SECURITY INSTABILITY AND RURAL ROAD FINANCING: EVIDENCE FROM NEPAL‡

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ABSTRACT. Transport infrastructure is important for economic growth. In Nepal, about 20 percent of rural residents have to spend more than 3 hours to go to the nearest marketplace. This paper addresses development challenges caused by security instability in the country. It finds that security concern undermines rural road development in many ways. Unstable security discourages firms from participating in public tenders, pushing up procurement costs. It also causes significant project delays and cost overruns. Security is also found to be an important factor to maintain the quality of rural roads. Besides security improvement, open competition and careful procurement planning are found to be crucial for good rural road procurement. Bidding documents can be distributed free of charge, and the bid preparation period should be extended. Heavy rainfall and the bidders' low-balling strategy also need to be taken into account to prevent massive project delays.

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INTRODUCTION

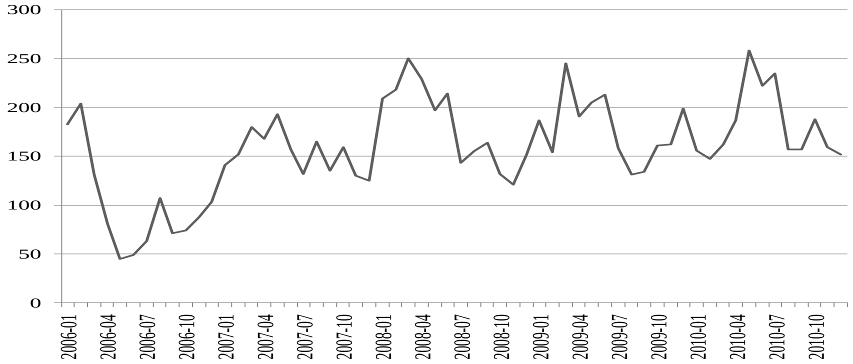
Transport infrastructure is among the most important driving forces for economic growth. Sustainable access to infrastructure is essential to improve living standards. In particular in rural areas, the lack of access to reliable transport infrastructure remains a significant constraint for people's daily life and local businesses in developing countries. About 900 million rural dwellers worldwide still live more than two kilometers of an all-weather road.

Rural road accessibility is one of the most crucial challenges to Nepal. The vast majority of rural residents in the country had to spend more than 30 minutes to access to paved roads. About one-third do not have any paved road within more than 3 hours. Lack of access to all-season roads significantly limits economic and social opportunities in rural and remote areas. About 20 percent of rural residents have to spend more than 3 hours to go to the nearest marketplace or agriculture center. Most urban people may find a health post within less than 30 minutes. However, for rural people, it often takes more than 1 hour (Nepal CBS, 2004).

Unstable security has been a matter of particular concern to implement road and other development projects in Nepal. According to the UN Nepal Security Database, about 200 security related incidents, such as abduction, attack and murder, happen nationwide every month (Figure 1). In rural areas of the Terai region, many security incidents were reported (Figure 2). Security conditions can affect rural road projects in various ways. First, the instability could discourage firms from applying for public tenders. Local news has frequently been reporting intimidation and other threats against competitors placing bids. Then, limited competition would likely result in high procurement costs and vulnerability to collusion and corruption (e.g., Kessel, 1971; Brannman and others, 1987; Paarsch, 1992; Iimi, 2006).

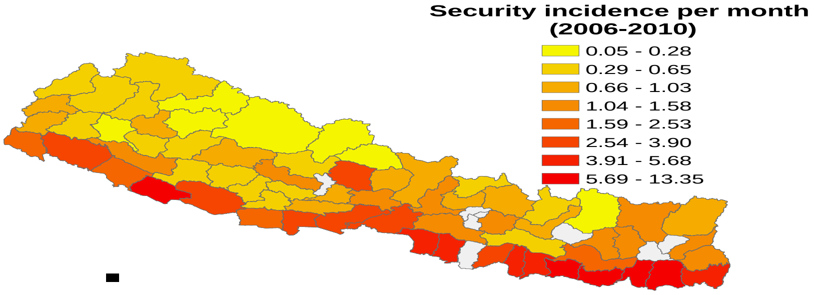
Second, security instability in project areas could also hamper the timely implementation of projects, causing project delays and cost overruns. In 19 project districts where our data were collected, more than 3 security incidents were reported every month during the project implementation. Any measures to avoid conflicts and abductions would likely add to project costs and project delays. In general, project delays and cost overruns are common problems of infrastructure projects in developing countries (e.g., Flyvbjerg *et al*., 2002; Alexeeva, Padam, and Queiroz, 2008).

Figure 1. Number of security-related incidents in Nepal



Source: UN Nepal Security Database.

Figure 2. Number of security-related incidents by district



Source: UN Nepal Security Database.

Finally, the quality of rural roads can also be affected by security conditions, because roads have to be maintained periodically even after the projects are completed. Where security concern is severe, it may be difficult to carry out routine maintenance. As a result, the road surface may tend to be deteriorated along with other exogenous factors, such as traffic and precipitation. Timely maintenance of infrastructure assets is essential in general. In Africa during the 1970s and 1980s, it is estimated that road assets valued at about $40-45 billion were lost because of inadequate maintenance, which would have cost only $12 billion (Harral and Faiz 1988).

The Nepal government has been making efforts to improve the justice and security systems to promote rule of law and inclusive and equitable growth (United Nations, 2011). To establish a sound and competitive marketplace and strengthen governance in public procurement, for example, the Procurement Act and Right To Information Act was enacted. However, there is still a long way to go. The current paper aims at examining possible impacts of security issues on the firms' bidding strategy, contract performance and the ex post quality of projects delivered. The remaining paper is organized as follows: Section II describes recent road developments in Nepal. Section III develops the empirical models and presents our data. Section IV discusses our main estimation results and some policy implications. Then, Section V concludes.

RECENT ROAD DEVELOPMENTS IN NEPAL

Nepal is one of the least developed countries in the world. About 29 million people live in the country, out of which half still live on less than $1.25 a day at 2005 international prices. Gross domestic product (GDP) per capita was about $430 in 2009. In the country, there exists some 17,000 km of road network. This is about 12 km per 100 sq. km of land area, which is compared unfavorably to other developing countries in the region (Figure 3). Not only quantity but also quality of roads has been poor. About 40 percent of roads in Nepal remain unpaved.

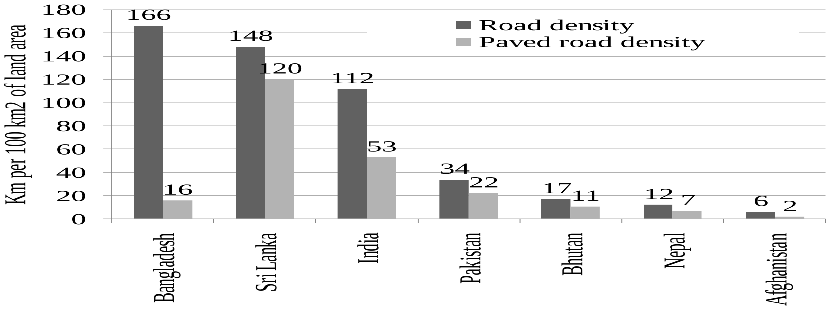
In particular in mountainous areas, road density remains low. Even if the significant concentration of population on the capital area is taken into account, the density is not high on a per population basis

(Figure 4). In many rural regions, roads are in operational condition only during the dry season.

To improve the road accessibility in rural areas, the government has been upgrading dry-season-only roads to all-season standards by providing structures, gravel surface and Otta seal, which is a low-cost paving option (World Bank, 2005; 2007). Some of the impacts have already been observed; the people's mobility increased by more than 20 percent and that their travel time declined dramatically from 2.6 hours to 32 minutes on average (World Bank, 2009). But available resources to rural road development continue to be limited compared to the massive remaining demand of the country. Thus, it is of importance to use the available resources more efficiently. Public procurement can play an important role to this end.

