Effect of corruption on educational quantity and quality : theory and evidence

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Abstract

Human capital development, through education and skill development, is instrumental for economic growth. And education and skills development require learning efforts. In the presence of corruption however, applicants have little incentive to learn as they can pass an exam or obtain a qualification by relying on bribery instead. In this paper, we present a simple model with corrupt and honest examiners, as well as applicants with heterogeneous innate ability. A key assumption is that effort and bribe are explicitly modelled as strategic substitutes. Our results show that "strong" candidates rely only upon effort; "medium" candidates choose positive levels of both bribe and effort, while "weak" candidates rely only on bribery. We also find that corruption may decrease education quality by lowering aggregate effort level, while increasing education quantity by increasing the aggregate chances of obtaining a degree. We explore these implications empirically and find support for the key predictions of the model.

Keywords

Bribery, Effort, Education

JEL Codes

D73, I21, O15

1. Introduction

Whether corruption has positive or negative effects on welfare has been a major theoretical debate in the corruption literature. The positive or "grease-in-the-wheel" view suggested that corruption may help overcome systemic governmental inefficiencies and distortions, through simple transfer from firms or individuals to corrupt officials (Leff, 1964; Huntington, 1968; Leys, 1970; or Lui, 1985). In contrast, the "sand-in-the-wheel" strand argued that, given officials' degree of discretionary power, corruption can lead to the creation of counterproductive regulations to extract more bribes, thereby reducing efficiency and welfare (Banerjee, 1997; Ades and Di Tella, 1999; Guriev, 2004).[1]

Available evidence tends to support the "sand-in-the-wheel" view, and corruption is now widely acknowledged as a major obstacle to economic and social development. Indeed, corruption has been found to negatively affect growth (Mauro, 1995, 1997; Kaufmann and Kraay, 2002; Méon and Sekkat, 2005; Swaleheen, 2011); deny government tax revenues (Friedman, 2000); and cause misallocations of public expenditures (Mauro, 1997; Tanzi and Davoodi, 1997; Mironov and Zhuravskaya, 2012), lowering in particular the quantity and quality of health care and educational services (Gupta et al., 2000). Corruption has also been found to discourage domestic investments (Gyimah-Brempong, 2002) as well as foreign investments (Wei, 2000; Smarzynska and Wei, 2000; Castro and Nunes, 2013).

In the basic bribery situation, an agent exploits his discretionary power for private gain. For instance, in exchange for a bribe, an official can lower tax burden or allocate a license to an undeserving firm (e.g., Amir and Burr, 2015). In the latter case, corruption substitutes itself for or undermine qualification (Drugov, 2010) or a capacitating activity, such as learning and skill building. This is particularly so in the education sector, our focus, where effort and learning are required to build human capital, pass an exam, or obtain a degree; and student time and engagement may be considered the single most important input in the educational process (Bishop, 1996). But clearly, corruption may substitute itself for learning effort, and anecdotal evidence abounds. For instance, in 2014, an audit of the 2011 entrance examination at the Ecole Normale Supérieure in Cote d'Ivoire revealed that 23 candidates who never sat the exam were

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[1] For instance, to attract bribes, the official could reduce the number of licences to allocate, be overzealous in his tax collection effort, or delay unnecessarily the production of an official document.

admitted. An applicant was ranked 3rd while actual ranking was 724th; another one was ranked 6th while actual ranking was 185th. [2]

Corruption in the education sector may have serious economic implications. [3] Education, as part of human capital, has been shown to have a positive effect on growth (Hanushek and Kimko, 2000; Barro, 2001). Yet, corruption can weaken incentives to work hard and acquire skills, thereby negatively impacting growth. Corruption in education can also affect the labour markets if firms only observe educational attainment but not the level of skills acquired (Costrell, 1994; Betts, 1998). In this case, the expected level of productivity conditional on graduating may be lower in the presence of corruption, leading to a lower level of wage (see e.g., Heyneman, Anderson, and Nuraliyeva, 2008).

