Bribes For Faster Delivery

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Abstract:

The paper models the practice of charging bribes for faster delivery of essential services in third world countries. It then examines the possibility of curbing corruption by supervision, and secondly, by introducing competition among delivery agents. It is argued that a supervisory solution eludes the problem because no hard evidence of the reduction of corruption can be established for this type of offenses. It is also shown that using more than one supplier cannot eliminate the practice, and the bribe paying part of the market attains a determinate proportion as the number of suppliers increases. However the bribe rate and average waiting time come down at a diminishing rate with increase in the number of suppliers, and this property can be used to determine an optimal number of suppliers.

JEL Classification: H8, D45

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1. Introduction

This paper analyzes the practice of charging bribes for faster delivery of publicly provided goods and services, a practice widely encountered in the third world. Typically the phenomenon arises where the principal uses a supplier to deliver a good or service at a publicly announced price. Unit delivery takes a finite time, so that customers wait to be served. They dislike waiting, and some are willing to pay to avoid it. The supplier then discretely announces that they can get faster delivery for an extra payment. Those willing to pay are serviced ahead of the existing queue. The supplier's payoff is revenue in excess of the announced price.

The problem would not be worth attention if the bribe sped up delivery for some leaving others unaffected; that would improve efficiency. However placing a subset of buyers ahead increases the average waiting time for others. Examples of this practice are ubiquitous in many developing and transitional economies. They are found in the provision of essential services like connection to power, water, telephone and gas. Services to repair these amenities have similar features: sped up by a bribe, they otherwise remain slow. Other examples are at queues for railway reservation, getting appointments with public authorities, getting a date for a court hearing, waiting to get a passport issued or even in queues for various statutory registrations.

Customer queues originate from two different reasons. One that has been widely studied reflects the excess demand for the good or service at the announced price. Our paper focuses on a different reason. Even when there is no excess demand for the product, queues appear as a result of the time taken for delivery. To put it differently, delivery as a distinct service may be in short supply compared to the flow demand for the product in any given period. These queues and the resulting bribes are worth analysis for at least two reasons. The first is that this problem, often seen as petty corruption, is widespread, and hence it is useful to understand the structure of these markets. The second reason is that bribes in a supply queue are in a class apart from problems analyzed in the enforcement literature. That literature analyzes situations where a *fall* in the level of the activity that reduces a principal's pay off is verifiable. For example in the case of evasion of income or commodity tax, a fall in evasion is evidenced by increase of tax revenue. In cases of work shirking, increase of labor productivity is an indicator of the reduction of work shirking. By contrast, in a supply queue, a fall of corruption can not be verified with an indicator or evidence. If the principal hires a supervisor and the latter reports a fall in the level of corruption, the report has to be accepted without evidence. As a consequence, supply queue corruption may not be eliminated unless supervisors are honest. But the problem is more prevalent in countries where collusion between agents and supervisors is also widespread. Thus this so-called petty corruption presents a tough problem for third world countries.

In this paper we first develop a model of markets with supply queue bribes. It is shown that in equilibrium the supplier partitions the market at a determinate point on the willingness-to-pay scale of buyers, places willing buyers ahead of the existing queue and serves the rest of the market residually. The partition point, the bribe rate and the average waiting time for residual buyers are shown to be independent of the price of the product, so that a deterrent pricing policy is unavailable. We then examine two commonly encountered suggestions for these markets: to employ supervisors and to introduce competition. Regarding supervision, it is noted that the usual procedure of setting expected penalty costs equal to potential bribe earnings is likely to be undermined by collusion. We then argue that no acceptable evidence or indicator can generally establish a fall in corruption in these market situations, and this makes it impossible to design a contract ensuring bribe-free equilibrium. We then examine the effects of introducing competition. It is shown that competition does not introduce any strategic difference in the behavior of suppliers; so that bribe taking persists. However there is a scale effect: the bribe rate and the average waiting time for residual buyers fall as the number of suppliers increases. Two results are worth mentioning here. The first is that even if the number of suppliers were to increase indefinitely, the bribe paying part of the market would not fall below a determinate proportion. This highlights the stubborn nature of the problem. The second is that due to the scale effect the average waiting time of residual buyers falls with the introduction of more supply agents. An optimal number of suppliers can be established by balancing the additional cost of hiring suppliers with the gains in average waiting time for residual buyers.