Nepal has several important projects to reconstruct and rehabilitate its rural roads. While the World Bank has been assisting the Rural Access Improvement and Decentralization Project (RAIDP) in 20 districts mainly in the Terai area, other donors, such as Asian Development Bank and UK Department for International Development (DfID), have been supporting other 45 districts under the Rural Reconstruction and Rehabilitation Sector Development Project.

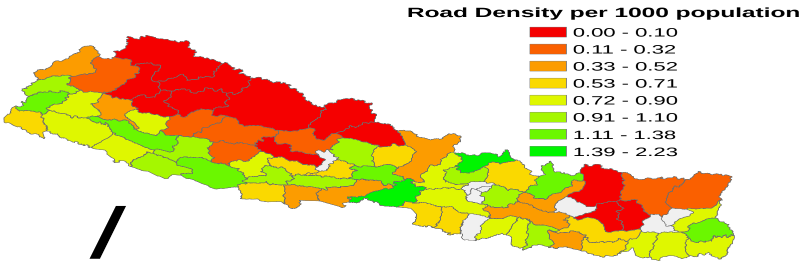
Figure 3. Road density in South Asia



Note: Figures are the latest available data in 2002-2007.

Source: World Development Indicators.

Figure 4. Road density in Nepal



Source: Central Bureau of Statistics, Nepal (2004).

Three entities share responsibility for the rural road projects. The District Development Committees (DDCs) are the main implementing agencies to prepare District Transport Management Plans, prioritize the local needs, mobilize community groups, and procure and manage civil works and services. However, the DDCs planning and implementation capacity remains weak. Thus, the Department of Local Infrastructure and Agricultural Roads (DOLIDAR) is playing an important role in coordinating DDCs and providing technical and engineering support to them. Then, the Ministry of Local Development (MOLD) is responsible for general oversight and monitoring.

With the assistance of the DOLIDAR and DDCs, we collected detailed procurement and contract data from 155 rural road upgrading works in 19 Terai districts assisted by the World Bank.[2] In each district, on average 8 road contracts were reviewed—half from World Bank-financed projects and half from government-owned projects. These districts have exhibited relatively good sector performance, such as road density, because the RAIDP selected these project districts according to a wide range of indicators,

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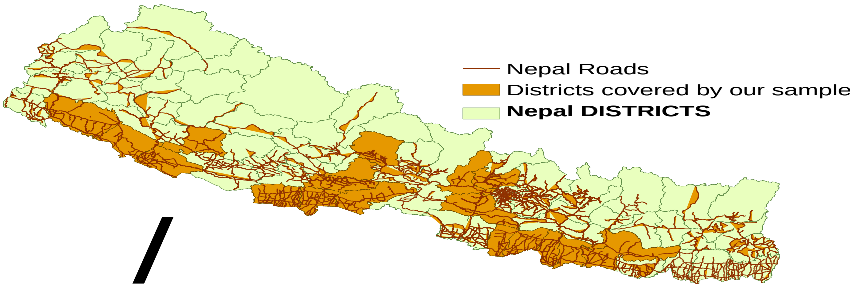
[2] *One of the 20 districts assisted by the RAIDP has not yet had road work contracts that can be evaluated at the time of our data collection.*

including project preparedness and implementation capacities at the local level (Figure 5).[3]

Figure 5. Existing road network and districts covered by our sample



Still, there seem to be significant differences in road procurement performance across districts. In our sample, the road procurement costs average NRs7.7 million or $0.1 million but vary from NRs100,000 to NRs40 million, depending on project specifications (Table 1).[4] The average unit cost of road upgrading is about NRs1.6 million or $23,000 per km, which is relatively low by global standard.[5] But there is still a significant difference in unit costs. Normalized bids, which are bid prices relative to engineering cost estimates, also vary

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[3] *Despite the original strategy of the RAIDP, the performance criteria to allocate resources were found to be unsuitable, because of the prevailing conflicts and unstable political conditions. Recently, the criteria have been somewhat simplified to focus on financial and physical progress of the works carried out.*

[4] An exchange rate of about 70 Nepal rupees to the U.S. dollar is assumed throughout the current paper.

[5] This is far below a range of unit cost estimates of $200,000 to $500,000 per km that are available in the literature (Fay and Yepes, 2003; Alexeeva, Padam and Queiroz, 2008; Foster and Briceno-Garmendia, 2010). This is mainly because of the project specifications. Our sampled roads are mostly unpaved, gravel roads with simple surface treatment if any. In some cases, the project costs increased $3,000-4,000 per km by adding to additional surface materials, such as otta seals. Still, they are relatively cheap.

from 0.55 in some districts, such as Dhanusa, to 1.05 in others, such as Syangja. There must be reasons behind this. One of the questions that the current paper addresses is why some districts spend twice as high costs as others.

Table 1. Rural road procurement costs in Nepal

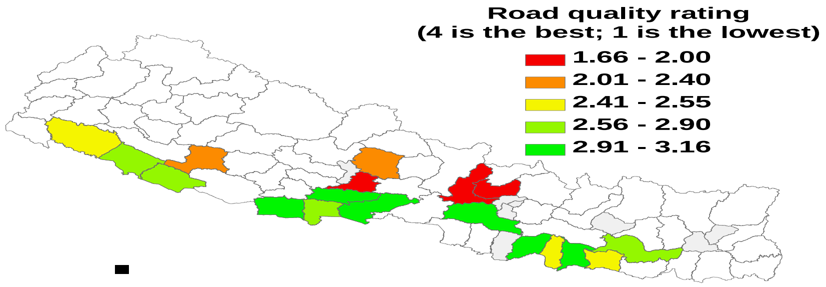
	Obs	Mean	Std. Dev.	Min	Max
Contract amount (million rupee)	156	7.76	7.95	0.14	39.89
Contract amount per km (million rupee)	156	1.63	2.32	0.02	21.97
Bid amount relative to engineering cost estimate	810	0.80	0.21	0.10	1.64

Contract performance also varied significantly across regions. Two types of contract performance are of particular interest in infrastructure projects: cost overruns and project delays. Infrastructure contracts are normally far from complete and enforceable. As a result, there are many delays and cost overruns in infrastructure projects. In the transport sector, 9 out of 10 projects experienced cost overruns (Flyvbjerg *et al*., 2002). About 30 percent of PPP infrastructure transactions underwent renegotiation shortly after the contracts were awarded (Guasch, 2004). Some ex post adjustments are necessary because of unanticipated technical difficulties, but others may be caused by the firms' opportunistic behavior, such as low-balling (Ware and others, 2007). Important, ex post adjustments are costly. For instance, each year of delay would add on average $4.6 million to a project cost of $100 million in the transport sector (Flyvbjerg *et al*., 2004).

Our sample projects experienced considerable delays but incurred relatively small cost overruns. The average delay is about 100 days. About 10 percent of the projects experienced more than 1 year of delay. Cost overruns seem to be prevailing. Half the contracts incurred certain cost overruns. But about 20 percent of the contracts experienced cost underruns, because of the reduced scope of the works. As a result, the average cost overrun is about 4 percent in the whole sample. Notably, this may be consistent with the view that firms might take advantage of the delay strategy, rather than low-balling, because ex post cost adjustments are normally difficult to justify in relatively simple rural road rehabilitation works. By contrast, projects can always be delayed. Thus, firms may be motivated to win a contract with an unrealistic schedule proposed, and then cut corners, delaying the project afterwards.

Finally, the quality of roads rehabilitated or upgraded needs to be examined, because this is the ultimate development objective and some of the efforts made by contractors are unobservable. To this end, transport specialists actually drove on each road segment and classified the road conditions into four categories: (i) very uncomfortable with continuous shakes and frequent slowdown and stops, (ii) uncomfortable with frequent shakes, (iii) fairly comfortable though occasionally jolting, and (iv) very comfortable throughout the entire road segment. This is a subjective rating but based on the field survey. Despite the small size of our sample, there is a clear trend even at first glance: The quality of roads is relatively low around the nation's capital, presumably because of the large traffic volume (Figure 6). There may be other physical factors, such as weather, and institutional reasons behind this.

