on the shared segment of *Héré* decreased during the period of the road construction, relative to those on the non-shared segment of the *Héré*.

We further test the model's predictions by evaluating heterogeneous effects of the road construction using rainfall as an exogenous event that intensifies the cost differential. During periods of heavy rainfall, drivers experience an additional inconvenience when choosing the segment under construction. This is because the road becomes more muddy and rivers become harder to cross.[2] In this case, checkpoints on the other segment gain even more bargaining power against drivers in the rainy season compared to the dry season. Conducting a triple-difference model, we find that drivers pay even more on the non-construction non-shared segment (i.e., the non-shared *Koury*) on rainy days, relative to dry days. Moreover, as predicted in the model, they pay less and experience fewer delays on the shared segment of *Héré* on rainy days compared to dry days.

Our paper speaks to three streams of literature. First, it contributes to the literature exploring the market determinants to highway corruption in developing countries. In their pioneering work, Olken & Barron (2009) show that military highway checkpoints in Indonesia extort more when competitors along the same road retreat. Oki (2016) finds evidence that the bribe level is associated with demand (road traffic) using the same West Africa data as this paper. Our paper departs from existing the literature by emphasizing the importance of checkpoints' locations in shaping spatial corruption equilibrium. To our knowledge, this is the first attempt to link spatial competition to corruption outcomes.

Second, the paper relates to work on the effectiveness of anti-corruption policies in general. There is evidence that traditional interventions, such as monitoring, rewards, and punishment, can effectively reduce corruption by changing the expected utility of corrupted officials (Olken, 2007; Duflo et al., 2012; Fisman & Miguel, 2007; Tella & Weinschelbaum, 2008). However, those traditional interventions have been mostly unsuccessful in West Africa. Cooper (2018) uses a field experiment along West African highways to find null effects of being "monitored" by a foreigner on checkpoint officials' extortion behavior. Foltz & Opoku-Agyemang (2015) leverage a 2010 Ghanian government policy that doubled police officers' salaries to evaluate if extra rewards can reduce petty corruption. Surprisingly, they find that Ghanaian police collect more bribes after the policy, relative to customs officers and police in control countries. We provide an explanation to the resilient

[2] During construction, some segments of the road were diverted onto makeshift dirt roads parallel to the original road to allow the workers to completely rebuild the road's underlayment and pavement. In addition, where bridges needed to be replaced, the deviations often descended into streams and seasonal rivers.

pattern of highway corruption. Specifically, we argue that spatial competition between checkpoint officials is an important factor in the robust positive corruption outcome because of spillovers: When the road construction took place on one corridor, corrupted officials who were unaffected by it increased their extortion from drivers. We argue that policy makers should take such spillover effects into account as they may offset the effect of a local anti-corruption intervention.

Finally, the paper contributes to the theoretical literature on bargaining. Canonical bargaining models predict instantaneous deals in equilibrium (Rubinstein, 1982). However, this is unrealistic in many settings where enforced delays are both common and a tactic of the bargaining participants, such as bargaining over bribes or union contracts. In the more recent literature, Yildiz (2003, 2004) build a bargaining model that allows time delay in a bargaining process when both parties are excessively optimistic. However, it does not allow each party to endogenize the waiting time, as is the case when delay is an explicit bargaining tactic. Our work contributes to the literature by building a model which incorporates time as an endogenous choice made by the officials in a bargaining negotiation.

The remainder of the paper is organized as follows. Section 2 provides more background on highway corruption in West Africa. Section 3 presents the model in detail. Section 4 describes the data. Section 5 presents empirical strategies and regression results. Section 6 provides robustness checks. Section 7 concludes.

2 Background

2.1 Petty bribes on inter-state corridors in West Africa

In West Africa, long-haul merchandise transportation uses inter-state highway corridors, which are vital trade routes for landlocked countries such as Mali. A typical truck driver travels two or three days along a 1000 km corridor to carry goods (typically oil, shipping containers, or general merchandise), from a port city to land-locked areas before taking goods back to the port for export.[3] En route, the driver frequently encounters checkpoints run by military (*gendarmerie*), police, or customs officials, where they are required to pay petty bribes in order to proceed. In most cases, an

[3] Many trucks, for example oil trucks, are mostly or entirely empty on the return trip to port. Accordingly, we account for the direction of travel in our estimates.

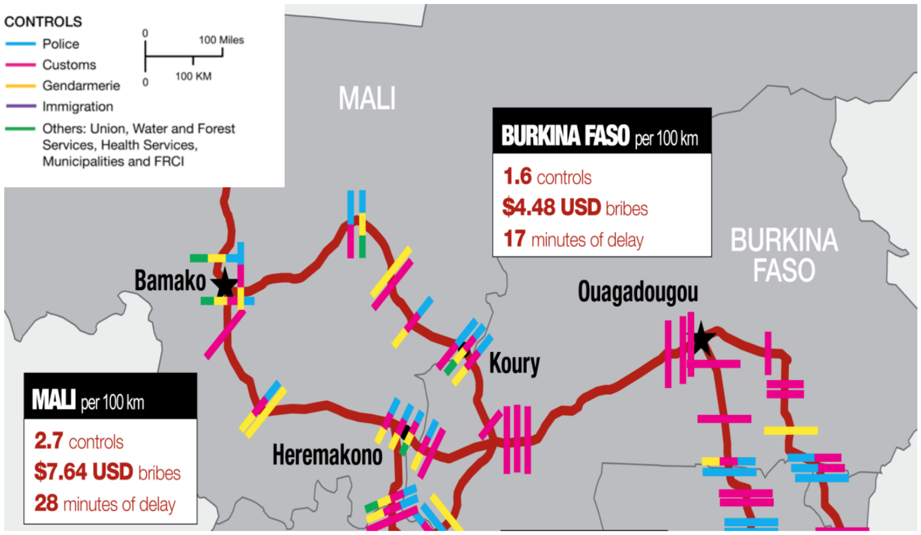
official on duty will stop the truck to check the driver's license and registration. Once the official has these in hand, he threatens the driver to pay for the return of his documents. Bribes are usually on the order of \$2–\$3 USD. If the driver refuses to pay, he is forced to remain at the checkpoint under some pretense, such as paperwork that is not in order or the truck is overweight (even though there is often not even a mechanism present to weigh the truck). Throughout the trip, the driver will be stopped 20 to 50 times, paying \$40–\$100 in total bribe payments and having 2–3 hours enforced delay.

Experienced drivers have some knowledge about the "going rate" at each stop due to their long-term interactions with checkpoint officials. When stopped, they will simply include a payment when handing over the requested documents. The "going rate" at a checkpoint is determined by the bargaining power of two sides. Officials price discriminate against drivers based on observable features, including the country where the truck is registered (foreigners pay more), the type and weight of goods, and the trip's direction (from or to port). A majority of drivers agree to pay the offered amount in order to proceed. When a driver has a lower willingness to pay, which is unobserved by officials upon the driver's arrival, he can negotiate the price by letting his truck stand in the way and cause traffic. The traffic also raises the possibility of the official being caught, in some cases causing the official to give up, either extorting less or simply letting the driver go.

Checkpoints located in vital places tend to have higher bargaining power against drivers. Along a corridor, checkpoints are usually no more than a patrol car or a makeshift roadblock. This is in contrast to checkpoints locate near the country borders and the entrances to large cities, which are often full stations with parking lots. Officials running the latter type of checkpoints often charge higher "going rates" than those at "wildcat" points both because they are able to stop trucks at parking lots to avoid traffic and because there is high demand for passing through these vital checkpoints.

2.2 The dual road system and road construction

We analyze a second source of spatial variation in officials' bargaining power against drivers: the competition between two parallel routes. Figure 1 illustrates the dual road system between Bamako and Ouagadougou. There are two corridors serving the needs of long-haul transportation between two cities. Starting from Ouagadougou, the two corridors share a single segment of road until they reach Bobo, the second largest city in Burkina Faso. The two corridors then proceed as two separate routes and cross the state border through *Koury* and *Hérémakono* (*Héré*). They eventually re-merge in the destination city of Bamako. The shared segment is 377km long. The distance from Bobo to Bamako through Koury is 624km, and the distance from Bobo to Bamako through Héré is 557km. There is 67km difference between the two non-shared segments, or 48 min difference in driving time. Economic theory suggests that checkpoints along the two non-shared segments are competitors to each other for driver-customers.



Source: Borderless Aliance Road Governant Report

Figure 1: Two corridors connecting Bamako and Ouagadougou

In the following section, we solve for the Nash equilibrium of bribes and enforced delays along each segment. To evaluate how the changes in bargaining power change bribes and delays, we exploit a road construction project occurring along the non-shared *Héré* segment, increasing costs to proceed along this segment. This construction was initiated by the Malian government in September 2009 to improve road conditions between Bougouni and Sikasso. The project, completed in March 2012, involved rebuilding and paving the road and constructing multiple bridges. On many of the segments from Bougouni to Sikasso, traffic was diverted off the road under repair onto a plowed dirt track through the bush. Similarly, where bridges were being repaired, the dirt track would go down into the gully to cross small seasonal streams without a bridge. Thus, the non-shared Héré road under construction was of poorer condition for drivers due to mud, dust, and the potential of getting stuck while crossing a stream. We argue that the extra inconvenience cost pushes drivers to choose the other segment, increasing the bargaining power of officials along the non-shared road *Koury*.