A small literature explores specifically the link between education and corruption. Ehrlich and Lui (1999) showed that corruption affects economic growth by diverting resources from human capital formation towards non-productive rent-seeking activities (political capital). Eicher et al. (2009) analyzed the interplay between education, corruption (embezzlement of public funds) and growth. They showed that education increases the rents obtained by a corrupt politician, but also the probability of being identified as corrupt and not being reelected. Corruption in turn affects investment in education by lowering income level. In contrast to these earlier studies, this paper examines how corruption may undermine the learning process at the root, by altering individuals' incentives to invest in education.

Our model is as follows. To obtain a qualification or pass an exam, valued at V, heterogeneous risk-neutral applicants have to pass a test, optimally choosing between learning effort and bribery to maximize their utility. [4] Applicants' heterogeneity is modelled as a difference in innate ability, denoted β. There are two types of officials: honest or corrupt. The types are determined by nature. For simplicity, honest officials take only learning effort (effort hereafter) into account in measuring the candidate's performance, while corrupt officials care only about the bribe size. Both effort and bribery positively contribute to the candidate's probability of success, but are costly. A key assumption in our model is that effort and bribe are explicitly modelled as strategic substitutes; and there is no detection probability or sanction.

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[2] See http://www.civox.net/Ecole-Nationale-de-l-Administration-Toute-la-verite-sur-les-fraudes-a-l-ENA_a5867.html

[3] For reviews of corruption in academe, see Heyneman (2004) and Rumyantseva (2005).

[4] In our model, bribery may be interpreted as any kind of effort not directed at learning and with the objective to obtain some favour or influence. So our definition of bribery goes beyond monetary payments (see Clark and Riis 2000).

Our results show behavioural heterogeneity regarding candidates' optimal choices of effort and bribe (see Fender, 1999). The "strong" candidates rely only on effort; "medium" candidates choose positive levels of both bribe and effort, while "weak" candidates rely only on bribery. Such behavioural differences result in inefficiencies, as the best candidates would fail if they encounter a corrupt official; while weak candidates may still succeed through bribery. Such a result is closest to Ahlin and Bose (2007) who, in a dynamic setting, showed that in the presence of honest officials and the opportunity to re-apply for a permit, efficient applicants have a lower willingness to pay a bribe and prefer to wait until the next period while inefficient applicants pay the bribe in the first period. As a result, the inefficient type is serviced ahead of the efficient one, which may even never be serviced.

By aggregating heterogeneous individual decisions into "economy-wide" effort level or expected rate of success, we provide a simple channel through which micro-level corruption decisions may translate into macro-economic effects, potentially impeding economic and social development.[5] Specifically, effort level or expected rate of success could be interpreted as education quality and education quantity respectively. Our results suggest that corruption may decrease education quality, as a higher proportion of corrupt officials lowers aggregate effort level and increases the proportion of candidates choosing to exert no effort at all. On the other hand, corruption may increase education quantity by increasing the chances of obtaining a degree, even without effort.

Although we focus on the education sector, our analysis has a more general applicability as it extends to most situations where corruption substitutes itself for learning and skill building to attain the desired goal. For instance, before obtaining a driver license, it is necessary to pass both a knowledge and a road test. If corruption may be used instead of effort to obtain a driver license (e.g., Bertrand et al., 2006), more unsafe drivers may be put on the road, which may translate into a higher number of road accidents or deaths. Likewise, firms are typically required to invest into satisfying some requirements before being eligible for certain licenses. In the presence of corruption, firms can buy these licenses rather than investing, possibly imposing negative externalities on society.

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[5] One characteristic of the corruption literature is that most theoretical studies of corruption are micro-models, while empirical studies focus on cross-country analyses, leaving a gap between these two approaches to study corruption.