Figure 6. Average road quality rating



EMPIRICAL MODELS AND DATA

The effects of security uncertainty are examined at three stages along the project cycle. At the procurement stage, an equilibrium bid function is estimated with the endogeneity of bidder participation taken into account. Unstable security conditions can affect both entry and price strategies of firms. At the project implementation stage, the contract performance is examined, focusing on cost overruns and project delays. Finally, at the post-project stage, the road conditions are evaluated in relation to security instability and other exogenous factors.

Equilibrium bid equation

Following the empirical auction literature (e.g., Porter and Zona, 1993; Gupta, 2002; Estache and Iimi, 2009; 2010; 2011), a conventional symmetric equilibrium bid function is considered to investigate the firms' bidding behavior in the road procurement market:

$$\begin{aligned} \ln bid_{it} &= \alpha_1 \ln num_t + \alpha_2 \ln secritybefore_t + X'_t \beta \\ &\quad + \alpha_3 \ln dist_{it} + \alpha_4 D(ethinicity_{it}) + W'_i \gamma + \varepsilon_{it} \end{aligned} \tag{1}$$

where bid_{it} is the amount of evaluated bid—both winning and losing—submitted by bidder i on road contract t. In the first-price sealed-bid format, both winning and losing bids are equally informative to estimate the equilibrium bid. num_t is the number of bidders who participated in auction t.

In theory, the equilibrium bid prices approach the lowest possible market price, as the number of bidders increases, because the probability of a firm's winning a contract declines if it has more contenders (e.g., Wilson, 1977; Milgrom and Weber, 1982; Wolfstetter, 1996). Many empirical auction studies are supportive of this (e.g., Kessel, 1971; Brannman *et al*., 1987; Paarsch, 1992; Iimi, 2006). Equation (1) is also a common functional form to capture the competition effect. As per Rezende (2005), the mapping between the winning bid and the number of bidders is never linear. In addition, given a certain standard distributional assumption, the competition effect tends to taper off quickly as the number of bidders grows.

In Nepal, the level of competition appears to be low but varies across regions. In some districts, such as Dhanusa, competitive bidding attracted more than 9 firms. But there were also less competitive auctions with 2-3 bidders in other districts, such as Kailali and Rautahat. In total, the average is about 6, which appears consistent with the existing literature showing that on average 3 to 6 bidders participated in competitive bidding for road infrastructure works (e.g., Gupta, 2002; De Silva, Dunne and Kosmopoulou, 2003; Alexeeva, Padam and Queiroz, 2008).

To measure the impact of security issues, *securitybefore* is defined by the number of security-related incidents that occurred in a project host district during the three months prior to each auction. In the broader context, governance often matters to public procurement particularly in developing countries (e.g., Estache and Iimi, 2009). A study in Nigeria shows that the majority of private firms answered that they decided not to submit their expressions of interest in public tenders, because they did not trust the selection process. There is a general perception that contractors are predetermined or must pay a bribe. In particular at the local levels, integrity tends to be relatively weak (World Bank, 2008).

X controls for other contract-specific technical characteristics, such as engineering cost estimates, length and width of roads, thickness of the surface, and materials to be used. The engineering cost estimate is among the important valuables to control the size of contracts and other contract-specific unobservables. How to package project components is an important question in public procurement, because it can encourage or discourage bidder participation (Grimm and others, 2006). In practice, significant flexibility is left to procurers.[6] In Nepal, most rural road contracts are fairly small. In general, small

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[6] The World Bank's current procurement guidelines stipulate that "[t]he size and scope of individual contracts will depend on the magnitude, nature, and location of the project. For projects requiring a variety of goods and works, separate contracts generally are awarded for the supply and/or installation of different items of equipment and plant."

contracts can attract more contractors that are relatively small yet specialized. However, dividing a project into too small contracts will sacrifice potential economies of scale in procurement, making the contracts less profitable and thus less attractive. Thus, there is an important tradeoff. In Africa, public road investment is found to exhibit significant economies of scale (Foster and Briceno-Garmendia, 2010). See Table 4 for detailed definition of other technical variables in X.[7]

Of particular note, weather may be an important determinant of road procurement costs. Our sample districts have a monthly precipitation of about 200 mm on average. Some districts, such as Banke and Nuwakot, have a lot more precipitation, particularly in summer (Figure 7).[8] Anticipated weather conditions may affect the firms' cost structure to undertake road works.

To account for heterogeneity across bidders, we include the distance—denoted by *dist*—between a project site and a contractor's location, which is calculated as a straight line distance between the two district capitals.[9] About half of the bidding firms come from the nation's capital, Kathmandu and its neighboring districts. The cost of undertaking a project may be high for those who are located far from the project site, because they may not have transaction with good local material suppliers. It is also costly to transport road work equipment, such as paver, across regions, especially in the mountainous areas. In addition, skill and equipment sets may be different across regions; thus, applying for contracts from distant places may add to production costs.

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[7] A small but positive value is used to avoid logarithms of zero in independent variables, if they are zero.

[8] Our monthly precipitation data are based on 20 weather stations that are close to our surveyed roads. Thus, the precipitation variables that we use in this paper are district-specific but time-variant and thus contract-specific.

[9] This is merely an approximation.

Ethnicity may also potentially affect the bidding strategy in Nepal. There are 103 castes and ethnic groups in the country.[10] *D*(*ethnicity*) is set to one if the dominant ethnicity is the same between a project host district and a bidder's home district.

Finally, a set of dummy variables representing the bidders' origin districts are also included in *W*. Firms may have unobserved comparative advantages. Local firms may have the cost and information advantage to supervise a project. Firms outside the district may have more work experience and stronger financial background.

Table 2. Summary statistics

Variable	Abbreviation	Obs	Mean	Std. Dev.	Min	Max
Bid equation:						
Evaluated bid amount (NRs million)	*bid*	599	13.70	70.90	0.27	1410.00
Number of bidders	*num*	106	5.86	4.04	1	15
Number of security incidents during the three months prior to each tender	*securitybefore*	106	10.95	10.21	0	38
Line distance between project and firm origin districts	*dist*	599	121.74	159.28	0	762.57
Dummy for the same dominant ethnicity between project and firm origin districts	D(*ethnicity*)	599	0.48	0.50	0	1
Engineering cost estimate (NRs million)	*cost*	106	9.22	9.80	0.32	39.40
Length of roads (km)	*length*	106	8.64	5.44	0.20	34.00
Number of lanes	*lane*	106	1.05	0.21	1	2
Thickness of road surface (mm)	*thickness*	106	7.11	9.33	0	50

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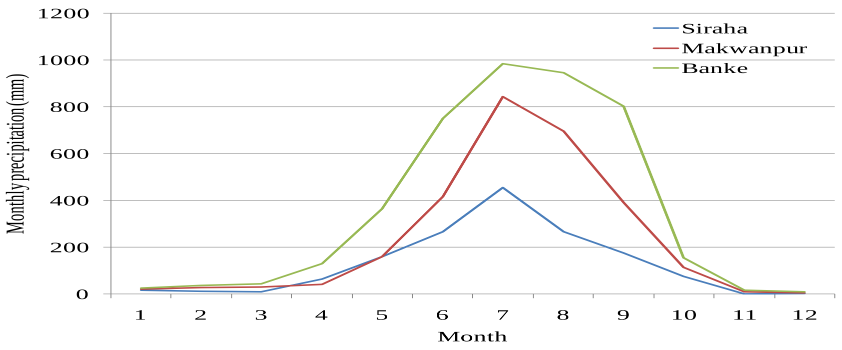
[10] In the 1991 census, there were 60 castes and ethnic groups in the country, some of which are re-categorized into new groups in the 2001 census.