The paper is structured as follows. In section 2 we model the structure of a market with supply queue corruption, and show that there is no solution to bribe taking based on appropriate pricing of the product, nor does enforcing a minimum number of sales per period help. In section 3, we explore the effect of employing a supervisor. It is shown that if the supervisor is honest, a mechanism is easily designed to eliminate supply line bribes. But if supervisors are potentially corrupt, bribe taking can be eliminated only in one-shot encounters between the supplier and the supervisor. Preventing collusion in repeated game situations, when possible, is costly. In section 4, we analyze the effect of introducing more agents rather than a supervisor. A model with two supervisors is first developed and then generalized to produce a number of results. We conclude in section 5 by putting the theoretical results in the perspective of the social and political environment in which supply queue corruption is commonly encountered.

2. A Model of Bribes for Faster Delivery

Assumptions:

1. Consumers are arranged in the ascending order of income in the continuous and closed interval (m, n), $m, n \in \Re$; $m, n > 0$. The distribution of consumers over income is uniform with density 1.

2. Consumers' dislike for waiting is modeled by assuming that besides from the product itself, they derive utility from a perceived quality q, negatively related to the average waiting time. If d is the average waiting time, then the perceived quality is $q = Q - d$, where Q is the quality corresponding to instant delivery. All buyers facing the same average waiting time perceive the same quality.

3. A consumer with income y, gets a surplus, $S = y.q - p$, where p is the price and q the quality. A consumer buys the product only if $S \geq 0$. If more than one quality are available, one with the highest surplus is purchased. Indifference leads to purchasing the higher quality. A consumer buys only one unit of the product, if at all.

4. Each unit takes T units of time for delivery. Total waiting time for all buyers is then

$$\int_m^n T(y-m)dy = \frac{T(n-m)^2}{2}, \text{ and average waiting time } d = \frac{T(n-m)}{2}.$$

Suppose the supplier sets a cut off point y, such that $m < y < n$, and delivers first to buyers in the closed interval $[y, n]$. Then total and average waiting time for $[y, n]$ are $\frac{T(n-y)^2}{2}$ and $\frac{T(n-y)}{2}$ respective ly.

Buyers in $[m, y)$ have to wait till those in [y, n] are served. Therefore their to tal waiting time is

$$\int_m^y \left(\frac{T(n-y)^2}{2} + T(\xi - m) \right) d\xi = \frac{T(n-y)^2}{2}(y-m) + \frac{T(y-m)^2}{2}.$$

Their average waiting time is $\frac{T(n-y)^2}{2} + \frac{T(y-m)}{2}$.

We will choose the unit T such that $T/2 = 1$.

Then the average waiting time for $[y,n] = (n-y)$, and that for $[m,y) = (n\text{-}y)^2 + (y-m)$.

Consider a supplier who has been employed at a fixed wage to deliver the product at price p, and remit the sales revenue to the principal. Suppose the supplier separates out [y, n], $m<y<n$, for priority delivery at a bribe. The bribe rate B must be such that consumers with income < y will choose not to pay it, while others will pay the bribe to buy priority. The consumer at the margin is indifferent between the two qualities. The indifference of the marginal consumer is given by:

$$y[Q-(n-y)]-p-B=y[Q-(n-y)^2-(y-m)]-p, \text{ giving}$$

$$B=y[(n-y)^2+2y-n-m] \qquad (1)$$

The supplier's objective is to maximise sales revenue net of what has to be passed on to the principlal. Denote this by r. Then $r=(n-y)y[(n-y)^2+2y-n-m]$ (2) For simplifying the presentation we now convert [m,n] into a normalized range [0,1]. On this new scale (2) can be rewritten by substituting n =1, m=0 and replacing y by a new variable $Y = (y-m)/(n-m)$. Revenue on the new scale is given by

$R = (1-Y)Y[(1-Y)^2 +2Y-1] = (1-Y)Y^3$, (3)

while bribe rate b is $Y[(1-Y)^2 +2Y-1] = Y^3$. (4)

This revenue function is maximized at $Y^*=3/4$, implying that the supplier will take a bribe from the top 25 per cent of buyers on the income scale, and serve the rest of the market residually. Equilibrium bribe rate, given by (4) is 0.4219 in normalized income units. As the supplier increases the cut off Y for taking bribes, the bribe rate increases [equation (4)] but the number of buyers from whom bribe is taken falls. These opposing tendencies produce the interior maximum.