3 Model

In this section, we develop a model to depict the bargaining process between drivers and checkpoint officials. We solve for both bribes and enforced delays as equilibrium outcomes of competition between checkpoints.

In the model, each checkpoint posts a package of price and waiting time for a driver to use its service.[4] A driver can select which routes to use when possible based on his valuation on cash and time. He can also choose to opt-out. One important feature of the model is that even though the waiting time is posted *ex ante*, making a deal can still be time-consuming. This relies on the assumption that checkpoint officials cannot perfectly infer the willingness to pay of a random driver solely based his observable features. Under incomplete information, an official increases the likelihood that a random driver will agree to pay after receiving the initial offer by threatening to make the driver wait if he rejects. The time-costly bargaining process in this model is in contrast to the instantaneous deal in classic bargaining models (Rubinstein (1982)). In this case, we argue that a time-costly process more closely matches the reality of the particular context under study.

We first deduce the Nash equilibrium of bribes and enforced delays when there is no road construction. To make the model tractable, we assume a single checkpoint on each segment.[5] We find that both the non-shared *Héré* and the non-shared *Koury* segments follow a Bertrand game equilibrium as both charge no bribe and no enforced delay.[6] On the other hand, the checkpoint along the shared segment solves a monopoly optimization problem as it is the only player on the road, giving it market power to set the positive price.

Next, we introduce an additional cost to pass through the non-shared *Héré*, reflecting the effects of road construction. The new Nash equilibrium features an increase in bribes and delays on the non-shared *Koury* due to increased bargaining power of the non-shared *Koury* relative to the non-shared *Héré*. The model reveals how the market adapts to a local action to deter corruption by displacing customers to another choice. Moreover, there is a decrease in total cost (cash plus time) to pass through the non-shared *Héré*. This result is driven by the extra competition from the non-shared segments.

We assume independence of checkpoints located on different segments of corridors; that is to say, officials at different checkpoints do not coordinate with each other to set the price. In reality, competition among checkpoints might not be perfect when prices are set by chief officers or even

[4]In reality the prices are not posted. This is an abstraction of a process where word of mouth between drivers along the route mean that prices are in-effect.

[5]Multiple checkpoints along each segment yield multiple equilibria.

[6]Notice here that zero bribes and waiting time is a metaphor for cases where bribes and enforced delays will not be set higher than the marginal cost.

the central government. In the last subsection, we further discuss corruption equilibrium in a benchmark situation where all checkpoints are managed by a single social planner. We find that the road construction has no effect on bribe outcomes along other segments. The social planner equilibrium thus serves as a benchmark for our empirical analysis.

3.1 Equilibrium in a decentralized world

We first consider a truck driver with an idiosyncratic willingness to pay b_0 to pass through a checkpoint immediately. The reference point is formed through repeated past interactions with officials. The driver's reference point is a function of the driver's characteristics (the type of goods, driver's nationality, and education level), the trip's direction, the driver's willingness to pay, the driver's budget constraint, and so on. Not all of these characteristics are observable to a checkpoint official upon his arrival. As a result, the checkpoint official will infer the driver's willing to pay using a random variable ϵ with distribution $F(.)$. Without loss of generality, we abstract away from all characteristics observable to the checkpoint official and only focus on ϵ.

Under incomplete information, the checkpoint official asks all drivers to pay a price b in exchange for immediate passage. If a driver rejects the offer, the official keeps him waiting at the checkpoint for time t. When the time expires, the driver automatically pays his reference point $b_0(\epsilon)$ and leaves. The automatic deal reflects that the official can perfectly figure out a driver's reference point during the waiting period, and that an official is reluctant to stop a driver for too long for fear of being caught.[7] Both the official and the driver suffer from delay costs $c(t)$ and $v(t)$, respectively.[8]

To summarize, each checkpoint posts a package (b, t) to "attract" driver-customers. The official extorts b immediately from drivers whose willingness to pay satisfies $b < b_0(\epsilon) + v(t)$. The official has to wait for time t and ultimately obtains payoff $b_0(\epsilon) - c(t)$ from drivers whose willingness to pay satisfies $b > b_0(\epsilon) + v(t)$. As a result, the official has the following expected payoff from a random driver:

$$R(b,t) = \int_{b<b_0(\epsilon)+v(t)} b\, dF(\epsilon) + \int_{b>b_0(\epsilon)+v(t)} (b_0(\epsilon) - c(t))dF(\epsilon).$$

[7]While enforcement levels are low, an official increases the probability of being caught by creating visible sign of his behavior such as a traffic jam.

[8]Since the delay length at each stop is less than one hour, we do not discount future utility, instead representing this as a direct utility reduction due to opportunity cost.

We next consider the flow of drivers along the road. Denote q as the demand of drivers to travel a corridor within a short period of time. This demand is negatively dependent on the sum of posted bribes $B = \sum b$ and delayed minutes $T = \sum t$ for all checkpoints they encounter along the trip. In the simple case where there is one corridor and a single checkpoint on it, drivers have no other option for long-haul travel. The monopolist checkpoint sets both posted bribes and time to maximize the revenue as follows:

$$\max_{b,t} \pi(b,t) = \max_{b,t} q(b,t)R(b,t). \tag{1}$$

When there are two competing corridors with some segments overlapping (as illustrated by figure 2a), drivers gain bargaining power against checkpoint officials facing competition from their counterparts along the alternative segment. The driver selects a road segment based on the packages offered by officials on the two roads. Denote the package offered by the non-shared *Koury*, the non-shared *Héré* and the shared segment as (b_k, t_k), (b_h, t_h), and (b_s, t_s), respectively.Drivers whose reference point satisfies $b_0(\epsilon) > \max\{b_k - v(t_k), b_h - v(t_h)\}$ will choose the segment offering $\min\{b_k, b_h\}$. A thorough enumeration of the driver's choice problem can be found in appendix C.1.

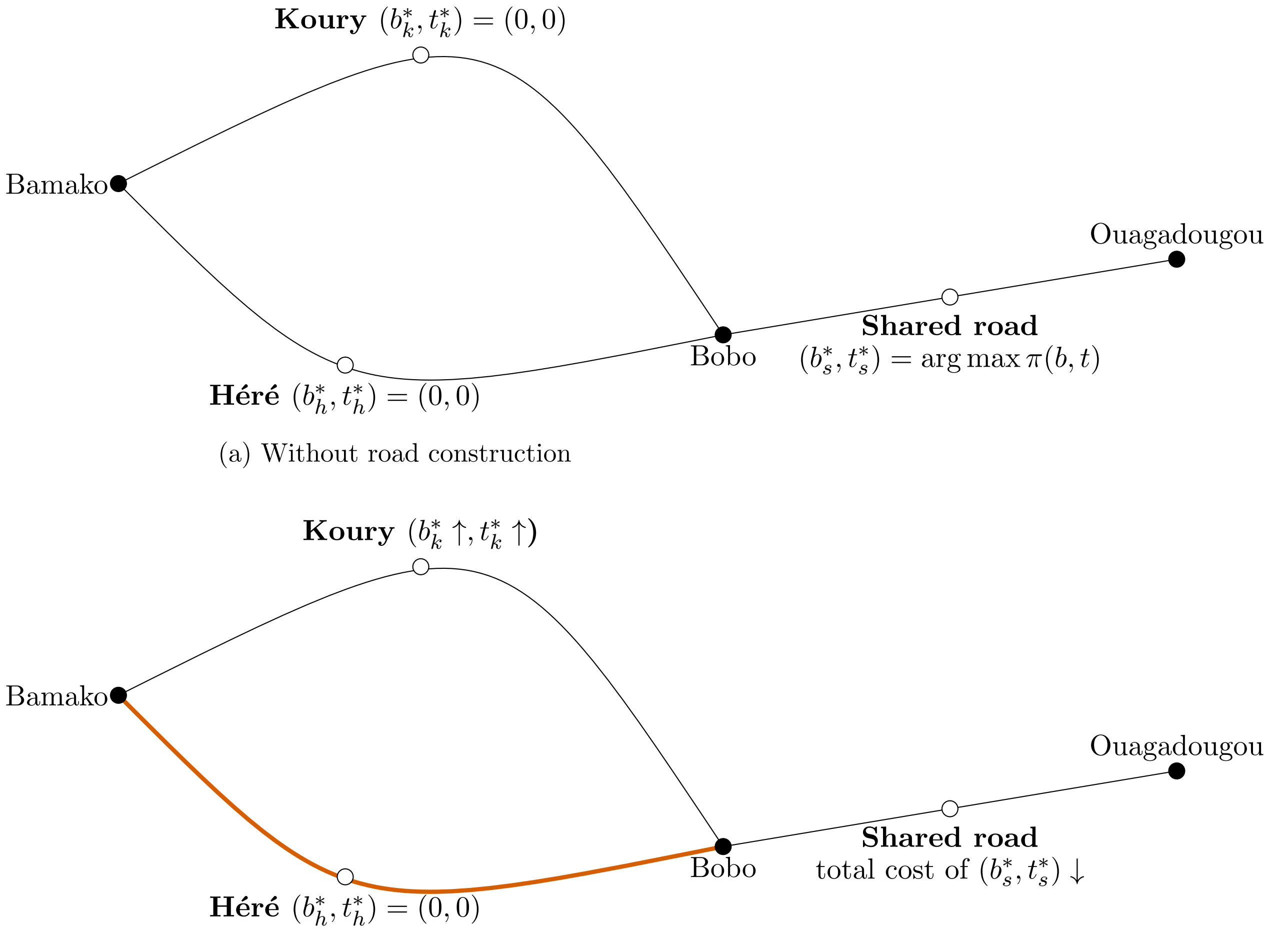
Proposition 1. *Under the market illustrated by figure 2a, there is a unique Nash Equilibrium defined by* $(b_k^*, t_k^*) = (b_h^*, t_h^*) = (0, 0)$*, and the shared checkpoint sets* (b_s^*, t_s^*) *to maximize* $\pi(b, t)$*.*

Proof. See Appendix C.1 ■

In essence, proposition 1 reveals that the competition between the non-shared *Koury* and the non-shared *Héré* checkpoints follows a Bertrand game. The two players lower their price to attract drivers until marginal profit goes to zero. In this sense, drivers benefit from competition that leads to lower transportation costs. Meanwhile, the shared checkpoint acts as a *de facto* monopolist along the whole trip since it faces no competition from others. It sets the bribe level and waiting time by solving optimizing problem (1).