Gravel (m3)	*gravel*	106	2279.6	2900.4	0	18600.0
Bitumen (kg)	*bitumen*	106	4762.4	14122.5	0	79029.6
Earthworks (m3)	*earth*	106	6742.0	12665.7	0	93403.0
Brickworks (m3)	*brick*	106	45.2	165.5	0	1204.1
Gabion (m3)	*gabion*	106	238.6	856.4	0	8400.0
Excavation (m3)	*excavation*	106	2952.1	5319.8	0	29266.6
Cement concrete (m3)	*cement*	106	32.7	74.5	0	507.8
Dummy variable for postqualification of bids	D(*postqualify*)	106	0.92	0.28	0	1
Bidder participation:						
Number of bidders purchasing bidding documents	*bdnum*	118	22.53	17.93	4	107
Price of bidding documents	*bdcost*	118	1547.6	1044.6	290.5	3576.1
Bid preparation period (days)	*bdpreptime*	118	25.94	9.25	6	52
Contract management:						
Cost overrun rate (percent)	*overrun*	155	3.73	6.25	-14.83	21.69
Project delay (days)	*delay*	152	107.25	208.09	-76	1217
Number of security incidents during the project implementation	*securityduring*	152	33.86	47.06	0	280
Precipitation during the project implementation (mm)	*rainduring*	155	1652.22	1724.13	0	8774.2
Difference between the winning bid and the second lowest bid (NRs million)	*lowball*	142	-0.32	2.70	-29.60	6.29
Project quality:						
Confortability rating (1 to 4)	*rate*	136	2.63	0.60	1	4

Average traffic speed (km per houir)	*speed*	148	24.71	10.13	7.50	57.00
Number of days for which a road has been used since the project completion	*age*	136	794.32	497.60	11	2656
Cumulative traffice since the project completion	*traffic*	132	150802	153255	0	807884
Number of security incidents after the project completion	*securityafter*	133	81.94	79.05	0	377
Precipitation after the project implementation (mm)	*rainafter*	136	4953.4	3591.9	0.0	18223.2

Figure 7. Average monthly precipitation for the past 10 years

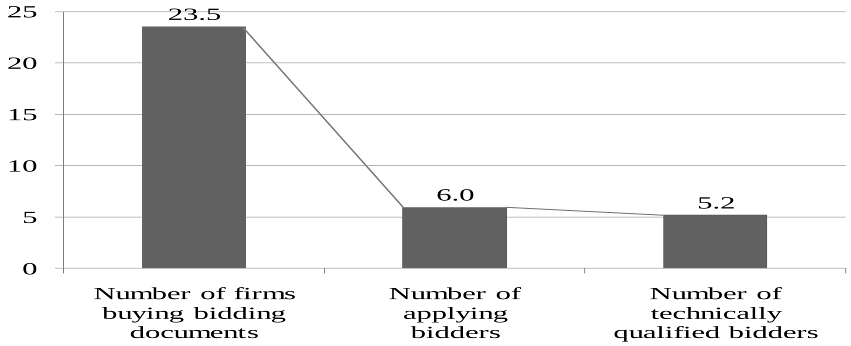


Source: Authors' calculation based on data from the Ministry of Environment, Nepal.

Bidder participation

One of the crucial empirical issues in estimating Equation (1) is that the number of bidders, *num*, is likely to be endogenous. Basic auction theory assumes it fixed. In reality, however, the bidder participation is a dynamic process. Firms may or may not decide to enter the market, even though showing their initial interest in public tenders. In Nepal, potential entrants do exist, if firms that bought the bidding documents are considered as potential contractors. But the vast majority of firms seem to be giving up the opportunity to participate in public tenders and engage in public works. At the initial stage, about 23 firms on average bought the bidding documents; but only 6 firms applied to the formal process. After the technical evaluation, 5 bids were compared for determining the winner (Figure 8).

Figure 8. Change in the number of bidders over the procurement process



Endogenous auction theory suggests that potential contractors may not enter the market because of entry costs. If a fixed positive cost is required for participating in an auction, bidders will enter until their expected profits are driven to the entry cost. At this level no more firms can expect nonnegative profits from new entry (McAfee and McMillan, 1987; Levin and Smith, 1994; Menezes and Monteiro, 2000). To empirically examine why firms decided not to apply for public tenders, the following entry equation is considered:

$$num_t = f(securitybefore_t, X_t, Z_t) \quad (2)$$

Equation (2) can be estimated by a generalized count regression model, i.e., zero-truncated negative binomial model, because the observed number of bidders *num* is a positive integer and typical of count data (e.g., Li and Perrigne, 2003; Li and Zheng, 2006; Ohashi, 2009).

In Equation (2), the bidder participation is assumed to depend on the security situation, contract size, and other project-specific technical characteristics in *X*. Of particular note, increasing security concern may discourage firms from applying for public tenders.

Z is a vector of instrument variables that particularly affect the firms' entry decisions. Following the endogenous auction literature, three instruments are considered. First, the number of firms who bought the bidding documents (denoted by *bdnum*) is included in *Z*. This is a good proxy of the maximum pool of contenders that could participate in each auction. The underlying idea is the same as the use of the number of plan holders or eligible bidders in the existing literature (e.g., Haile, 2001; Paarsch, 1997; De Silva, Dunne, Knkanamge and Kosmopoulou, 2008). Second, the price of bidding documents (denoted by *bdcost*) is used. This is clearly an explicit cost of entry, though not necessarily economically significant in Nepal.[11] Finally, the number of days granted for contractors *to p*repare bids (denoted *b*y *bidpreptime*) is also include*d* in *Z*. The bid preparation is a costly and time consuming task for firms, especially in technically complex infrastructure projects. Thus, granting a longer bid preparation period can reduce the entry costs for prospective contractors, particularly inexperienced firms. In addition, an unreasonably short invitation to bid is one of the yellow flags that may signal corruption or collusion, which will also discourage firms from bidding (Ware *et al.*, 2007).[12]

The paper also estimates a binary probability model to examine the firms' entry strategy in detail. Letting a binary variable, $entry_{it}$, be 1 if

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[11] In our sample, bidding documents cost about NRs300 to NRs3,500 with an average of NRs1,800 or $25.

[12] The World Bank's *Guidelines: Procurement under IBRD Loans and IDA Credits* stipulate "[g]enerally, not less than 6 (six) weeks from the date of the invitation to bid or the date of availability of bidding documents, whichever is later, shall be allowed for ICB. Where large works or complex items of equipment are involved, this period shall generally be not less than 12 (twelve) weeks to enable prospective bidders to conduct investigations before submitting their bids (Clause 2.44, pp. 21)."

bidder *i* participates in auction *t* and zero otherwise, the probability of bidder *i*'s participating in auction *t* is:

$$\Pr(entry_{it}=1)=\Phi(securitybefore_t, dist_{it}, D(ethnicity_{it}), X_t, W_i, Z_t)$$

$$\Pr(entry_{it}=0)=1-\Phi(securitybefore_t, dist_{it}, D(ethnicity_{it}), X_t, W_i, Z_t) \tag{3}$$

In this case, each bidder's decision about whether to apply for a public tender is regressed on explanatory variables. Thus, bidder-specific characteristics, such as *dist* and *ethnicity*, can be incorporated in the model. The existing literature shows that the firm location would likely matter to bidder participation (e.g., Porter and Zona, 1993; Price, 2008). The entry costs may be high for firms located far from a project site, because they may not be familiar with project site conditions or may not be acquainted with local market partners.