Average wait time for residual buyers in equilibrium is given by $d_n = (1-Y^*)^2 +Y^*$, while a group $[0,Y^*)$ should have average waiting time Y^* in a bribe-free situation. The expression $(d_n/Y^*) -1 = C$, can be used as a measure of the time cost of corruption imposed on each person in the group $[0,Y^*]$. For $Y^*=0.75$, C works out as 0.0833 on the normalized scale.

Since in (3) R is independent of p, setting a different price does not influence the supplier's behavior. Secondly the common suggestion that the supplier be forced to sell a specified number of units per period does not achieve anything. It is easy to check that the average waiting time for the market as a whole does not change under bribes. Bribe taking only alters the average waiting time for the two parts of the market. Bribe payers get served before others, and as a group enjoy a smaller average waiting period. Others wait out through this whole period and their average waiting period as a group increases. Since only the average waiting time for the market is observable through sales flow, but that for its separate parts are not, potential monitoring is rendered difficult. For the same reason, enforcing a maximum permissible delay for individual buyers also does not achieve anything. The waiting time for the buyer last serviced is the same whether bribes are taken or not. We summarize these observations in the following proposition.

Proposition 1: (i) The supplier sets a determinate separation point on the willingness-to-pay scale, and charges bribes from those willing to pay.

(ii) The equilibrium can not be altered by a price policy.

(iii) Insisting on a specified number of sales per period or a maximum permissible waiting time for individual buyers does not alter the equilibrium.

The next two sections explore the possible effects of supervision and competition on the equilibrium characterized in this section.

3. Supervision and the nature of evidence

The normal supervisory solution of setting a fine for the supplier with expected value no less than his gains from queue manipulation generally fails because of collusion between the supervisor and the supplier. The standard method of weaning away the supervisor from collusion is to pay him a reward for reporting, large enough to ensure that the supplier can not pay him this amount and yet retain some gains. This method too is likely to fail in repeated encounters between the supervisor and the supplier as the following argument shows.

We first construct a one-off game between the supervisor and the supplier in an optimal contract designed by the principal. The supervisor is contracted to provide a report $\{\rho\}$ on the level of corruption with evidence, where ρ can take two values, Y^* or 0. If the evidence is verified to be correct, the supplier is fined an amount $f\rho$, while the supervisor gets a reward $P\rho$, $P>f$. The value of f is set such that $\pi f\rho \geq R(\rho) = R(Y^*)$, π being the probability that the supervisor gets to learn the correct state of the market. All parameters are common knowledge.

If the supervisor finds out the true value of $Y^*(>0)$, a bribe negotiation sets in between the supplier and the supervisor. In this negotiation, the reservation level payoff for the supervisor is $P\rho$, while that of the supplier is $f\rho$. However since $P > f$, there is no bribe rate $\beta>0$ such that $(f-\beta)\rho$ and $(\beta-P)\rho$ are both positive, implying that the bargaining set is empty. Hence no bargain takes place, and the supplier has to pay the fine. But $\pi f\rho \geq R(\rho) = R(Y^*)$, so the supplier will not take any bribes at all.

We now show that this contract does not sustain bribe-free equilibria over repeated encounters. Suppose the above bribe free equilibrium is enforced in every play in a repeated game. Then there is no bribe, but nor is there any reward for the supervisor. Intuitively, it appears that the supervisor would be better off accepting a feasible bribe from the supplier and ignoring the reward. More formally, let δ denote the common time discount rate for the supplier and the supervisor. Note that if the supervisor reports the defaulting supplier in the first period, then his earning stream is ($P\rho$, 0, 0, 0, ...) with present value $P\rho$. On the other hand if he takes a bribe β, $\beta < P$, from the supplier each period, the earning stream is ($\beta\rho$, $\beta\rho$, $\beta\rho$, $\beta\rho$, ...) with present value $\beta\rho/(1-\delta)$. For any given P, there exist values of β such that $P > \beta > P(1-\delta)$.