Suppose now we introduce an extra inconvenience cost w if the driver uses the non-shared *Héré* to transport merchandise. The red, bolded line in figure 2b represents the additional cost of road construction. The new equilibrium is thus:

Proposition 2. *With road construction occurring on the non-shared Héré, the Nash Equilibrium*



(a) Without road construction

(b) With road construction

Figure 2: Model Illustration

on the non-shared Héré is still (0,0). For the non-shared Koury, both the posted bribe b_k^* and time t_k^* increase. For the shared segment, the total cost (cash plus time value) decreases.

Proof. See Appendix C.2. ■

It is not surprising that both bribes and enforced delays increase on the non-shared *Koury* segment. As long as it provides a package such that $\min\{b_0(\epsilon)+v(t_k), b_k\} < \min\{b_0(\epsilon)+v(t_h), b_h\}+w$, the *Koury* official can keep all drivers away from the *Héré* segment. On the other hand, the total cost of passing through the shared segment decreases because of extra competition from the *Koury* segment. The model cannot explicitly distinguish between drops in the bribe, time, or both without further assumptions on the functional forms. For example, both posted bribe b_s (or t_s) on the shared segment will decrease when the flow of drivers $q(B,T)$ is linear with B and T, and the elasticity of $R(b,t)$ with respect to b (or t) is a decreasing function of b (or t).

To summarize, the model reveals that competition along two parallel roads facilitates long-haul transportation as checkpoints on the non-shared segment reduce the level of bribes they demand of drivers. Moreover, construction on the *Héré* pushes drivers to the *Koury* corridor, redistributing the bribe benefits to checkpoints unaffected by the road construction. In section 5, we test the model's predictions using a difference-in-differences framework. We compare the difference in bribes between checkpoints on the non-shared *Koury* during construction to those on the non-shared *Héré*. We also investigate how bribe outcomes change in the shared segment.

3.2 Equilibrium in a centralized world

The model assumes independence of checkpoints located on different segments of corridors. This precludes checkpoint officials from colluding with each other to set the price. In reality, however, decisions made be made by chief officers or the central government, rather than by the lower-ranked officers actually stationed at checkpoints. In this subsection, we solve for the corruption equilibrium when all checkpoints are managed by a single social planner. The social planner maximizes total revenues from all checkpoints along the road. One interesting equilibrium is that the two non-shared segments set equal bribe levels and waiting times. Formally, they set $(b_k^*, t_k^*) = (b_h^*, t_h^*) = (b_n^*, t_n^*)$

such that

$$(b_n^*, t_n^*) = \arg\max_{b_n, t_n} q(b_n + b_s, t_n + t_s) R(b_n, t_n).$$

Here the subscription n indicates that the segment is "non-shared". The social planner sets (b_s^*, t_s^*) on the shared segment as follows:

$$(b_s^*, t_s^*) = \arg\max_{b_s, t_s} q(b_n + b_s, t_n + t_s) R(b_s, t_s).$$

Taking advantage of the symmetric nature of two maximization problems yields $(b_n^*, t_n^*) = (b_s^*, t_s^*) = (b^*, t^*)$. Therefore, the social planner will set prices and delays equally at all checkpoints in equilibrium.

The "equal price" equilibrium is theoretically not the only Nash Equilibrium. In fact, when one of the non-shared checkpoints sets the package to (b^*, t^*), this is a Nash Equilibrium as long as the other non-shared checkpoint sets a bribe level and waiting time greater than b^* and t^*, respectively. In this case, all drivers will choose the non-shared segment. We argue that, however, the "equal price" equilibrium is the only Nash Equilibrium that makes sense in reality. When two non-shared segments set unequal price, one of them will have to manage the entire flow of drivers while the other manages none. A social planner would, in all likelihood, want to produce an equitable distribution of the workload between the corridors as would be the case with equal prices, though we do not impose this assumption on our model."

When the equilibrium bribe level and waiting time are equalized among all checkpoints, road construction along the non-shared *Héré* will not affect the bribe level or waiting times along either the shared or non-shared segments. Instead, all drivers will choose *Koury* whose package has already been optimized by the social planner. Therefore, we expect null effects of road construction on the non-shared *Koury* and the shared segment if price-setting is highly centralized. In this sense, the social-planner model serves as a benchmark to our competition model. Rejecting the null hypothesis that the road construction had null effects on bribe outcomes on other segments not only quantifies its spillover effects, but also rejects the hypothesis that checkpoints fully collude as would be the case in the social planner problem. In section 6, we also explore the social planner hypothesis by running regressions by authority and limiting analysis to Mali checkpoints only.

4 Data

4.1 Bribes and enforced delays along the road

Our data on bribes and enforced delays comes from the Improved Road Transport Governance (IRTG) project sponsored by USIAID's West Africa Trade Hub. From 2006 to September 2012, the study team surveyed over 10,000 truck drivers along six main inter-state corridors that connect major cities in West Africa. The drivers recorded bribes paid and enforced delays at more than 250,000 stops. At the beginning of a trip, local enumerators would approach the truck driver in ports or inland depots and ask if the driver was willing to take the survey. If so, the driver would be given a survey and he would record money paid and minutes delayed each time he was stopped along the journey. At the end of the trip, another team of enumerators would collect these surveys.

The enumerator team only surveyed long-haul drivers who traveled across a whole trade route. Moreover, it only surveyed those drivers with all paperwork for the truck and cargo in order. Focusing on "legitimate" drivers excludes the cases where drivers with illegal papers, trucks, or cargo pay higher bribes in order to proceed. This data therefore provides a lower bound of all bribes actually paid by trucks. According to Bromley & Foltz (2011), the drivers being surveyed represented about one-third of long-haul trucks on these routes.

Since data accuracy relies on self reports, there are concerns whether drivers systematically concealed or exaggerated bribery activities. According to Oki (2016) and Salisbury et al. (2018), under-reporting is very rare since road bribery is so common that it is not a social taboo to discuss. Another concern is that drivers might over-report bribery to voice their complaints. This is unlikely to be a major issue in our setting as we focus on relative, rather than absolute, levels of bribery. It is unlikely that the extent to which drivers exaggerate bribery varies across segments and/or time.

We use data on the two corridors connecting Bamako and Ouagadougou. We further limit the sample to trips within one year of the end of the road construction project because we have a short post-period (March 2012 - September 2012). Table 1 provides summary statistics of main variables at both the stop (Panel A) and the trip levels (Panel B). Patterns of bribery are similar across the two corridors. A stop at a checkpoint typically involves payment of more than 1,700 CFA franc ($3) and an enforced delay of more than 7 minutes. An average trip requires 41,000 - 45,000 CFA franc ($67-$74) in total bribes as well as three hours of enforced delay over 23 - 25 stops. Meanwhile, drivers traveling along the two corridors are similar to each other. For example, almost all drivers encountered a stop in their home country (0.98 for both corridors).