2. The Benchmark Case

We start by presenting a model without corruption before turning to the case with corruption. Our model builds on De Paola and Scoppa (2007). In this model, applicants are risk neutral with utility function:

$$U(e, \beta) = Pr(S = 1) V - c(e) = \beta eV - \frac{1}{2} e^2$$

This utility function is derived as follows. To obtain a qualification or pass an exam, valued at $V \in [0,1]$, heterogeneous risk-neutral applicants have to pass a test, by choosing a learning effort level e; which also denotes the skill level acquired in the learning process. Applicants are characterized by their innate ability β, uniformly distributed on [0, 1]. In this section, we assume that the examiners are all honest, meaning that only e is taken into account in performance evaluation. A candidate's performance, denoted s, therefore depends only on effort e and innate ability β such that:

$$s = \beta e.$$

The final performance is given by $s - \varepsilon$, indicating that performance is measured with error ε, uniformly distributed on the interval [0, 1]. To pass an exam, performance must be higher or equal to a given threshold, here zero ($s - \varepsilon \geq 0$). We define S a random variable which is equal to 1 if an applicant is successful in passing an exam; and 0 otherwise:

$$\begin{cases} S = 1 \ \ if \ s - \varepsilon \geq 0 \\ S = 0 \ \ \ otherwise \end{cases}$$

An applicant therefore passes his/her exam with probability:

$$Pr(S = 1) = Pr(s - \varepsilon \geq 0) = P(s \geq \varepsilon) = \int_0^s d\varepsilon = \beta e \, .$$

The partial derivative relative to effort is: $\frac{\partial Pr(S=1)}{\partial e} = \beta \geq 0$, indicating that the probability of success is increasing in effort level. However, it is worth noting that effort exerted by a candidate increases chances of success but does not guarantee it. Likewise, the partial derivative relative to innate ability β is: $\frac{\partial Pr(S=1)}{\partial \beta} = e \geq 0$, suggesting that the probability of success increases with ability.

The cost function of effort is given by $c(e) = \frac{1}{2}e^2$. This function is increasing and convex since $c'(e) = e \geq 0$ and $c''(e) = 1$.

The optimal value of effort is given by $\frac{\partial U(e,\beta)}{\partial e} = 0 \implies e^* = \beta V$.

Optimal effort is monotonically increasing in applicants' innate ability β and in the value of V. All types of applicants exert a positive amount of effort except the lowest type whose optimal effort level is 0. The aggregate effort is given by:

$$E(e^*) = \int_0^1 e^* f(\beta) d\beta = \int_0^1 \beta V f(\beta) d\beta = V \int_0^1 \beta d\beta = \frac{V}{2}.$$

The aggregate probability of success is given by:

$$E(S = 1 | 0 \leq \beta \leq 1) = E(\varepsilon \leq \beta e^* | 0 \leq \beta \leq 1) = \int_0^{\beta e^*} \varepsilon f_{\varepsilon | 0 \leq \beta \leq 1}(\varepsilon) \, d\varepsilon$$

$$= \int_0^{\beta e^*} \varepsilon \frac{f(\varepsilon, 0 \leq \beta \leq 1)}{f(0 \leq \beta \leq 1)} d\varepsilon = \int_0^{\beta e^*} \varepsilon f(\varepsilon, 0 \leq \beta \leq 1) \, d\varepsilon = \int_0^{\beta e^*} \varepsilon \, d\varepsilon = \frac{\beta^2 e^{*2}}{2}$$

$$= \frac{\beta^4 V^2}{2}.$$

3. The Case with Corruption

Now, among the examiners, we assume that there exists a proportion θ that is corrupt and *(1-θ)* that is honest. Officials' types are private information but θ is common knowledge.[6] As in the previous section, applicants are characterized by their innate ability β, uniformly distributed on [0,1]. To obtain a qualification, a candidate chooses between effort e, bribe b, or a combination. In this case, final performance is measured as $s - \varepsilon = (1 - \theta)\beta e + \theta b - \varepsilon$ where the error ε is uniformly distributed on [0, 1].

The probability of success of a candidate is given by

$$P(S = 1) = P(s - \varepsilon \geq 0) = (1 - \theta)\beta e + \theta b$$

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[6] This assumption denotes the presence of intrinsically motivated agents that resist corruption (see e.g. Ahlin and Bose 2007).