Now consider the following game repeated indefinitely. The supplier first moves with two possible actions: 'take bribe' and 'do not take'. Then the supervisor moves in. If the supplier has played 'do not take' then the supervisor has only one strategy, 'report truthfully'. Otherwise the supervisor plays either 'collude' or 'report truthfully'. The strategy 'collude' denotes accepting some bribe rate $\beta < P$ from the supplier, and reporting 0. Now consider the following strategy profiles:

supplier: 'take bribe' in the first play of the game. Subsequently play 'take bribe' if the supervisor played 'collude' in the last play; 'do not take' otherwise.

supervisor: 'collude' if the agent has taken bribe, 'report truthfully' otherwise.

For all β such that $f > \beta > P(1-\delta)$, this strategy profile is a Nash equilibrium for the repeated game. The pair 'never take bribe' for the agent and 'always report' for the supervisor constitutes another Nash equilibrium. But the supervisor's profile in this latter equilibrium is dominated by his strategy in the earlier one. Assuming that the supplier knows it, this profile can be deleted, and the only equilibrium is the profile described above.

Given these observations there are two theoretically possible deterrent mechanisms. The first is to ensure that no β may exist such that $f > \beta > P(1-\delta)$, by setting $P \geq f/(1-\delta)$. If the reward is set at such a high level, the equilibrium of the game is 'never take bribe', 'always report'. Bribes are not taken and the supervisor, too, never gets a reward. However, in this case, given the environment in which our problem is set, it is likely that the supervisor would try to alter the game by pre-committing to collude.

The second possibility is to employ supervisors for a sufficiently small number of periods so that the single-period reward for reporting, $P\rho$, exceeds the present value of the stream of feasible bribes significantly. In this case, too, the supervisor can pre-commit to collude, but because of the large payoff from defection, it is more difficult to make the pre-commitment appear credible. Note however that if the cost of hiring and training a supervisor is large, this solution will be costly for the principal.

The difficulty of designing a deterring fine-reward scheme highlights a difficult aspect of supply queue corruption. In a potentially collusive situation, the principal needs to base incentives on the positive contribution of the collusive group (Tirole, 1992). That requires the principal to have a way of assessing this contribution independently of the supervisor. For example, in the case of auditor-taxpayer collusion, the contribution can be assessed by the increase in tax revenue. In the case of work avoidance, it is assessed by increase in production. In these cases the reward schemes are based on those independently verifiable quantities. The supply queue problem eludes this solution because the principal has no way of assessing the relevant contribution independently of the supervisor. The contribution that the principal is looking for is a *reduction* in the practice of bribes. But while the existence of bribes can be established by 'hard evidence' (Tirole, 1986), its absence or reduction can not. The principal has to rely on the word of the supervisor as evidence of the absence or waning of bribe taking.

To appreciate the problem reconsider setting $P > f$. We noted that it does not work because in equilibrium the supervisor gets no reward and hence develops an incentive to encourage bribe taking in repeated games. This suggests that a sustainable bribe-free equilibrium would need a contract that rewards the supervisor according to the degree of absence of corruption rather than corruption reported. But a contract of this kind can not be effectively used because the principal has no way of assessing the absence of corruption independently of the supervisor’s report. For example, suppose the contract makes the reward an increasing function of the degree to which bribe taking is reduced. This would ensure that rewards continue if the report is $\{0\}$. But in that case the supervisor's best strategy would be to allow the agent to take bribes against a side payment and also collect rewards by reporting $\{0\}$.

4. Introducing Competition

This section explores the effects of introducing competition into the market. We first develop a model with two suppliers and then generalize it to many.

Assume that two suppliers 1 and 2 are hired, and each is to sell to one half of the market and produce that many sales receipts. Suppose both suppliers try to sell with bribes to a part of the market and set off two cut-off points Y_1 and Y_2 respectively.

First suppose $Y_1 \neq Y_2$. Without any loss of generality, let $Y_2 > Y_1$. This implies that

1 sells at a bribe to $[Y_1, Y_2)$ and sells $1/2 – (Y_2-Y_1)$ units without bribes.

2 sells at a bribe to $[Y_2,1]$ and sells $1/2 – (1-Y_2)$ units without bribes.