Table 1: Summary Statistics

	Koury Corridor		Here Corridor	
	Mean	S.D.	Mean	S.D.
Panel A: Stop-level				
Bribes, CFA franc	1754	1832	1741	1916
Enforced Delay, min	7.74	8.40	7.39	9.79
Driver in own country	0.98	0.15	0.98	0.13
Vehicle in country of registration	0.36	0.48	0.40	0.49
Any holiday time	0.14	0.35	0.15	0.35
Observations	10305		12061	
Panel B: Trip-level				
Total bribes, CFA franc	45545	23689	41336	23749
Total enforced delays, min	200.9	90.2	175.5	105.8
Number of stops in a trip	25.96	6.81	23.74	7.79
Weight vehicle	17.75	3.73	17.84	3.79
Mechandise weight	39.11	11.53	38.66	11.73
type_veh==Container	0.02	0.15	0.02	0.14
type_veh==Tanker	0.01	0.07	0.01	0.10
edu==Primary	0.75	0.43	0.77	0.42
edu==JSS	0.19	0.39	0.19	0.39
edu==SSS or higher	0.01	0.07	0.00	0.04
Whether from port city?	0.55	0.50	0.44	0.50
Observations	397		508	

4.2 Daily precipitation in Mali

While construction on the *Héré* corridor produced additional costs, these costs, especially the chance of getting stuck in the mud for extended periods, will be highest during the rainy season and most acute during actual rainy days. As we do not know the exact extra cost of passing through the *Héré* corridor in a rainstorm, we instead use the rainfall level as a proxy. We do this because the rainfall will disproportionately worsen the condition of the road segment under construction. We expect that checkpoints on the non-shared *Koury* will gain more bargaining power over drivers

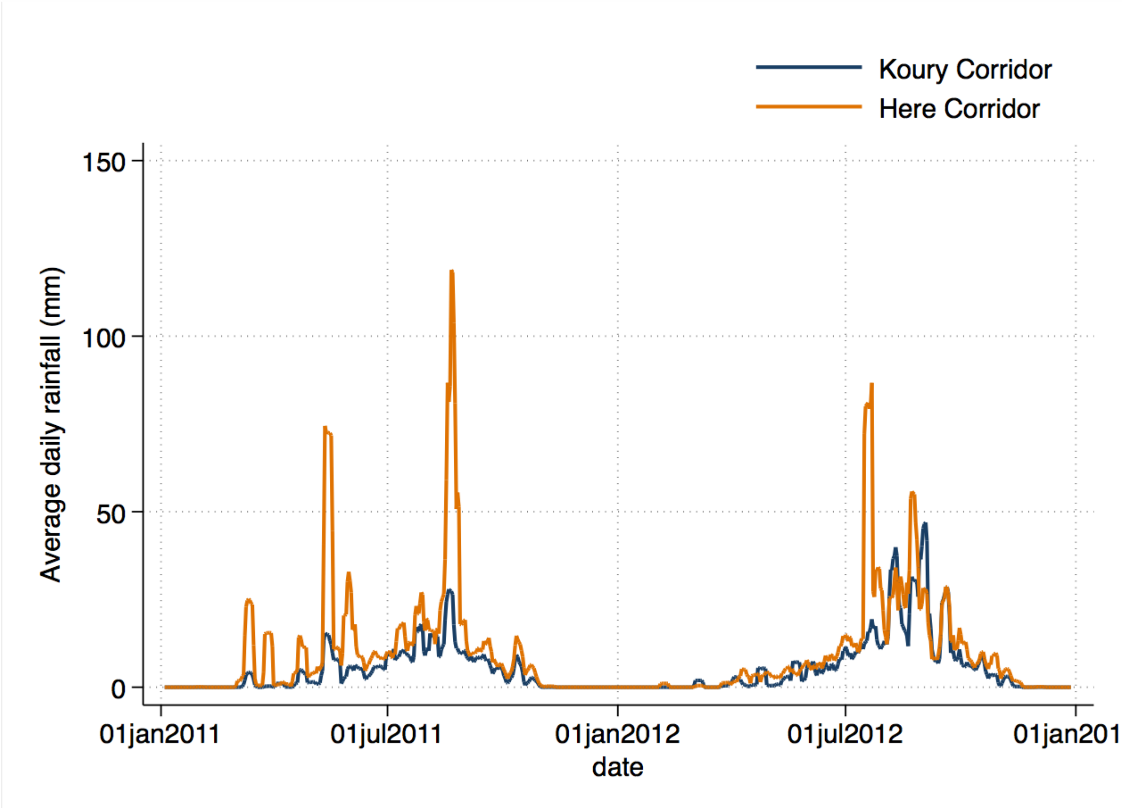


Figure 3: Daily precipitation in Mali communes that include the two corridors

on rainy days compared to dry days.

We collect rainfall data from the Modern-Era Retrospective analysis for Research and Applications (MERRA-2), available from NASA. The data includes daily precipitation (unit mm) for every commune in Mali, the country's third-level administrative unit. We merge the bribery data with the rainfall data through the commune in which the checkpoint is located. We only include daily precipitation in Mali as most of the two shared segments are within Mali. Moreover, the construction only targets routes within Mali.

Figure 3 presents average daily precipitation in all communes along the two corridors. There is significant seasonal variation in the precipitation level. The dry season (October - May) sees almost no rainfall, while the rainy season (June - September) can see as much as 100mm per day. In the regression analysis, the rainfall level will be a proxy of road conditions on the *Héré* corridor as segments that are not well paved become much more muddy, stream crossings become treacherous, and trucks run the risk of getting stuck in the mud for extended periods of time.

5 Empirical results

In this section, we implement a difference-in-difference design to test the two predictions of the theoretical model: (1) Road construction increases both bribes and time delayed on the non-shared *Koury* relative to the non-shared *Héré*; and (2) construction decreases total cost (bribe plus time) on the shared segment relative to the non-shared *Héré*. The first two subsections provide evidence supporting the model's predictions. In subsection 5.3, we show how the effects of road construction vary by rainfall level using a triple-difference design. In line with the model's predictions, higher levels of inconvenience costs on the non-shared *Héré* due to rainfall strengthen the effects found in hypotheses (1) and (2).

5.1 Non-shared *Koury* vs. non-shared *Héré*

We compare the two non-shared road segments by estimating the following difference-in-differences model:

$$Y_{ict} = \beta \mathbb{1}\{Construction\} \times \mathbb{1}\{Koury\} + X_t'\gamma + \theta_c \times \delta_d + \eta_m + \sigma_r \times m + \epsilon_{ict}. \tag{2}$$

Individual observations are stops that take place along the two non-shared segments only. The dependent variable Y_{ict} is either bribes paid or minutes delayed during a stop i at checkpoint c during a trip t. The coefficient of interest is β, where the interaction indicator is equal to one if the trip was before March, 2012, and the trip took place on the *Koury* Corridor. This coefficient identifies the change in stop-level bribes (or delayed minutes) on the *Koury* during road construction compared to the change in bribes (or delayed minutes) on the *Héré*. We include a vector of trip-level characteristics X_t, including vehicle weights; vehicle type; merchandise on board; driver's nationality and education level; and a holiday indicator. We further control for checkpoint-level heterogeneity using checkpoint-direction fixed effects $\theta_c \times \delta_d$, and control for time trends through month fixed effects η_m as well as route-specific linear monthly trends $\sigma_r \times m$. Standard errors are clustered at the checkpoint-authority level.

Table 2 presents results of estimation equation (2). The dependent variable is bribe level in columns (1) and (2) and enforced delay in columns (3) and (4). Odd numbered columns omit control variables, while the even numbered ones include these controls. We find that construction increases both bribes and minutes delayed on the *Koury* segment, relative to the changes of bribe outcomes on the *Héré* segment. As shown in column (2), construction increases bribery payments on the *Koury* segment by extra 560 CFA franc (about $1) compared to the *Héré* segment. This increase represents a 30% increase over the outcome mean. Meanwhile, column (4) shows that a driver spends 2.1 more minutes waiting during a stop on the *Koury*.

Table 2: Effects of the road construction on bribes and enforced delays on the *Koury* corridor, using stop-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction × Koury	540.800***	560.727***	1.917***	2.092***
	(166.014)	(170.143)	(0.449)	(0.469)
Truck & merchandise types		×		×
Driver Characteristics		×		×
Holiday		×		×
Checkpoint-Direction FE	×	×	×	×
Month FE	×	×	×	×
Corridor-specific Time Trends	×	×	×	×
N	18973	18805	18973	18805
R^2	0.556	0.565	0.634	0.639
Outcome Mean	1856.839	1857.474	7.859	7.886

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is a driver's stop at a checkpoint during a certain trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is registered in that country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is at his home country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

We further investigate the change in bribes on the *Koury* segment using an alternative, trip-level specification (3). We first aggregate bribes and enforced delays up to the segment level. We then regress these aggregated variables on the same set of variables as in equation (2). For controls that are not constant along a trip, we generate their trip-level counterparts using the maximum value.[9]

$$Y_t^{aggr} = \beta \mathbb{1}\{Construction\} \times \mathbb{1}\{Koury\} + X_t'\gamma + \sigma_r \times \delta_d + \eta_m + \sigma_r \times m + \epsilon_t. \tag{3}$$

Here, β identifies the change in total bribes (minutes) on the non-shared *Koury* segment during construction, relative to that on the non-shared *Héré* segment. We now control for corridor-level heterogeneity by including corridor-direction fixed effects $\sigma_r \times \delta_d$, and we control for time trends using month fixed effects η_m and corridor-specific linear monthly trends $\sigma_r \times m$. We estimate heteroskedastic standard errors instead as trips are fairly independent of each other.

The trip-level specification serves two main functions: 1) as a robustness check to the stop-level one and 2) avoiding potential concern about checkpoint selection. Checkpoints are sometimes no more than a patrol car or a makeshift roadblock. Those flexible checkpoints can easily exit and re-enter the market. In the stop-level analysis with checkpoint fixed effects, only checkpoints that appear both during and after construction contribute to the identification of β. This may result in bias if checkpoints' exit decisions are associated with road construction. The trip-level specification avoids this problem by adding up all those exit decisions as zeros.

Table 3 presents estimates for regression (3). In general, we find a similar pattern to that in table 2, as total bribes (and waiting times) along the non-shared *Koury* increase more than that along the non-shared *Héré*. However, the results are only significant at 10 percent level, which are probably due to reduced power of smaller sample size.