Contract performance

To examine why these post-award adjustments happened, the following equation is examined:

$$\begin{aligned} Y_t = {} & \alpha_1 \ln securityduring_t + \alpha_2 \ln rainduring_t + \alpha_3 \ln num_t + \ln \alpha_4 \ln lowball_t \\ & + \alpha_5 \ln dayscontracting_t + X'_t \beta + \varepsilon_t \end{aligned} \tag{4}$$

where *Y* is a measurement of ex post adjustments, for which two variables are used: the rate of cost overruns relative to the original contract amount (denoted by *overrun*) and the number of days for which a project delayed (denoted by *delay*).

The likelihood of ex post adjustments depends on both technical and institutional factors. *X* can capture potential impacts on the technical side. For instance, large-size or technically complex contracts may be more likely to incur cost overruns or project delays, though few geotechnical difficulties are expected in rural road projects. In addition, weather may be another exogenous technical determinant of post-award adjustments. Heavy rain and storms may interrupt civil works, causing delays and cost overruns. *rainduring* is constructed to measure the amount of cumulative precipitation during the project implementation period.

On the institutional side, security is a factor of particular interest in Nepal. Strikes and intimidations may cause delays of rural road projects. This impact is captured by the number of security-related incidents that actually happened during the period of project implementation, denoted by *securityduring*. Note that this is different from *securitybefore*, which is defined by the number of incidents before the projects.

Auction theory suggests several other institutional factors that can provoke ex post contract adjustments. There is a view that post-award adjustments may result from excess competition in the auction. This is a part of a “winner’s curse” phenomenon (e.g., Kagel and Levin, 1986; Klemperer, 1998; Hong and Shum, 2002; Athias and Nunez, 2006). If competition is too intense, bidders are forced to be more aggressive. Consequently, it may turn out that the winner was too optimistic. This will be captured by *num*.

Another relevant view is that post-award amendments could be caused by firms’ opportunistic bidding practices, such as low-balling (underbidding) strategy. The current procurement systems are often not effective to prevent bidders from taking the low-balling strategy. Thus, bidders may manipulate their bids and propose unreasonable offers to win a contract, while anticipating that public contracts could be renegotiated after the contract award (Guasch, 2004; Ware *et al*., 2007). To test this hypothesis, the difference between the winning evaluated bid and the second lowest bid is calculated (*lowbid*).[13] In our data, the low balling ratio—relative to the second lowest bid amount—is mostly less than 10 percent. But in some cases, the difference exceeds 30 percent.[14]

Finally, the government effectiveness needs to be high in order to manage public contracts well and avoid unnecessary ex post adjustments. In Nepal, the government capabilities seem to differ considerably at the local level. To measure this, *dayscontracting* is defined by the number of days required to award a contract after the bid opening. It is hypothesized that less effective procurers (with a greater value of *dayscontracting*) would experience larger cost overruns or project delays.

Quality of projects

To assess the quality of roads rehabilitated or upgraded, the following equation is investigated:

$$Q_t = f(age_t, traffic_t, securityafter_t, rainafter_t, X_t) \quad (5)$$

For the quality of roads *Q*, two measurements are used. One is a subjective indicator, which is a rating to by transport specialists who

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[13] An alternative variable that allows to test the low-balling hypothesis is the difference between the winning bid and the mean bid at that auction. This may have the advantage to see the case where the two lowest bidders would take the low-balling strategy. If this is the case, we cannot test the low-balling hypothesis by our low-balling indicator, *lowbid.* We constructed and tested both variables. The meaning regression results have been generated only when the low-balling is measured by our *lowbid*.

[14] Our *lowbid* is constructed by comparing the winning bids with the second lowest bids that were deemed to be substantially responsive in technical terms. Technically nonresponsive bids are ignored.

drove on the road, i.e., $rate_t$={1, 2, 3, 4}.[15] In this case, the ordered probit model is used to estimate Equation (5), because *rate* is an ordered discrete variable. Another is a more objective indicator, i.e., the average speed at which a normal vehicle actually ran on the rehabilitated or upgraded road (ln*speed*). In this case, the equation can be estimated by the ordinary (log)linear regression.

The quality of roads must of necessity depend on physical factors, such as traffic volume and duration for which a road segment has been used. In addition, roads are deteriorating over time anyway. Thus, *age* is defined by the number of days for which the road has been used since the project was completed. The cumulative traffic volume, *traffic*, is calculated by *age* multiplied by the average daily traffic (ADT). The road condition is also potentially dependent on weather, especially, precipitation. Increased precipitation would cause rapid deterioration on the road surface. Particularly, unpaved or gravel roads are vulnerable to precipitation. Thus, *rainafter* is defined by the cumulative amount of precipitation after the project completion.

The possible effect of security issues on the quality of roads is less direct than these physical effects. Assuming that periodical maintenance is essential to keep the road quality, security instability is problematic, because it may hamper timely road maintenance. Therefore, *securityafter* is defined by the cumulative number of security-related incidents that occurred in each project district.

MAIN ESTIMATION RESULTS AND POLICY IMPLICATIONS

Equilibrium bid function

The equilibrium bid function is first estimated by an ordinary least squares (OLS) technique. As theory predicts, the coefficient of the number of bidders is negative (Table 3). However, this may potentially

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[15] The rating has four grades: (1) very uncomfortable with continuous shakes and frequent slowdown and stops, (2) uncomfortable with frequent shakes, (3) fairly comfortable though occasionally jolting, and (4) very comfortable throughout the entire road segment.

be biased, because the endogeneity of the bidder participation has not been controlled yet.

With the endogeneity taken into account, the competition effect is still found to be significant. According to the two-stage least squares (2SLS) regression, in which the number of bidders is replaced with the predicted value from a zero-truncated negative binomial model, the coefficient of *num* is estimated at -0.285, which is statistically significant. The instrumental variable (IV) regression where the number of bidders is directly instrumented by *Z* (and other exogenous variables) also generates a significant coefficient of -0.338. A policy implication is straightforward: Competition should be intensified to contain the public procurement cost of rural road projects.

Security instability has been found to be a cost factor of rural road development in Nepal. The coefficient of *securitybefore* is significantly positive across all the models; where security concern is high, firms would likely raise their bids, possibly because of expected project delays or necessary security measures to prevent incidents. The estimated coefficient indicates that the public road procurement costs could be saved by more than 20 percent if security incidents were halved. This is significant and avoidable losses to the economy.

Regarding other explanatory variables, engineering cost estimates turned out to be a good proxy of bid prices. The estimated coefficients are all close to one. Contrary to our prior expectation, on the other hand, the firm location does not seem to be an important determinant of bid prices.

[16] Ethnicity does not affect bids, either.

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[16] One empirical possibility is that the potential distance effect may have been captured by a combination of bidder location and project site dummy variables. In fact, if all the dummy variables for bidder and project locations are excluded, the significance of ln*dist* increases.

Table 3. Estimated bid function

	OLS			2SLS with ztnb			IV		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *num*	-0.134	(0.050)	***	-0.285	(0.123)	**	-0.338	(0.179)	*
ln *securitybefore*	0.234	(0.046)	***	0.237	(0.045)	***	0.234	(0.042)	***
ln *dist*	0.045	(0.040)		0.054	(0.039)		0.037	(0.040)	
D(*ethnicity*)	0.222	(0.156)		0.258	(0.161)		0.219	(0.165)	
ln *cost*	0.959	(0.038)	***	1.015	(0.059)	***	0.999	(0.049)	***
ln *length*	0.061	(0.048)		0.067	(0.048)		0.057	(0.050)	
ln *lane*	0.092	(0.225)		0.145	(0.236)		0.102	(0.217)	
ln *thickness*	0.030	(0.028)		0.048	(0.030)		0.037	(0.028)	
ln *gravel*	0.017	(0.012)		0.013	(0.013)		0.019	(0.012)	
ln *bitumen*	-0.028	(0.010)	***	-0.037	(0.012)	***	-0.029	(0.010)	***
ln *earth*	-0.008	(0.013)		0.014	(0.016)		0.015	(0.022)	
ln *brick*	0.014	(0.017)		0.016	(0.017)		0.012	(0.016)	
ln *gabion*	0.006	(0.011)		0.013	(0.012)		0.012	(0.012)	
ln *exavate*	0.003	(0.014)		0.007	(0.015)		0.006	(0.015)	
ln *cement*	0.002	(0.017)		-0.018	(0.023)		-0.014	(0.022)	
D(*postqualify*)	0.162	(0.153)		0.022	(0.176)		0.006	(0.220)	
Constant	-0.910	(0.482)	*	-1.658	(0.692)	**	-1.301	(0.591)	**
Obs.	599			591			591		
R-squared	0.893			0.891			0.889		
F-statistics	875.0			808.1					
Wald chi2							38941		
No. of dummy variables:									
Project districts	18			18			18		
Bidders' home districts	25			25			25		

Note: The dependent variable is the number of bidders, num. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. 2SLS with ztnb = two stage least squares with the zero truncated negative binomial regression as a first stage. For this model, *num* is replaced with the predicted number of bidders from the first stage.