Average waiting time offered by the two suppliers for the non-bribe segment are:

$$\text{For 1, } (Y_2 - Y_1)^2 + (1/2 - Y_2 + Y_1)$$
$$\text{For 2, } (1-Y_2)^2 + (Y_2 - 1/2)$$

In equilibrium the average waiting time offered to residual buyers must be equal for the two suppliers. If they are not, some consumers will keep shifting from $[0,Y_1)$ to $[Y_1, Y_2)$ thus altering both Y_1 and Y_2. Therefore in equilibrium

$$(Y_2 - Y_1)^2 + (1/2 - Y_2 + Y_1) = (1-Y_2)^2 + (Y_2 - 1/2), \text{ implying}$$
$$(1 - Y_2) = (Y_2 - Y_1) \qquad (5)$$

The two sides of equation (5) represent the share of the bribe paying buyers as also the average waiting time offered to them by the two suppliers. In equilibrium they are equal.

Given this equality, let d_b and d_n denote the common delivery time offered by the two suppliers for bribe paying and non-bribe parts of the market, and let b_1 and b_2 be their bribe rates. For the buyer at Y_2 the following holds:

$Y_2(Q-d_b)-p-b_1 = Y_2(Q-d_b)-p- b_2$, so that $b_1=b_2$.

Therefore the suppliers' revenues given by $b_1(Y_2-Y_1)$ and $b_2(1-Y_2)$ are also equal.

The equilibrium therefore implies that buyers in $[Y_1, 1]$ are equally shared by the two suppliers, serviced with identical average waiting and charged equal bribes.

Clearly this outcome is equivalent to setting $Y_1=Y_2=Y$, with each supplier selling at random to half the buyers in $[Y, 1]$ with bribes and to half the buyers in $[0,Y)$ without bribes.

Revenue maximizing equilibrium for both suppliers is given by the choice of Y_1 (or Y_2) that maximizes either $b_1(Y_2-Y_1)$ [or $b_2(1-Y_2)$]. Write the revenue function for 1 as $Y_1(d_n-d_b)(Y_2-Y_1) = Y_1[(Y_2-Y_1)^2+Y_1/2 –(Y_2-Y_1)](Y_2-Y_1)$. In view of (5), this simplifies to

$R=(1/8)Y_1(1-Y_1)(Y_1^2+ 2Y_1-1)$, with maximum at $Y_1= 0.7726$. The equilibrium bribe rate = $Y_1(d_n - d_b)=(1/4)Y_1(Y_1^2+2Y_1-1)$ equals 0.2205.

Compared to the one supplier case, the bribe rate is seen to fall significantly. But the proportion of the market that pays bribe is not significantly affected. The fall in the bribe rate, nearly a half, is pronounced because with two suppliers the average delay is halved in the bribe part and reduced by nearly half in the non-bribe part of the market. Since the bribe rate depends on the difference between the qualities, it falls significantly. This is entirely a scale effect resulting from introducing more resources. But competition does not introduce any strategic element to undermine bribe taking as such.

The argument can be repeated with three suppliers to show that in equilibrium they will take bribes and equally share the bribe-paying segment. If $y_1<y_2<y_3$ are the cutoff points set by the three suppliers, then the requirement that in equilibrium the waiting time offered by each supplier to residual buyers must be equal, leads to $1-y_3 = y_3-y_2 = y_2-y_1$. This in turn would imply that the bribe rates and revenues of three suppliers are equal. Thus y_1 separates bribe payers from residual buyers and will be set so as to maximize the identical revenue of the three suppliers.

In general suppose there are v suppliers. Let Y_v denote the separation point between bribe payers and residual buyers, so that each supplier sells with bribes to $(1-Y_v)/v$ buyers, and without bribes to Y_v/v buyers. The average waiting times are $[(1- Y_v)/v]^2 +Y_v/v$ and $(1-Y_v)/v$ for the non-bribe and bribe parts of the market. The revenue of individual suppliers is given by the sequence on v

$R_v = (1/v)Y_v(1-Y_v)[\{(1- Y_v)/v\}^2 +Y_v/v- (1-Y_v)/v]$. (6)

The sequence of first order conditions for maximum can be written as

$6Y_v^2 -6Y_v +1 = (1/v)(1-6Y_v+9Y_v^2-4Y_v^3)$, (7)

while the second order conditions are

$(2Y_v-1) > (-2Y_v^2+3Y_v-1)/v$. (8)

As $v\rightarrow\infty$, (7) approaches the limiting equation $6Y_v^2 -6Y_v +1 = 0$, which solves as $Y_v^* = 0.7886$, where (8) is satisfied.