This probability of success increases with innate ability, effort and bribe because

$$\frac{\partial P(S=1)}{\partial b} \geq 0, \quad \frac{\partial P(S=1)}{\partial e} \geq 0 \quad \text{and} \quad \frac{\partial P(S=1)}{\partial \beta} \geq 0.$$

The cost function is given by:

$$C(e,b) = \frac{1}{2}(e^2 + b^2) + keb \quad \text{where } k \in [0,1].$$

This cost function assumes that effort and bribery are strategic substitutes and k is a measure of the degree of substitutability.[7] An increase in the level of effort increases the marginal cost of bribe and vice-versa. As a result, a risk neutral applicant's utility function is given by:

$$U(e,b,\beta) = P(S=1)V - C(e,b) = \big((1-\theta)\beta e + \theta b\big)V - \frac{1}{2}(e^2 + b^2) - keb$$

The applicant chooses effort e and bribe b in order to maximize this utility function.

Optimal Behavior

Let λ (resp μ) be the Lagrange multipliers associated to e (resp b). The Lagrangian is given by:

$$L(e,b,\lambda,\mu) = \big((1-\theta)\beta e + \theta b\big)V - \frac{1}{2}(e^2 + b^2) - keb + \lambda e + \mu b.$$

The Lagrangian is a concave function. So, using Karush-Kuhn-Tucker (KKT) sufficient conditions, we find the following:

$$\begin{cases} \nabla L(e,b,\lambda,\mu) = 0 \\ e \geq 0, \ b \geq 0, \ \lambda \geq 0, \ \mu \geq 0 \\ \lambda e = 0, \ \mu b = 0 \end{cases}$$

$$\Rightarrow \begin{cases} (1-\theta)\beta V - e - kb + \lambda = 0, \ \theta V - b - ke + \mu = 0 \\ e \geq 0, \ b \geq 0, \ \lambda \geq 0, \ \mu \geq 0 \\ \lambda e = 0, \ \mu b = 0 \end{cases}$$

By resolving the first equations, for $k \neq 1$ we obtain:

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[7] See Dixit (2002) for such a modelling of substitutable tasks, with actions interacting in the cost, but not in the production function. If $k = 0$, effort and bribery are independent, while if $k = 1$, they are perfect substitutes.

$$e^* = \frac{\left((1-\theta)\beta - k\theta\right)V}{1-k^2} + \frac{\lambda}{1-k^2} - \frac{k\mu}{1-k^2},$$

$$b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2} - \frac{k\lambda}{1-k^2} + \frac{\mu}{1-k^2}.$$

We will now discuss the various solutions by analyzing different cases:

Case	1	2	3	4
e^*	0	$\frac{((1-\theta)\beta - k\theta)V}{1-k^2}$	0	$(1-\theta)\beta V$
b^*	0	$\frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$	θV	0
λ^*	$-(1-\theta)\beta V$	0	$(k\theta - (1-\theta)\beta)V$	0
μ^*	$-\theta V$	0	0	$(k(1-\theta)\beta - \theta)V$

Proposition 1: The optimal levels of bribe and effort result in a probability success $P(S = 1) \in [0,1]$.

Proof:

Case 1 can be excluded since the non-negativity constraints of the Lagrange multipliers would be violated.

In case 2, $e^* > 0$ and $b^* > 0$, then $e^* + b^* = \frac{(\theta + (1-\theta)\beta)V}{k+1}$.

We have $\theta + (1-\theta)\beta$ as a convex combination of β and 1 (this combination is inferior or equal to 1 because $\beta \leq 1$ and $0 \leq \frac{V}{k+1} \leq 1$). So, if $0 \leq e^* + b^* \leq 1$, then $0 \leq (1-\theta)\beta e^* + \theta b^* \leq 1$ as a convex combination, noting that $P(S = 1) = (1-\theta)\beta e + \theta b$.

The optimal solution is $e^* = \frac{((1-\theta)\beta - k\theta)V}{1-k^2}$ and $b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$. The applicant exerts some effort in addition to bribery in order to obtain her qualification. This situation resembles the case where an applicant obtains the exams but not the solutions (see Tucker 2000).