[9]There are three such variables: whether the truck is in the country of registration, whether the driver is in his home country, and whether the stop date is a holiday. Taking the first variable as an example, we define its counterpart at the trip level as a dummy equal to one if the truck is ever in the country of registration during the trip.

Table 3: Effects of road construction on bribes and enforced delays on the *Koury* corridor, using trip-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction × Koury	8639.388**	7316.769*	26.121*	24.296*
	(4182.448)	(3942.306)	(13.396)	(13.153)
Truck & merchandise types		×		×
Driver Characteristics		×		×
Holiday		×		×
Corriodor-Direction FE	×	×	×	×
Month FE	×	×	×	×
Corridor-specific Time Trends	×	×	×	×
N	905	895	905	895
R^2	0.831	0.854	0.896	0.900
Outcome Mean	38937.901	39038.883	164.796	165.724

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is the unique trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle was ever in the registration country during the trip, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is ever in his home country during the trip and his education level. Holiday is a dummy indicating whether there is any holiday during the trip. Standard errors are heteroskedastic and shown in parentheses.

5.2 Shared *Héré* vs. Non-shared *Héré*

We implement specification (4) to evaluate how bribe levels and enforced delays on the shared segment of *Héré* change with road construction on the shared segment of *Héré*:

$$Y_{ict} = \beta \mathbb{1}\{Construction\} \times \mathbb{1}\{Share\} + X_t'\gamma + \theta_c \times \delta_d + \eta_m + \epsilon_{ict}. \tag{4}$$

This analysis considers stop-level observations during trips through the *Héré* corridor. The dummy $\mathbb{1}\{Share\}$ is equal to one if a stop takes place on the shared road segment, and the dummy $\mathbb{1}\{Construction\}$ is equal to one if the trip occurred before March 2012. The coefficient of interest β identifies the change in stop-level bribes (minutes) on the shared segment during road construction, relative to the change of that on the non-shared *Héré*. We again include trip-level characteristics X_t, checkpoint-direction fixed effects $\theta_c \times \delta_d$, and month fixed effects η_m. There is no corridor-specific time trend as here we use only one corridor for analysis.

Table 4 presents results of regression (4). The dependent variable is bribes in columns (1) and (2) and enforced delay in columns (3) and (4). The coefficients on β are consistent with the hypothesized relationship, albeit statistically insignificant. In contrast, we find statistically significant effects of the road construction on enforced delays on the shared segment. Construction decreases waiting time by roughly 1.5 minutes (a 19% decrease), relative to the change in enforced delay on the non-shared segment. Consistent with the second model's prediction, the total cost (bribe plus time delay) is reduced on the shared segment relative to the non-shared segment during construction.

Table 4: Effects of road construction on bribes and enforced delays on the shared segment, using stop-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction × Share	-62.253	-53.644	-1.492***	-1.462***
	(103.500)	(104.297)	(0.406)	(0.401)
Truck & merchandise types		×		×
Driver Characteristics		×		×
Holiday		×		×
Checkpoint-Direction FE	×	×	×	×
Month FE	×	×	×	×
N	12057	11938	12057	11938
R^2	0.187	0.204	0.321	0.326
Outcome Mean	1741.312	1741.498	7.395	7.427

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is trip-specific checkpoint stops. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is in the registration country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is in his country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

Similarly, we also implement a trip-level analysis of equation (4) as a robustness check. The dependent variable here is bribes or enforced delays aggregated up to the segment level (the shared segment and the non-shared segment):

$$Y_{st}^{aggr} = \beta \mathbb{1}\{Construction\} \times \mathbb{1}\{Share\} + X_t'\gamma + D_s \times \delta_d + \theta_m + \epsilon_t. \tag{5}$$

Here we include trip characteristics X_t. We control for heterogeneity by the trip direction and segment using shared-checkpoint fixed effects $D_s \times \delta_d$. We also control for common time trends using month fixed effects θ_m.

Table 5 presents results of regression (5). In contrast to table 4, we now find that both bribes and minutes delayed decrease on the shared segment during construction. Specifically, construction leads to a extra reduction in bribes by 4,205 CFA franc (20%) and enforced delays by 21 minutes (23%) on the shared segment, compared to the non-shared segment.

Table 5: Effects of road construction on bribes and enforced delays on the shared segment, using trip-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction $\times$ Share	-4341.775***	-4205.658***	-21.585***	-21.364***
	(1643.492)	(1608.062)	(6.345)	(6.313)
Truck & merchandise types		$\times$		$\times$
Driver Characteristics		$\times$		$\times$
Holiday		$\times$		$\times$
Share-Direction FE	$\times$	$\times$	$\times$	$\times$
Month FE	$\times$	$\times$	$\times$	$\times$
N	1001	989	1001	989
R^2	0.656	0.675	0.737	0.742
Outcome Mean	20978.022	21025.278	89.085	89.664

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is the unique trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is ever at the registration country during the trip, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is ever in his home country during the trip and his education level. Holiday is a dummy indicating whether there is any holiday during the trip. Standard errors are heteroskedastic and shown in parentheses.

5.3 Heterogeneous Effects by rainfall level

Next, we implement a triple-difference model to evaluate how the effects of road construction on other road segments vary by rainfall level. Rainfall serves as a proxy for actual road conditions on the *Héré* corridor as construction bypass roads are poorly paved and become much more muddy during rainfall. Therefore, a journey taking place during a rainy season generates higher inconvenience costs to the driver along the *Héré* corridor. We expect a positive coefficient of the triple interaction term for regressions that compare the non-shared *Koury* corridor with the non-shared *Héré* corridor, and a negative one for regressions that compare the shared segment with the non-shared segment of the *Héré* corridor.

Table 6 presents results for the comparison between the non-shared *Koury* and the non-shared *Héré* using stop-level data. Precipitation is the rainfall level (unit mm) of the commune where a driver was stopped on that date. We assume that checkpoint officials and drivers on the *Koury* corridor infer the rainfall level on the *Héré* corridor based on rain they experience on their own road. When drivers and *Koury* officials observe heavy rain, they infer heavy rain on the *Héré* corridor as well.

Column (2) of table 6 presents results from the triple-difference using bribes as the outcome. The coefficient of the triple-interaction term is barely significant at 10 percent level, though in a consistent direction of our direction. If the coefficient estimate is accurate, then it means a 10 mm increase in daily precipitation (a small rainstorm) would further increase bribes on the non-shared *Koury* corridor by 47 CFA. Since precipitation in Mali ranges from almost 0mm in the dry season to 50-100 mm in the rainy season, bribes per stop during a trip in July could be 235-470 CFA higher than during a trip in January, increasing the average bribe per stop between 10-20%. Column (4) shows null effects of rainfall on enforced delay. This may be due to the fact that both drivers and officials are unwilling to stand in the rain for extended periods negotiating.

Table 7 presents results for the comparison between the shared segment and the non-shared segment of the *Héré* corridor. Since we are only using Mali precipitation data, it is inappropriate to use daily stop-level precipitation for checkpoints outside of Mali. Therefore, the unit of analysis is the trip as in Table 5. The new precipitation variable is now the average precipitation of all stops a driver ever encounters in the Mali during the trip. Though significant only at 10 percent level, the results of column (2) and (4) show effects consistent with our expectation. If the estimate is accurate, a 1 mm increase in average precipitation on the Malian non-shared segment decreases the segment-total bribes by 113 CFA (column 2) and enforced delays by more than one-half minute (column 4). If trip-average precipitation increases by 30 mm, then the extra reduction of bribes and enforced delays is almost equivalent to the main effects of the road construction in the dry season (the first coefficient of the column 2 and column 4). The results are consistent with the model's prediction that checkpoints on the shared segment reduce extortion in general due to extra

Table 6: Heterogeneous effects on bribes and enforced delays on the *Koury* corridor by rainfall level, using stop-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction × Koury	560.727***	648.364***	2.092***	1.652***
	(170.143)	(180.402)	(0.469)	(0.495)
Road Construction × Koury × Precipitation		4.721*		-0.007
		(2.803)		(0.010)
Koury × Precipitation		2.787		-0.011
		(2.434)		(0.011)
Precipitation		-0.481		0.003
		(0.383)		(0.003)
Truck & merchandise types	×	×	×	×
Driver Characteristics	×	×	×	×
Holiday	×	×	×	×
Checkpoint-Direction FE	×	×	×	×
Month FE	×	×	×	×
Corridor-specific Time Trends	×	×	×	×
N	18805	15361	18805	15361
R^2	0.565	0.556	0.639	0.598
Outcome Mean	1857.474	1808.977	7.886	7.115

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is a driver's stop at a checkpoint during a certain trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is at the registration country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is in his home country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

competition from the non-shared segment during construction.

Table 7: Heterogeneous effects on bribes and enforced delays on the shared segment by rainfall level, using trip-level data

	Bribes (CFA)		Enforced Delay (min)	
	(1)	(2)	(3)	(4)
Road Construction × Share	-4205.658***	-3434.248**	-21.364***	-21.186***
	(1608.062)	(1682.114)	(6.313)	(6.565)
Road Construction × Share × Average Prcp		-113.956*		-0.547*
		(60.209)		(0.297)
Share × Average Prcp		21.488*		-0.123
		(11.971)		(0.082)
Average Prcp		-19.577		0.113
		(12.424)		(0.078)
Truck & merchandise types	×	×	×	×
Driver Characteristics	×	×	×	×
Holiday	×	×	×	×
Share-Direction FE	×	×	×	×
Month FE	×	×	×	×
N	989	978	989	978
R^2	0.675	0.682	0.742	0.746
Outcome Mean	21025.278	21243.354	89.664	90.564

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The unit of observation is the unique trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is ever at the registration country during the trip, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is ever in his home country during the trip and his education level. Holiday is a dummy indicating whether there is any holiday during the trip. Standard errors are heteroskedastic and shown in parentheses.