Bidder participation

Both a generalized count regression and a probit model are performed to examine the bidders' entry strategy. As expected, security concern would discourage bidder participation. The probit model has a negative and significant coefficient on *securitybefore*, meaning that a fewer firms would apply for public road works where security-related incidents are likely to happen (Table 4). Hence, security instability has a twofold disadvantage on public procurement. On one hand, firms' concern over security would add to their bid prices, as discussed above. On the other hand, security concern would also restrain competition, which will push up procurement costs further.

According to our estimation results, high entry costs generally deter potential entrants from entering the market. In the negative binomial model, the coefficient of the price of bidding documents is negative and significant. Thus, not surprisingly, lowering the price of bidding documents could increase the number of bidders in public tenders. In addition, granting a longer period for bid preparation also helps to enhance competition. The coefficient of *bidpreptime* is significantly positive in the negative binomial model as well as the first stage regression of the IV estimator.

Distance does matter to the bidder participation. The first stage of the IV regression estimates the coefficient of *dist* at -0.06, which is statistically significant. The probit model is also supportive of this, exhibiting a negative and significant coefficient of -0.19. Therefore, together with our bid estimation results (Table 3), it can be concluded that the firm location does not matter directly to the firm's cost structure but does influence the bidders' participation decisions, which would in turn affect the equilibrium bid strategy through the competition effect.

Work description and contract packaging have been found to influence the bidder participation. There is a collinearity issue among our project specification variables. But the results indicate that firms would prefer earthwork-intensive works; the coefficient of *earth* is all positive. On the other hand, firms would be less interested in undertaking contracts involving cement works; the coefficient of *cement* is all negative. In addition, the negative binomial model has a significantly positive coefficient on engineering cost estimates. Thus, holding everything else constant, small contracts are less attractive to firms. This is possibly because small contracts are not profitable enough to cover the entry costs that firms have to bear regardless of whether they win or lose the contract.

Table 4. Estimation of bidder participation decision

	Zero truncated negative binomial			1st stage of IV			Probit		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
bdnum	-0.002	(0.004)		0.104	(0.058)	*			
bdcost	-0.0003	(0.0001)	***	0.178	(0.121)		0.0002	(0.0001)	
bidpreptime	0.025	(0.010)	***	0.321	(0.092)	***	-0.009	(0.009)	
securitybefore	0.005	(0.008)		-0.022	(0.050)		-0.024	(0.007)	***
ln *dist*				-0.060	(0.027)	**	-0.190	(0.050)	***
D(*ethnicity*)				-0.089	(0.136)		-0.222	(0.207)	
ln *cost*	0.362	(0.112)	***	0.018	(0.078)		-0.102	(0.116)	
ln *length*	0.052	(0.099)		0.029	(0.070)		0.161	(0.075)	**
ln *lane*	-0.051	(0.370)		0.001	(0.158)		0.028	(0.412)	
ln *thickness*	0.072	(0.060)		-0.014	(0.043)		0.100	(0.058)	*
ln *gravel*	-0.010	(0.027)		-0.001	(0.012)		-0.081	(0.034)	**
ln *bitumen*	-0.010	(0.026)		0.014	(0.015)		-0.055	(0.024)	**
ln *earth*	0.124	(0.038)	***	0.105	(0.016)	***	0.054	(0.032)	*
ln *brick*	-0.022	(0.028)		-0.045	(0.014)	***	-0.021	(0.037)	
ln *gabion*	0.054	(0.024)	**	0.031	(0.013)	**	0.038	(0.024)	
ln *excavate*	0.006	(0.023)		0.002	(0.010)		-0.007	(0.016)	
ln *cement*	-0.126	(0.032)	***	-0.079	(0.011)	***	-0.071	(0.028)	**
D(*postqualify*)	-0.752	(0.218)	***	-0.716	(0.161)	***	0.653	(0.245)	***
Constant	-4.501	(1.330)	***	-1.468	(0.763)	*	0.570	(1.661)	
Obs.	118			591			2119		
Wald chi2	1498.88						436.39		

R-squared		0.779	
F-statistics		305.25	
Pseudo R2			0.180
No. of dummy variables:			
Project districts	18	18	17
Bidders' home districts	0	25	28

Note: The dependent variable is the number of bidders, *num*, for the zero truncated negative binomial regression. For the 1st stage of the instrumental variable regression, the first four independent variables are in logarithm. In the probit model, the dependent variable is a binary variable which is set to 1 if a potential contractor participates in competitive bidding, and zero otherwise. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Contract performance

Security has been found to be the most important factor that caused ex post contract amendments—both cost overruns and project delays. In the regressions on cost overruns, the coefficient of *securityduring* is significantly positive at 1.24 (Table 5). In addition, the number of security incidents also has a positive and significant impact on *Delay* (Table 6). Thus, not surprisingly, rural road projects would experience more cost overruns and project relays, if security-related incidents happened during the project implementation.

Heavy rainfall would also cause project delays, but not cost overruns. In the regression on delays, *rainduring* has a positive and significant coefficient of 0.33. This is consistent with our expectation. Rural road projects are relatively inexpensive and technically simple. Thus, heavy rain will interrupt civil works, causing project delays. But the project costs are less susceptible.[17]

Regarding the institutional factors, there is no clear indication showing the winner's curse. The number of bidders has been found to have a negative coefficient, implying that intense competition could help to keep discipline among bidders and restrain them from provoking opportunistic renegotiation. There is some indication supportive of the low-balling strategy, which seems to have ended up with a retard of projects. The coefficient of *lowball* is significantly positive at 0.08-0.1 in the regressions on project delays.[18]

Finally, the coefficient of *dayscontracting* has been found to be positive and significant in both cost overrun and project delay equations. This means that more ex post contract adjustments are likely to happen when it takes more time for a contract to be awarded. Underlying reasons remain open to discussion. It can be because technically complex works would require more time to be evaluated and incline to post-award amendment. It can also be because of the lack of government effectiveness; procuring entities with low implementation capabilities may need to spend more time to award a contract, and at the same time, be less effective to manage public contracts. If this is the case, the risk of alleged corruption and collusion may also have to be concerned. In general, lengthy contract renegotiation is less transparent and more vulnerable to corruption, and ex post contract amendment may also reflect corruptive activities (e.g., Ware *et al.*, 2007).

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[17] One might think that unexpected changes in precipitation may be more relevant to post-award contract adjustments than actual precipitation, because potential contractors may already have anticipated normal precipitation and reflected it to their bids. If this is the case, actual precipitation may not impact on cost overruns or project delays. To consider this possibility, another variable is constructed by subtracting the average monthly precipitation in the one-year period prior to each tender from the actual precipitation per month during the project implementation period. The results were not significant.

[18] Recall that our *lowball* is defined by the difference between the winning bids and the second lowest bids. A positive coefficient means that more delays happen when the winning bid undercuts the second price.