Partially differentiating e^* and b^* with respect to θ gives:

$$\frac{\partial e^*}{\partial \theta} = -\frac{(\beta + k)V}{1-k^2} \leq 0 \text{ and } \frac{\partial b^*}{\partial \theta} = \frac{(1+k\beta)V}{1-k^2} \geq 0, \text{ or all } k \in [0,1[.$$

The graphs below depict the evolution of optimal effort and bribe according to the proportion of corrupt examiners.

Figure 1: **Evolution of the optimal effort (blue curve) and optimal bribe (black curve) according to the proportion of corrupt examiners.**
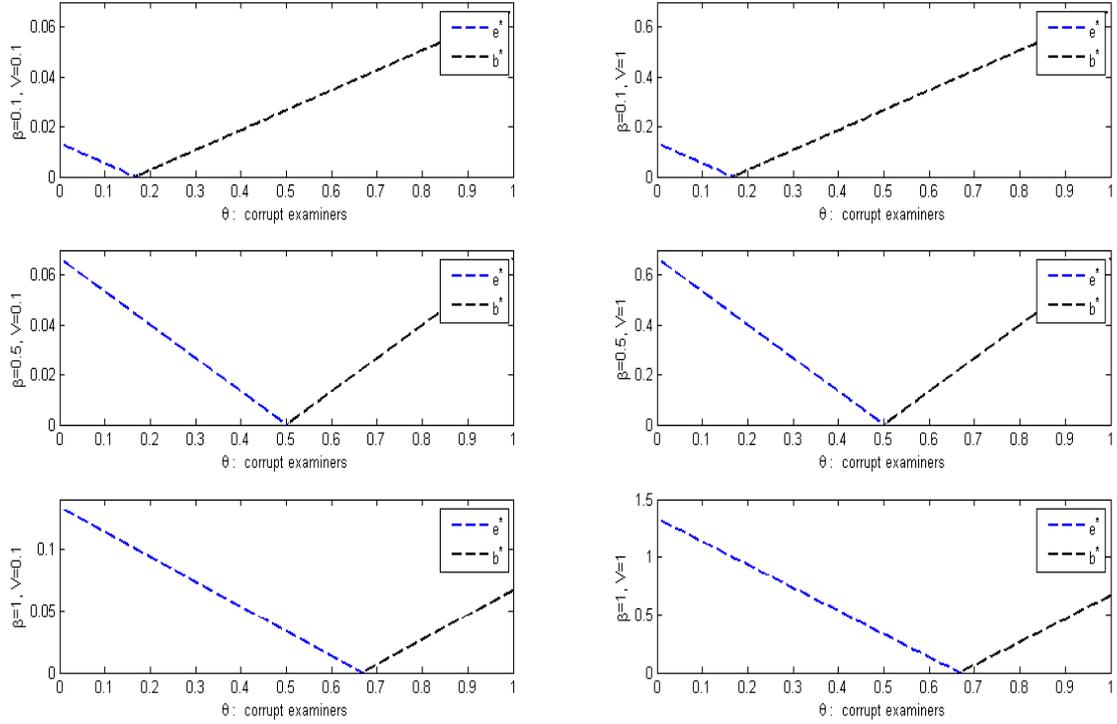
Note: The curves are represented with $k = \frac{1}{2}$. The curves correspond to the evolutions of the optimal values according to the proportion of corrupt examiners θ. The variations of optimal values depend on the selected values of innate ability β and qualification V. The amplitudes of optimal values depend on V. In summary, optimal values of effort and bribe are proportionally linear in qualification V, but the slopes of the curves depend on innate ability. The curves show that e^* decreases with θ while b^* increases.

Partially differentiating e^* and b^* with respect to β gives:

$\frac{\partial e^*}{\partial \beta} = \frac{(1-\theta)V}{1-k^2} \geq 0$ and $\frac{\partial b^*}{\partial \beta} = -\frac{k(1-\theta)V}{1-k^2} \leq 0$ for all $k \in [0,1[$. This implies that optimal effort increases in innate ability β while the optimal bribe decreases with β.