6 Robustness checks

In this section, we test the parallel trend assumption using an event study (subsection 6.1) and limiting the analysis to a more homogeneous sub-sample (subsection 6.2). The event study shows statistically insignificant effects of road construction once construction is completed, validating the parallel trend assumption. Moreover, there is a decline in the effect of construction as construction approaches completion. In subsection 6.2, we conduct difference-in-differences estimation by three main authorities along the road (military police or *gendarmerie*, police, and customs). We also limit analysis to Mali checkpoints and border checkpoints only. The effects of road construction remain robust after using these more homogeneous sub-samples. Moreover, the statistically significant effects within a certain authority and within Mali reject the "social planner" story where price setting done by chief officers or the central government. The only exception is the *gendarmerie* sub-sample. This may reflect that military is more hierarchical than other authorities.

6.1 Event study

The difference-in-differences estimation requires an assumption of stability in outcome variables in the absence of the treatment. In our setting, this would imply that the two corridors should not differ in trends of bribes or enforced delays if there were no road construction. Unfortunately, our data does not include data from before construction began, so we implement an post-trend test instead.

Below is the event study specification (6) that tests the parallel trends assumption for the non-shared *Koury* and the non-shared *Héré*. In this specification, we interact the *Koury* indicator with a set of quarter dummies starting from quarter one of 2011 to quarter three of 2012. Unlike a typical pre-trend event study test, here the periods used to test parallel trends are those after construction was completed (quarters two and three of 2012). The estimation equation is as follows:

$$Y_{ict} = \sum_{q=-4}^{2} \beta_q \mathbb{1}\{quarter\ q\} \times \mathbb{1}\{Koury\} + X_t'\gamma + \theta_c \times \delta_d + \eta_m + \sigma_r \times m + \epsilon_{ict} \tag{6}$$

Here, the dummy $\mathbb{1}\{quarter\ q\}$ is equal to one if a trip took place in quarter q. As an example, $q = -4$ refers to the first quarter in 2011, while $q = 2$ refers to the third quarter in 2012. We normalize the coefficient for the second quarter in 2012 to be zero (i.e. $\beta_1 = 0$). If the ex-post parallel trends assumption holds, the coefficient β_2 of the third quarter in 2012 should be statistically insignificant.

Figure 4a presents coefficients for different quarters where the dependent variable is the bribe level. The x-axis label "11m1-3" refers to the first quarter of 2011, "11m4-6" to quarter two of 2011, and so on. We find that the coefficient of the third quarter of 2012 is indeed statistically insignificant. Moreover, it is smaller in magnitude than the other coefficients. Both findings provide the best possible validation of the parallel trends assumption given the constraints of available data. The coefficients for quarters before the end of construction are mostly positive and statistically significant. More interestingly, there is a decline in magnitudes for those coefficients as construction nears completion. This indicates that the effect of road construction on corruption diminishes gradually as conditions on the non-shared *Héré* segment of road improve. For example, bridge repairs likely finished months before the final paving of the whole route was complete. As a result, officials along the *Koury* corridor lost bargaining power against drivers as the costs of driving on the non-shared *Héré* segment diminished.

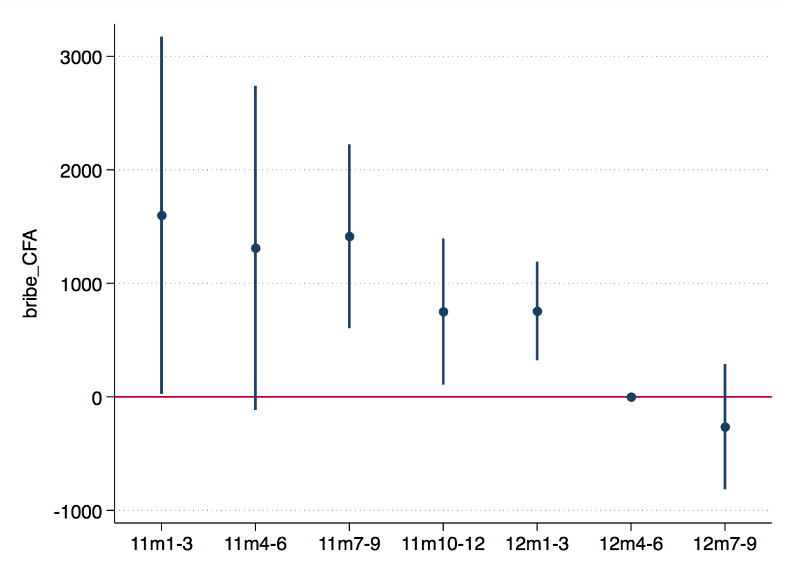
Figure 4b provides counterpart results to figure 4a using minutes delayed as the dependent variable. Similarly, we find a small and statistical insignificant coefficient for the third quarter in 2012. Moreover, there is a even clearer pattern of diminishing effects of road construction as it neared completion.

In appendix A, we provide additional event study figures that test the parallel trend assumption between the shared segment and the non-shared segment of *Héré* corridor as well. Figure 5a shows coefficients and confidence intervals using the bribe level as the dependent variable. Again, we find a small and statistically insignificant coefficient for the third quarter of 2012. We also find a statistically significant coefficient for the second quarter in 2011, after which the remaining coefficients are all statistically insignificant. This again shows a declining trend of the effect. This is also the case in figure 5b, which uses the delay in minutes as the dependent variable. In figure 5b, the coefficients from the second quarter of 2011 to the first quarter of 2012 come closer to zero over time, indicating a diminishing effect of construction on the shared segment in terms of enforced delay.

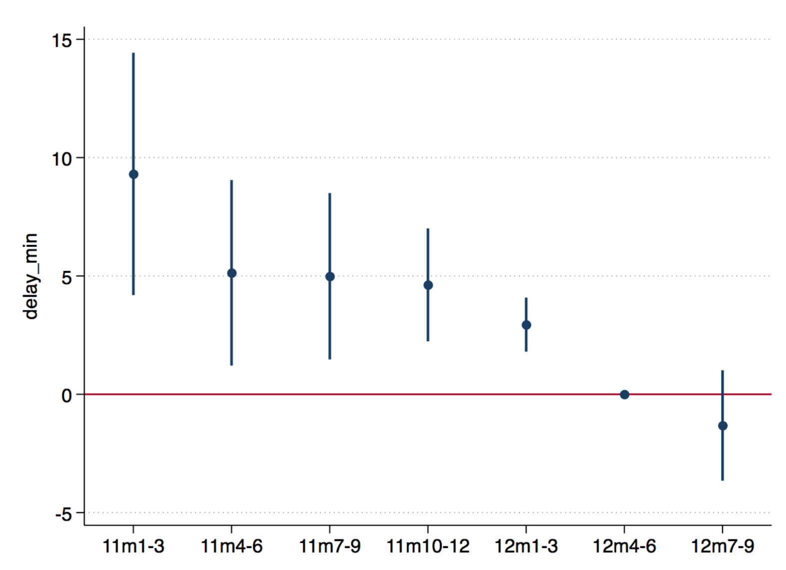
6.2 Difference-in-differences with sub-samples

We conduct difference-in-differences using sub-samples for two reasons: First, by narrowing down checkpoints of one authority or in one place, we better control for unobserved heterogeneity, which further validates our results found in section 5. Second, we can test if the "social planner" story holds for each authority or each country. If our results are still statistically significant by using either checkpoints of one authority or checkpoints in one countries, we can reject the hypothesis that prices are set by chief officials of that authority or the central government.

Table 8 shows the effects of road construction on the non-shared *Koury* using three main authorities. We find statistically significant effects on bribes for police and customs checkpoints. For enforced delays, coefficients are statistically significant for military and police checkpoints, while



(a) Effects on bribes



(b) Effects on enforced delays

Figure 4: Event Study for the non-shared *Koury* vs. the non-shared *Héré*

effects for customs checkpoints are marginally significant at the 10% level. The only exception is bribe level at military checkpoints. These robust results ameliorate concerns that the effects found in table 2 are driven by unobserved heterogeneity of officials.

Table 9 shows the effects of construction on the shared segment using customs checkpoints only. We do not do this same limited analysis using military and police checkpoints because there are very few checkpoints managed by military or police in Burkina Faso. Compared to table 4, we now have statistically significant coefficients for both bribes and enforced delays. This again confirms that heterogeneity in officials does not threaten our identification strategy. If anything, it actually masks the effects of road construction on the shared segment.

Table 10 presents results using Mali checkpoints (columns (1) and (2)) and border checkpoints respectively (columns (3) and (4)). Using the Mali sub-sample allows us to control for variation in government regulation, national environment, and so on. Border checkpoints are defined as those within 20km of the national border. Since checkpoints near the border are typically a formal station with parking lots, we exclude small *ad-hoc* checkpoints along the road. This helps control for unobserved heterogeneity of checkpoints that is not fully absorbed by checkpoint fixed effects. We find that the effects remain robust to both Mali checkpoints and border checkpoints.