Table 5. OLS estimation of cost overruns

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *securityduring*	1.245	(0.645)	**													2.022	(0.698)	***
ln *rainduring*				-0.316	(0.265)											-1.094	(0.336)	***
ln *num*							-2.046	(0.710)	***							-3.701	(0.975)	***
ln *lowbid*										0.050	(0.097)					0.024	(0.092)	
ln *dayscontracting*													1.460	(0.600)	**	0.617	(0.755)	
ln *cost*	-0.032	(0.821)		0.945	(0.755)		0.990	(0.658)		0.834	(0.758)		0.029	(0.755)		0.846	(0.869)	
ln *length*	-1.821	(0.727)	**	-1.899	(0.687)	***	-1.671	(0.649)	***	-1.629	(0.863)	*	-1.395	(0.702)	**	-1.727	(0.750)	**
ln *lane*	1.072	(3.606)		2.028	(3.540)		1.485	(3.448)		1.705	(3.632)		2.410	(3.477)		0.262	(3.918)	
ln *thickness*	-0.241	(0.493)		-0.372	(0.508)		-0.229	(0.482)		-0.738	(0.522)		-0.170	(0.513)		-0.128	(0.496)	
ln *gravel*	-0.163	(0.220)		-0.038	(0.203)		-0.053	(0.217)		-0.151	(0.219)		-0.089	(0.218)		-0.231	(0.210)	
ln *bitumen*	0.941	(0.242)	***	0.966	(0.271)	***	0.903	(0.249)	***	1.008	(0.265)	***	0.928	(0.269)	***	0.909	(0.246)	***

ln *earth*	0.676	(0.299)	**	0.505	(0.250)	**	0.691	(0.260)	***	0.621	(0.260)	**	0.527	(0.248)	**	0.855	(0.325)	***
ln *brick*	-0.242	(0.396)		0.103	(0.399)		0.008	(0.377)		-0.013	(0.431)		-0.002	(0.391)		-0.343	(0.416)	
ln *gabion*	-0.071	(0.232)		-0.097	(0.231)		0.004	(0.229)		-0.163	(0.238)		-0.108	(0.222)		0.014	(0.234)	
ln *exavate*	-0.199	(0.131)		-0.168	(0.135)		-0.127	(0.128)		-0.141	(0.151)		-0.227	(0.141)	*	-0.191	(0.137)	
ln *cement*	0.224	(0.234)		0.049	(0.240)		0.013	(0.224)		0.052	(0.244)		0.226	(0.252)		0.059	(0.250)	
D(*postqualify*)	3.954	(2.329)	*	4.056	(2.070)	**	3.084	(2.075)		3.911	(2.209)	*	3.037	(2.033)		4.545	(2.577)	*
Constant	-6.759	(9.272)		-13.97	(8.553)	*	-14.92	(7.980)	*	-15.15	(9.170)	*	-7.742	(8.766)		-12.15	(9.071)	
Obs.	152			155			155			142			154			138		
R-squared	0.558			0.540			0.559			0.544			0.556			0.624		
F-statistics	9.68			9.29			9.61			8.54			8.14			10.58		
No. of dummy variables:																		
Project districts	18			18			18			18			18			18		

Note: The dependent variable is the cost overrun rate, *overrun*. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Table 6. OLS estimation of project delays

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *securityduring*	1.131	(0.273)	***													1.133	(0.243)	***
ln *rainduring*				0.326	(0.150)	**										0.043	(0.162)	
ln *num*							-0.509	(0.346)								-0.504	(0.355)	
ln *lowbid*										0.0	(0.0	*				0.1	(0.0	*

										89	39)	*				05	35)	**
ln *dayscontracting*													0.820	(0.252)	***	0.497	(0.369)	
ln *cost*	1.000	(0.299)	***	1.449	(0.297)	***	1.776	(0.280)	***	1.519	(0.305)	***	1.286	(0.317)	***	0.706	(0.325)	**
ln *length*	-0.962	(0.283)	***	-0.851	(0.312)	***	-0.943	(0.340)	***	-1.423	(0.295)	***	-0.759	(0.314)	**	-1.072	(0.283)	***
ln *lane*	0.902	(2.356)		1.500	(2.157)		1.339	(2.044)		1.844	(2.053)		1.599	(2.042)		1.388	(2.416)	
ln *thickness*	-0.326	(0.182)	*	-0.393	(0.202)	*	-0.365	(0.201)	*	-0.329	(0.242)		-0.290	(0.188)		-0.138	(0.193)	
ln *gravel*	-0.024	(0.116)		0.022	(0.116)		0.035	(0.114)		0.063	(0.121)		0.020	(0.125)		-0.072	(0.116)	
ln *bitumen*	-0.113	(0.081)		-0.123	(0.094)		-0.126	(0.098)		-0.067	(0.102)		-0.125	(0.087)		-0.086	(0.086)	
ln *earth*	-0.195	(0.118)	*	-0.262	(0.105)	**	-0.274	(0.100)	***	-0.253	(0.105)	**	-0.316	(0.101)	***	-0.107	(0.128)	
ln *brick*	-0.122	(0.127)		0.042	(0.125)		0.068	(0.124)		0.171	(0.115)		0.030	(0.115)		-0.064	(0.115)	
ln *gabion*	-0.112	(0.084)		-0.135	(0.090)		-0.101	(0.099)		-0.126	(0.095)		-0.125	(0.089)		-0.083	(0.084)	
ln *excavate*	0.051	(0.058)		0.061	(0.058)		0.081	(0.055)		0.061	(0.061)		0.043	(0.059)		0.022	(0.059)	
ln *cement*	-0.207	(0.090)	**	-0.280	(0.096)	***	-0.332	(0.093)	***	-0.279	(0.096)	***	-0.226	(0.099)	**	-0.136	(0.090)	
D(*postqualify*)	0.720	(0.866)		0.474	(0.846)		0.649	(0.782)		0.936	(0.917)		0.464	(0.773)		0.761	(0.973)	
Constant	-12.081	(3.499)	***	-17.00	(3.405)	***	-18.61	(3.396)	***	-16.37	(3.602)	***	-14.69	(3.730)	***	-10.59	(3.559)	***
Obs.	152			155			155			142			154			138		
R-squared	0.607			0.562			0.548			0.613			0.572			0.709		
F-statistics	18.40			12.91			12.16			12.77			12.85			23.39		
No. of dummy																		

variables:						
Project districts	18	18	18	18	18	18

Note: The dependent variable is the number of days of project delays in logarithm, ln *delay*. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Quality of projects delivered

The ordered probit regressions show the fact that roads are degrading due to various physical factors. The quality of post-project roads depends on the duration of use of upgraded roads, traffic volume, precipitation and security issues. The road quality rating is estimated to deteriorate over time; the coefficient of *age* is -0.57. Traffic has also been found to damage road surfaces; the quality ratings decline, as the volume of traffic increases. Precipitation is estimated to have a negative effect on the road quality as well.

Nonetheless, security has been found the most important factor to explain the road quality rating. The number of security incidents after the project completion has a negative and significant coefficient of -0.42. In addition, with all the factors taken into account simultaneously, the security impact stands as a dominant determinant. This remains unchanged, even if the quality is measured by the average speed of the traffic; average speed tends to be low where security is more unstable (Table 8). These findings can be interpreted to mean that periodical road maintenance would be delayed or hampered where security is unstable. It is worth recalling that timely road maintenance is of particular importance in Nepal, because many roads remain to be paved and it rains a lot.

The quality of roads also depends on road specifications. Roads built to a high specification are more likely to be rated high. The coefficients of *lane* and *thickness* are consistently positive and significant across the models. Not surprisingly, the road conditions would be good if the road surface is thicker. Wider roads also normally follow higher standards and thus tend to be in good condition.