Partially differentiating e^* and b^* with respect to V gives:

$\frac{\partial e^*}{\partial V} = \frac{((1-\theta)\beta - k\theta)}{1-k^2}$ and $\frac{\partial b^*}{\partial V} = \frac{(\theta - k(1-\theta)\beta)}{1-k^2}$. These variations of $\frac{\partial e^*}{\partial V}$ and $\frac{\partial b^*}{\partial V}$ depend on the innate ability value β.

If we suppose that $\beta + k \neq 0$, then:

- for all $\theta \in [0, \frac{\beta}{\beta+k}]$, $\frac{\partial e^*}{\partial V} \geq 0 \implies e^*$ increases according to the qualification.

- for all $\theta \in [\frac{\beta}{\beta+k}, 1]$, $\frac{\partial e^*}{\partial V} \leq 0 \implies e^*$ decreases according to the qualification.

For the variation of bribe with respect to the qualification, we have:

- for all $\theta \in [0, \frac{k\beta}{1+k\beta}]$, $\frac{\partial b^*}{\partial V} \leq 0 \implies b^*$ decreases according to the qualification.

- for all $\theta \in [\frac{k\beta}{1+k\beta}, 1]$, $\frac{\partial b^*}{\partial V} \geq 0 \implies b^*$ increase according to the qualification.

In case 3, the optimal solution is $e^* = 0$ and $b^* = \theta V$. The applicant exerts no effort to obtain her degree and relies solely upon bribery. Using Tucker (2000)'s example, this can correspond to the case where the applicant obtains the exams and the solutions. Applicants pay a fixed price whenever they do not exert any effort, and b^* in this case is independent of innate ability β.

In case 4, the optimal solution is $e^* = (1 - \theta)\beta V$ and $b^* = 0$. The applicant does not resort to bribery to get the degree or pass an exam. This coincides with the case where the applicant does not try to obtain either the exams or the solutions. The level of effort is decreasing in the proportion of corrupt officials and increasing in ability.

Using the results of case 2, it is possible to find the values of β that makes an individual indifferent between $e^* = 0$ and $e^* = \frac{((1-\theta)\beta - k\theta)V}{1-k^2}$, or between $b^* = 0$ and $b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$. The results are summarized in the following proposition.

Proposition 2: There exists a threshold $\beta_l = \frac{k\theta}{(1-\theta)}$ such that for all $\beta \in [0, \beta_l]$, a candidate does not exert any effort in order to obtain qualification. There also exists a threshold $\beta_h = \frac{\theta}{k(1-\theta)}$ such that for all $\beta \in [\beta_h, 1]$, a candidate relies solely on effort in order to obtain qualification. For $\beta \in [\beta_l, \beta_h]$, a candidate uses both effort and bribery to get their qualifications $e^* = \frac{((1-\theta)\beta - k\theta)V}{1-k^2}$ and $b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$.

Proof:

β_l is obtained using $e^* = \frac{((1-\theta)\beta - k\theta)V}{1-k^2} = 0$, giving:

$$(1 - \theta)\beta_l - k\theta = 0 \quad \Leftrightarrow \quad \beta_l = \frac{k\theta}{(1-\theta)}, \text{ assuming } \theta \in [0,1[.$$

β_h is obtained in a similar way by equalizing $b^* = 0$ where $b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$ with $V \neq 0$.

Then $\theta - k(1-\theta)\beta_h = 0 \Leftrightarrow \beta_h = \frac{\theta}{k(1-\theta)}$, assuming $\theta \in [0,1[$.

Note that $\beta_l \leq \beta_h$. We assume $0 \leq \beta_l \leq \beta_h \leq 1$ and $\theta \leq min\left(\frac{k}{1+k}, \frac{1}{1+k}\right) = \frac{k}{1+k}$. Note also that when θ tends to $\frac{1}{1+k}$, then β_l tends to 1 and effort remains zero.

Partially differentiating β_l and β_h with respect to θ gives:

$$\frac{\partial \beta_l}{\partial \theta} = \frac{k}{(1-\theta)^2} \geq 0 \text{ and } \frac{\partial \beta_h}{\partial \theta} = \frac{1}{k(1-\theta)^2} \geq 0 \implies \beta_l \text{ is increasing in } \theta.$$

A higher proportion of candidates does not acquire any skill when θ increases. As β_h is also increasing in θ, a higher proportion of candidates that was initially relying only on effort, now substitute effort for bribery.