All three tables serve as evidence of parallel trends by using more homogeneous checkpoints along two corridors. Moreover, table 9 and the first two columns of table 10 provides strong evidence that corruption along corridors is not coordinated by leadership in either police or the customs system, or by the Malian central government. We are not able to provide conclusive evidence for the military system, however, as the coefficient in the first column of table 9 is insignificant. This may reflect that military is more hierarchical than police or customs systems,lending it to more of a social planner type outcome.

7 Conclusion

In this paper, we argue that effective anti-corruption interventions require an improved understanding of the market structure that shapes corruption behavior. We demonstrate this idea in the setting of highway corruption in West Africa, where long-haul drivers encounter frequent stops by checkpoint officials and are asked to pay petty bribes. We build a theoretical model to depict competition between checkpoints along a dual road system. The model endogenizes the length of the bargaining process between checkpoint officials and truck drivers. In doing so, we present a more realistic version of bargaining where short-term delay is the primary of strategy for both parties to the negotiation, a common bargaining strategy in developing countries. Our theoretical model contributes to the literature by developing the first model with endogenous negotiation time in the bargaining process.

Specifically, our model predicts a Bertrand-style equilibrium where checkpoint officials on both roads in the two competing corridors set prices and waiting times to be zero. We further exploit an exogenous shock to costs generated by road construction on the non-shared *Héré* corridor. This enables us to explore how the corruption equilibrium changes under a different market structure. The model predicts that the extra inconvenience costs incurred by the construction project push drivers to choose the non-shared *Koury*. These costs increase the bargaining power of checkpoints officials along that route, leading to more extortion of drivers. Moreover, checkpoints officials along the shared segment will reduce required bribe amounts and enforced delays as they face more competition from the non-shared *Koury* segment.

Empirically, we confirm the model's predictions using a difference-in-differences framework. We find that bribes and minutes delayed on the non-shared *Koury* segment increase during construction. Furthermore, we find evidence that the total cost of passing through the shared segment decreases during construction, relative to that on the non-shared segment of the *Héré* corridor. We further explore heterogeneous effects of construction by interacting it with rainfall level. As the *Héré* corridor is of relatively poorer condition under heavy rain, checkpoints along the *Koury* corridor gain more bargaining power on rainy days relative to dry days. We do find the effects of construction are heightened on rainy days.

This work reveals that competition among corrupted agents facilitates public services. The spatial competition generated from two parallel corridors forces officials to keep the "going rate" for bribes low to attract driver-customers. As a result, the total cost for long-haul transportation declines. This suggests that increasing competition may be a way to fight against corruption, especially when other methods are not feasible. Here, providing more paved inter-state corridors for merchandise transportation would increase competition and reduce bribes. That said, an important caveat is that increasing competition, even if it reduces corruption, is not always desirable to society. Burgess et al. (2012) find that competition among forestry officials in Indonesia increases deforestation by facilitating illegal logging. Whether competition is conducive to citizens and the public good depends on the nature of the service under study. In our setting, where officials are asking for bribes to allow the public to do something legal (use a public road), competition among officials that lowers prices is welfare-enhancing. In a setting like that considered by Burgess et al. (2012), bribes allow the public to do something illegal (logging), and competition that lowers bribe costs is bad for the public good.

Our paper also shows that a reduction in competition caused by a local construction project leads to a redistribution of corruption benefits towards checkpoints unaffected by the road construction. Such a spillover effect should be taken into account by policy-makers considering anti-corruption interventions, since their effectiveness may be offset by corrupted officials beyond the scope of the intervention. Such spillover effects of local interventions have been found in myriad settings. Maheshri & Mastrobuoni (2019) find that hiring security guards causes more robberies against unguarded banks. Dell (2015) shows that the Mexican drug war led to an increase in drug-related violence along alternative drug routes. In general, a national anti-corruption policy can avoid such spillover effects. When such a policy is not available, it is important to carefully evaluate possible spillovers caused by local interventions.

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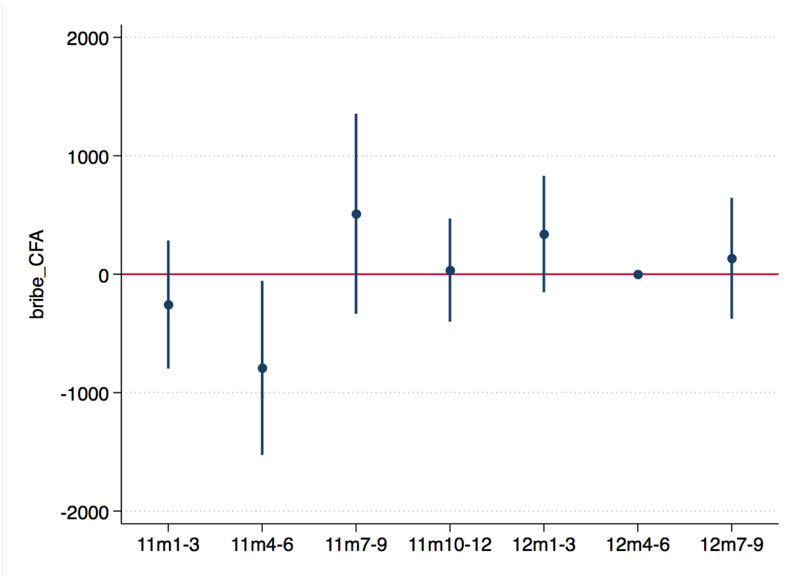
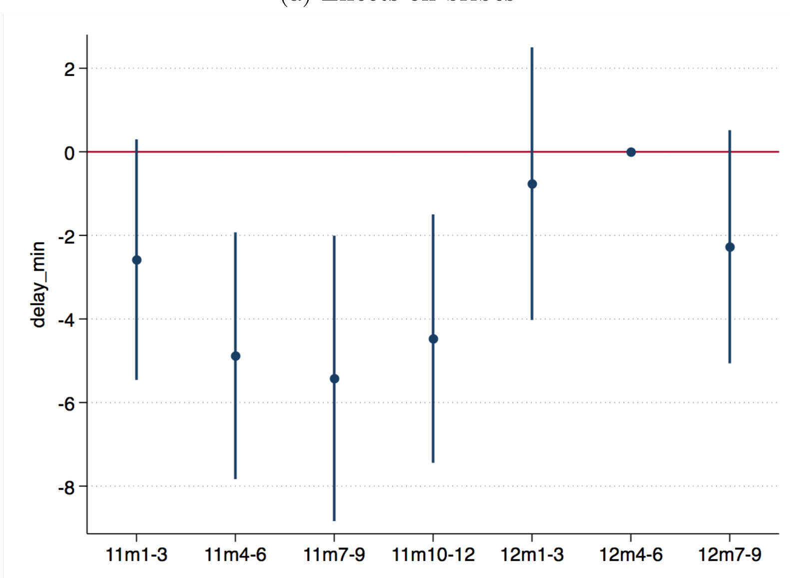
Appendix

A Figures



(a) Effects on bribes



(b) Effects on enforced delays

Figure 5: Event Study for the shared *Héré* vs. the non-shared *Héré*

B Tables

Table 8: Effects of road construction on bribes and enforced delays on the *Koury* corridor, by authority

	Bribes (CFA)			Enforced Delay (min)		
	(1) military	(2) police	(3) customs	(4) military	(5) police	(6) customs
Road Construction × Koury	-56.395	548.367**	685.227*	1.399***	2.654***	1.553
	(191.846)	(208.312)	(365.654)	(0.489)	(0.646)	(1.077)
Truck & merchandise types	×	×	×	×	×	×
Driver Characteristics	×	×	×	×	×	×
Holiday	×	×	×	×	×	×
Checkpoint-Direction FE	×	×	×	×	×	×
Month FE	×	×	×	×	×	×
Corridor-specific Time Trends	×	×	×	×	×	×
N	4989	5467	5952	4989	5467	5952
R^2	0.706	0.723	0.701	0.657	0.679	0.636
Outcome Mean	1286.931	1871.246	2236.072	7.469	8.883	8.117

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The table evaluate the effects of road construction using three main authorities. Checkpoint officials along the corridors are mainly from the *gendarmerie* (military), police, and customs. The unit of observation is the driver's stop at a checkpoint during a certain trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is at the registration country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is in his home country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

Table 9: Effects of road construction on bribes and enforced delays on the shared segment, using customs authority only

	Bribes (CFA)	Enforced Delay (min)
	(1)	(2)
Road Construction × Share	-496.680***	-1.845***
	(164.002)	(0.497)
Truck & merchandise types	×	×
Driver Characteristics	×	×
Holiday	×	×
Checkpoint-Direction FE	×	×
Month FE	×	×
N	4985	4985
R^2	0.426	0.350
Outcome Mean	1861.785	7.157

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: The table only uses stops by customs officials for analysis. Customs is the only authority operating checkpoints in both Mali and Burkina Faso, and both during and after construction. The unit of observation is the driver's stop at a checkpoint during a certain trip. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is at the registration country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is in his home country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

Table 10: Effects of the road construction on bribes and enforced delays on the *Koury* corridor, using Mali and border checkpoints respectively