Table 7. Ordered probit regression of road quality rating

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
In *age*	-0.567	(0.162)	***												
In *traffic*				-0.328	(0.099)	***							0.200	(0.257)	
In *securityafter*							-0.429	(0.133)	***				-0.679	(0.391)	*
In *rainafter*										-0.557	(0.146)	***	-0.290	(0.291)	
In *cost*	0.035	(0.324)		0.077	(0.340)		0.073	(0.311)		0.053	(0.322)		0.028	(0.332)	
In *length*	-0.151	(0.259)		-0.128	(0.269)		-0.088	(0.260)		-0.154	(0.260)		-0.106	(0.274)	
In *lane*	3.329	(0.915)	***	4.086	(0.966)	***	3.017	(0.907)	***	3.631	(0.920)	***	3.904	(0.987)	***
In *thickness*	0.390	(0.176)	**	0.365	(0.176)	**	0.387	(0.175)	**	0.393	(0.180)	**	0.287	(0.171)	*
In *gravel*	0.071	(0.074)		0.081	(0.083)		0.088	(0.079)		0.065	(0.075)		0.086	(0.087)	
In *bitumen*	-0.055	(0.075)		-0.057	(0.075)		-0.061	(0.075)		-0.054	(0.075)		-0.056	(0.074)	
In *earth*	0.006	(0.076)		0.050	(0.079)		-0.040	(0.080)		0.006	(0.075)		0.024	(0.084)	
In *brick*	0.063	(0.112)		0.088	(0.119)		0.026	(0.131)		0.073	(0.118)		0.069	(0.160)	
In *gabion*	0.141	(0.097)		0.082	(0.093)		0.141	(0.095)		0.131	(0.097)		0.121	(0.096)	
In *excavate*	-0.110	(0.049)	**	-0.144	(0.048)	***	-0.115	(0.049)	**	-0.122	(0.050)	**	-0.144	(0.047)	***
In *cement*	0.010	(0.090)		-0.00	(0.096)		0.015	(0.092)		0.013	(0.093)		-0.03	(0.108)	

				4									9		
D(*postqualify*)	0.396	(0.657)		-0.005	(0.673)		0.152	(0.661)		0.338	(0.655)		-0.151	(0.682)	
Obs.	136			128			133			136			125		
Wald chi2	181.11			185.06			188.48			196.97			201.52		
Pseudo R2	0.482			0.512			0.480			0.485			0.522		
No. of dummy variables:															
Project districts	18			18			18			18			18		

Note: The dependent variable is the quality rating. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. Due to multicollinearity, ln *Age* is omitted from the last column model.

Table 8. OLS estimation of average traffic speed

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *Age*	0.007	(0.042)													
ln *Traffic*				0.044	(0.017)	**							0.207	(0.042)	***
ln *securityafter*							0.0002	(0.037)					-0.271	(0.070)	***
ln *rainafter*										-0.005	(0.032)		-0.044	(0.023)	*
ln *cost*	0.082	(0.057)		0.068	(0.058)		0.081	(0.057)		0.082	(0.057)		0.042	(0.055)	
ln *length*	0.120	(0.038)	***	0.160	(0.039)	***	0.114	(0.037)	***	0.115	(0.037)	***	0.181	(0.032)	***
ln *lane*	0.244	(0.267)		0.286	(0.248)		0.224	(0.270)		0.248	(0.269)		0.333	(0.164)	**
ln *thickness*	0.010	(0.032)		0.053	(0.029)	*	0.008	(0.032)		0.009	(0.031)		0.051	(0.029)	*
ln *gravel*	0.014	(0.015)		0.010	(0.014)		0.015	(0.016)		0.014	(0.015)		0.003	(0.016)	
ln *bitumen*	-0.031	(0.013)	**	-0.037	(0.013)	***	-0.030	(0.013)	**	-0.030	(0.013)	**	-0.032	(0.012)	***

ln *earth*	-0.019	(0.017)		-0.022	(0.017)		-0.019	(0.020)		-0.018	(0.017)		-0.018	(0.017)	
ln *brick*	-0.014	(0.018)		0.004	(0.018)		-0.019	(0.018)		-0.014	(0.017)		0.015	(0.016)	
ln *gabion*	0.001	(0.014)		-0.003	(0.014)		0.002	(0.013)		0.002	(0.013)		0.006	(0.013)	
ln *excavate*	-0.004	(0.010)		-0.008	(0.009)		-0.004	(0.010)		-0.004	(0.010)		-0.008	(0.009)	
ln *cement*	0.015	(0.014)		0.016	(0.014)		0.016	(0.014)		0.015	(0.014)		0.011	(0.014)	
D(*postqualify*)	-0.081	(0.104)		-0.028	(0.109)		-0.100	(0.107)		-0.085	(0.104)		0.004	(0.094)	
Constant	1.754	(0.738)	**	1.128	(0.747)		1.850	(0.699)	***	1.849	(0.734)	**	0.400	(0.812)	
Obs.	148			141			145			148			138		
R-squared	0.478			0.714			0.675			0.678			0.759		
F-statistics	12.86			13.48			13.33			12.97			19.41		
No. of dummy variables:															
Project districts	18			18			18			18			18		

Note: The dependent variable is the average speed in logarithm. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. Due to multicollinearity, ln *Age* is omitted from the last column model.

CONCLUSION

Transport infrastructure is important for economic growth. In particular in rural areas, the lack of access to reliable transport infrastructure remains a significant constraint for people's daily life and local businesses. But available public resources are limited, as usual.

Public procurement is an important instrument to use resources efficiently. Still, how to design an efficient procurement system is a challenge in the infrastructure sector, because infrastructure projects are often technically complex, highly customized and politically sensitive. Competition in competitive bidding is often limited. The bid evaluation process tends to be complex and less transparent. In addition, infrastructure work contracts are far from complete; many projects undergo massive cost overruns and project delays. As the result, it remains unclear whether public infrastructure procurement costs are really minimized. In addition, infrastructure assets will deteriorate quickly if not well maintained.

Security instability, which is an important, continual challenge in Nepal, seems to be complicating efficiency and effectiveness of public procurement. About 200 security-related incidents happen nationwide every month. This paper therefore addresses a series of procurement and contracting issues in rural road projects. New data were collected from 155 rural road upgrading works in Nepal, on which about 820 bids were submitted.

The paper shows that security instability is a priority area to be addressed. At the procurement stage, it is found that firms would add to their bids if security concern is high around project sites. In addition, security concern also discourages firms to apply for public tenders. This could end up with pushing up public procurement costs further. At the project implementation stage, security has also been found to be an important determinant of cost overruns as well as project delays, causing significant adverse effects on the fiscal efficiency and budgetary credibility. It is also found that the quality of roads upgraded tends to be low where more security incidents occur after the projects. This may be because security incidents would hamper timely road maintenance in rural areas. Unpaved roads need to be maintained periodically.

While addressing security issues may be a long-term objective, there are many other short-term measures to improve efficiency in public procurement and enhance effectiveness of rural road projects. The paper shows that competition is essential to enhance procurement efficiency. To increase competition, implicit and explicit entry barriers need to be removed. Bidding documents can be distributed free of charge, for example, by introducing an e-procurement system. Providing a longer period for bid preparation is also a no-cost measure for procurers to encourage bidder participation. Contract packaging is another policy measure to invite more potential bidders. The paper shows that too smaller contracts would not be profitable enough to attract contractors, because of the presence of the entry sunk costs incurred.

To mitigate cost overruns and project delays, careful project and procurement planning is necessary. It is found that precipitation is among the important determinants of project delays. It rains a lot in Nepal. Some flexibility may be necessary for the budget to accommodate this. In addition, the lengthy contracting process is found to lead to cost overruns and project delays. Thus, the procurement capacity needs to be developed more at the local level. The procurement systems also need to be designed to detect the low-balling, because it is likely to result in large project delays.

Finally, the paper shows that rural roads would deteriorate over time anyway. In addition to security instability, traffic and precipitation would accelerate the road deterioration. This recalls us of the importance of carrying out timely routine road maintenance. Without proper maintenance, road assets would be depreciated quickly.

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