Thus bribes can not be eliminated by competition and at least 21per cent of the market remain under its influence. We may summarize these observations in the following proposition:

Proposition 2: With increase in the number of suppliers bribes do not disappear and the share of the market under bribes asymptotically approaches a definite limit. But the bribe rate falls rapidly.

In view of proposition 2 that bribes are not eliminated by competition, arguably an alternative objective of the principal could be to reduce the average waiting time for residual buyers. Clearly as v increases, the average waiting time for residual buyers $[(1-Y^*_v)^2]/v^2 + Y_v^*/v$ falls, and goes to zero in the limit. However with increase in v the principal introduces and pays for more delivery-related resources as wages. Therefore it is useful to get a measure of how waiting time improves in relation to additional resources spent.

If there were no bribes, the residual group of buyers would enjoy an average waiting time of Y^*_v/v with v suppliers in the market. Let $d_{n,v}$ denote their average waiting time when there is a bribe-taking equilibrium. The sequence $[C_v] = [d_{n,v}/(Y^*/v) -1] = [(1-Y^{*2})/vY^*]$ provides an indication of how waiting time for residual buyers improves as more resources are spent. Table I shows the values of Y_v^* and C_v agaist v.

Table I: Values of Y^* and C_v against v

ν	Y^*_ν	C_ν
1	0.75	0.0833
2	0.7726	0.0335
3	0.7785	0.0210
4	0.7812	0.0153
5	0.7828	0.0120
6	0.7838	0.0099
...	...	...
$\to\infty$	$\to$0.7887	$\to$0.0000

Proposition 3: In relation to the potentially achievable minimum, the average waiting time for residual buyers improves rapidly with the introduction of the first few competitors. Marginal gains fall as more competitors are introduced.

The optimal number of suppliers can be established if the principal has a valuation function to convert residual buyers' waiting time into monetary costs. Let w be the wage per period per supplier, and α a measure of cost per unit of average waiting time for residual buyers. Then the principal's objective would be to minimize ($\nu w + \alpha . d_{n\nu}$). Note that Y_ν^* increases with ν and the function $[(1-Y)^2]/\nu^2 + Y/\nu$ falls with ν. Therefore $d_{n\nu} < d_{n,\nu\text{-}1}$ for all ν. Assume that $w < \alpha(d_{n1}-d_{n2})$, ie the gain in going from one supplier to two exceeds the extra wage cost. Then the procedure for locating the optimal ν is to increase the number of suppliers from ν-1 to ν until the inequality $w < \alpha(d_{n,\nu-1}-d_{n,\nu})$ ceases to hold.

5. Concluding Remarks

Preceding sections highlight the difficulty of controlling supply line bribes in openly corrupt environments. If control is attempted through supervision, the solution most likely to work is frequent turnover of supervisors. This would presumably require significant resource in hiring and training. However, even this solution is subverted if the supervisor can pre-commit to accepting a bribe from the agent. The possibility of pre-committing is made difficult by shortening the tenure of the supervisor but it can not be ruled out. The second type of solution explored in the paper is through introducing multiple agents. Though in this case the proportion of consumers affected by bribes may not come down significantly, the fall in the average wait of residual buyers and that of the bribe rate can be counted as gains.

These theoretical solutions however are often unworkable for factors not modeled in our paper. Supply queue corruption is generally prevalent in public bodies, where the authority to employ a supervisor or more agents is situated outside the jurisdiction of the principal at the local level. Therefore a local principal, when she wants to restrain corruption, finds herself wanting in resource and/or jurisdiction. In opposite cases when the higher authorities get interested, the principal at the local level may in fact try to protect corrupt practices. In this situation, a bribe chain operates from the agent to the local principal via the supervisor, if employed. There are also situations where a third party protects corruption in the supply of several essential services in a particular locality. The third party involved is often the local boss or muscleman, who gets a share of the bribes. In other instances, they are local politicians who use their control of the corrupt process to selectively favor clients in 'getting things done'. Local bosses or politicians can thwart effective supervision by arranging and underwriting the pre-commitment of supervisors that we referred to in section 3. In other instances, local politicians with a reach at higher levels of the government can simply stop a reform attempt at inception.

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