	Mali Checkpoints		Border Checkpoints	
	(1) bribes	(2) delays	(3) bribes	(4) delays
Road Construction × Koury	594.357***	1.859***	755.424***	2.690***
	(195.731)	(0.541)	(206.432)	(0.531)
Truck & merchandise types	×	×	×	×
Driver Characteristics	×	×	×	×
Holiday	×	×	×	×
Checkpoint-Direction FE	×	×	×	×
Month FE	×	×	×	×
Corridor-specific Time Trends	×	×	×	×
N	15485	15485	5625	5625
R^2	0.556	0.598	0.556	0.757
Outcome Mean	1801.950	7.080	2602.489	12.495

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

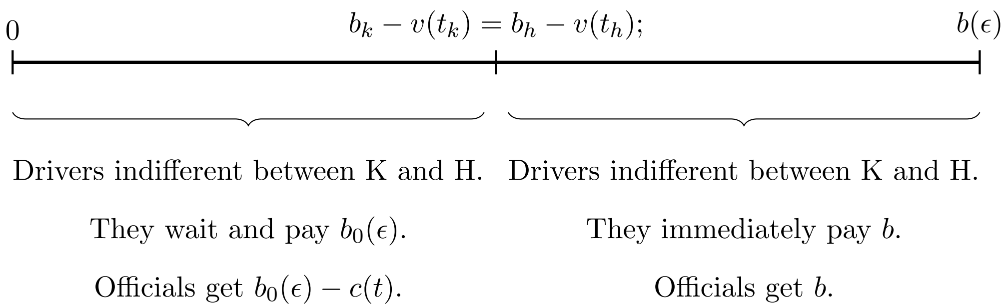
Notes: The first two columns use stops at Mali checkpoints only, while the last two use stops at border checkpoints only. Border checkpoints are defined as those within 20km from the national border between Mali and Burkina Faso. Truck and merchandise types include weight of vehicle, weight of merchandise, whether the vehicle is at the registration country, whether the vehicle is a container, and whether the vehicle is a tanker. Driver characteristics include whether the driver is in his home country and his education level. Holiday is a dummy indicating whether the stop date is a holiday. Standard errors are clustered at checkpoint-authority level and shown in parentheses.

C Model proof

C.1 A proof of proposition 1

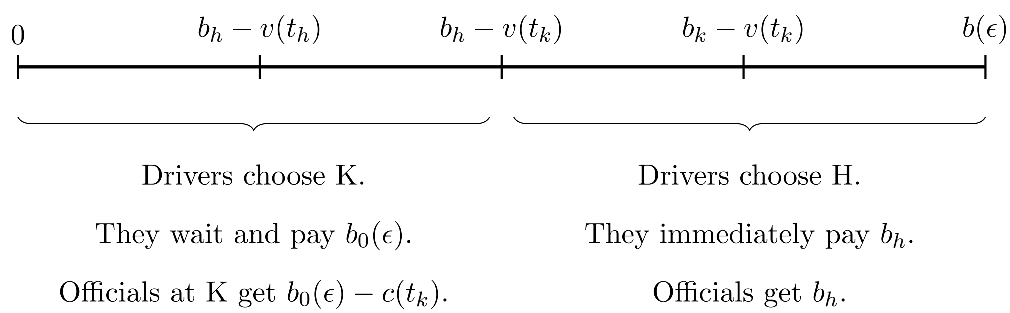
Proof. First, notice that $(b_k, t_k) = (b_h, t_h) = (0, 0)$ is indeed a Nash equilibrium as no one is willing to deviate. In the next step, we want to show that this is the *only* equilibrium. We do so by providing a dominant strategy for each case, excluding all other cases.

Case 1: $b_k = b_h > 0$ **and** $v(t_k) = v(t_h) > 0$. In this case, the separation of drivers between the two segments can be shown below. The official in K is better off if he sets bribe and time a bit lower but where $b_k - v(t_k) = b_h - v(t_h) > 0$ still holds. He increases revenue by attracting all drivers on the road.



Case 2: $b_k > b_h > 0$ **and** $v(t_k) > v(t_h) > 0$. In this case, all drivers choose H because $\min\{b_0(\epsilon) + v(t_k), b_k\} > \min\{b_0(\epsilon) + v(t_h), b_h\}$. Knowing this, the K official can set both bribe and time slightly lower than those in H and attract all drivers.

Case 3: $b_k > b_h > 0$ **and** $v(t_h) > v(t_k) > 0$. In this case, the division of drivers across the two segments can be shown below. Drivers with $b_0(\epsilon) > b_h - v(t_k)$ choose H and pay b_h immediately; drivers with $b_0(\epsilon) < b_h - v(t_k)$ choose K, wait for time t, and pay $b_0(\epsilon)$. This is not a Nash equilibrium because the H official can set $v(t_h) = v(t_k)$. By doing so, he keeps all drivers with $b_0(\epsilon) > b_h - v(t_k)$ while attracting a proportion of drivers with $b_0(\epsilon) < b_h - v(t_k)$ from K.



Case 4: $b_h = t_h = 0$ **and** $b_k > 0, t_k > 0$. In this case, H official is better off raising bribes and times a little bit but still with $\min\{b_0(\epsilon) + v(t_k), b_k\} > \min\{b_0(\epsilon) + v(t_h), b_h\}$.

Case 5: $b_h = t_k = 0$**, and** $b_k > 0, t_h > 0$**.** In this case, H official is better off by raising b_h a little bit but still with $b_h < \min\{b_k, b_0(\epsilon)\}$. ■

C.2 A proof of proposition 2

Proof. We prove the proposition for the Koury segment and the shared segment separately.

For the Koury checkpoint, it is obvious that any package with $0 < \min\{b_0(\epsilon) + v(t_k), b_k\} < \min\{b_0(\epsilon) + v(t_h), b_h\} + w$ dominates the (0,0) package. In this case, the official sets a positive bribe price without losing any drivers to the Héré route. For both a positive t_k and a positive b to be a dominant strategy, we must assume that $c(t)$ is much smaller than $v(t)$. This basically says that a driver values time more than a checkpoint official does. This is close to reality, as the driver has a trip to complete, while the official is sitting at his office.

For the shared segment, we prove it by transferring the question to a single-road-two-checkpoint case. Construction allows the Koury checkpoint to charge positive bribes equal to the value of the inconvenience costs. The case can be translated to a single-road situation where the checkpoint on the shared segment competes against the other checkpoint charging positive $(\bar{b}, \bar{t})$. Similarly, the case without road construction is equivalent to a single-road-single-checkpoint situation, in which $(\bar{b}, \bar{t}) = (0, 0)$. Now denote the revenue from a single driver:

$$R(b,t) = \int_{b<b_0(\epsilon)+v(t)} b \, dF(\epsilon) + \int_{b>b_0(\epsilon)+v(t)} (b_0(\epsilon) - c(t)) dF(\epsilon).$$

Also denote its elasticity with respect to bribes $\delta_b^R = R_b(b,t)\frac{b}{R(b,t)}$, and the elasticity of driver flow with respect to bribes $\delta_b^q = q_b(B,T)\frac{b}{q(B,T)}$. For the checkpoint on the shared segment, the first order condition satisfies:

$$\delta_b^q + \delta_b^R = 0, \text{ with } \delta_b^q < 0.$$

When q is linear in B and T, we have $\delta_b^q|_{\bar{b}=0} < \delta_b^q|_{\bar{b}>0} < 0$. This result is because q is a decreasing function of B, and $q_b(B,T)$ is a constant. For the first order conditions to hold, δ_b^R must increase when $\bar{b}$ becomes positive. This can be achieved by reducing the b if δ_b^R is a decreasing function of b. We can observe without assumption that the optimal point $R(b,t)$ should always be an increasing function of b. This is because $R_b(b,t)$ is positive (otherwise δ_b^R will be negative). To make δ_b^R a decreasing function of b, the only assumption needed is that $R_b(b,t)b$ is a decreasing function of b. In fact, the assumption holds when ϵ, $v(t)$, and $c(t)$ are relatively small compared to b. To make the point more clearly, we parameterize the problem as follows: ϵ is uniformly distributed within interval $[0,\bar{\epsilon}]$, $b_0(\epsilon) = \epsilon$, and $q(b,t) = 1-(b+v(t))$. As a result,

$$\begin{aligned}
R(b,t) =& \frac{1}{\bar{\epsilon}}[\int_{b-v(t)}^{\bar{\epsilon}} b d\epsilon + \int_0^{b-v(t)} (\epsilon - c(t)) d\epsilon] \\
=& \frac{1}{\bar{\epsilon}}[b\epsilon|_{b-v(t)}^{\bar{\epsilon}} + (\frac{1}{2}\epsilon^2 - c(t)\epsilon)|_0^{b-v(t)}] \\
=& \frac{1}{\bar{\epsilon}}[-\frac{1}{2}b^2 + \frac{1}{2}v(t)^2 - bc(t) + c(t)v(t) + b\bar{\epsilon}].
\end{aligned}$$

Therefore, the partial derivative with respect to b is:

$$[R(b,t)*b]_b = -\frac{3}{2}b^2 + 2b[\bar{\epsilon} - c(t)] + [\frac{1}{2}v(t)^2 + c(t)v(t)] \approx -\frac{3}{2}b^2.$$

The proof for decreased t of the shared checkpoint after the road construction is similar to that of b. ■