4. Aggregate Effort

Since effort and bribery are substitutes, an intuitive implication is that a higher proportion of corrupt officials decreases the expected level of effort exerted by candidates. At the societal level, this may translate in a lower level of acquired skills, and therefore a lower level of education quality.

The expected level of effort is given by the expression below:

$$E(e^*) = \int_0^1 e^* f(\beta)\, d\beta = \int_0^{\beta_l} e^* f(\beta)\, d\beta + \int_{\beta_l}^{\beta_h} e^* f(\beta)d\beta + \int_{\beta_h}^1 e^* f(\beta)d\beta$$

$$= \int_0^{\beta_l} 0\, d\beta + \int_{\beta_l}^{\beta_h} \frac{((1-\theta)\beta - k\theta)V}{1-k^2}\, d\beta + \int_{\beta_h}^1 (1-\theta)\beta V d\beta$$

$$= \frac{V}{1-k^2}\left[\frac{(1-\theta)\beta^2}{2} - k\theta\beta \right]_{\beta_l}^{\beta_h} + V\left[\frac{(1-\theta)\beta^2}{2} \right]_{\beta_h}^1$$

$$= \frac{V}{1-k^2}\left[\frac{(1-\theta)\left(\beta_h^2 - \beta_l^2\right)}{2} - k\theta(\beta_h - \beta_l)\right] + \frac{V(1-\theta)(1-\beta_h^2)}{2}.$$

We replace $\beta_l = \frac{k\theta}{(1-\theta)}$ and $\beta_h = \frac{\theta}{k(1-\theta)}$ in the expression above to obtain respectively:

$$\frac{kV\theta}{1-k^2}(\beta_h - \beta_l) = \frac{V\theta^2}{1-\theta}, \quad \frac{V(1-\theta)(\beta_h{}^2-\beta_l{}^2)}{2(1-k^2)} = \frac{V\theta^2(1+k^2)}{2k^2(1-\theta)} \quad \text{and} \quad \frac{V(1-\theta)(1-\beta_h{}^2)}{2} = \frac{V(k^2(1-\theta)^2-\theta^2)}{2k^2(1-\theta)}.$$

As a result, the expected level of effort is given by:

$$E(e^*) = \frac{V(1-2\theta)}{2(1-\theta)} \quad \text{with} \quad \frac{\partial E(e^*)}{\partial \theta} = -\frac{V}{2(1-\theta)^2} \le 0.$$

This result suggests that the expected level of effort exerted by applicants decreases with the proportion of corrupt examiners. Therefore, a higher proportion of corrupt officials can lead to a lower level of education quality. The expected level of effort converges to the result obtained in the model of the Benchmark case (not considering the corruption) if the proportion of corrupt graders tends to zero.

5. Aggregate Rate of Success

In this section, we compute the expected rate of success among applicants in the presence of corruption. We distinguish three cases according to applicants' types.

Case 1: $\beta \in [0, \beta_l]$

In the presence of corruption, this type of candidate relies solely on bribery. Since an applicant in this interval chooses $e^* = 0$, he will be disqualified by honest officials whose proportion is $(1-\theta)$. On the other hand, he may be successful if he encounters a corrupt official, leading to a first inefficiency result.

Conditional on the official being corrupt, the bribe paid is $b^* = \theta V$. Taking into account the proportion of corrupt official, we obtain that the probability of success is $\theta^2 V$. So, the average probability of success is given by:

$$E(S = 1 | 0 \le \beta \le \beta_l) = E(\varepsilon \le \theta^2 V | 0 \le \beta \le \beta_l)$$

$$= \int_0^{\theta^2 V} \varepsilon \frac{f(\varepsilon, 0 \le \beta \le \beta_l)}{f(0 \le \beta \le \beta_l)} d\varepsilon$$

$$= \int_0^{\theta^2 V} \varepsilon \frac{f(\varepsilon, 0 \le \beta \le \beta_l)}{\beta_l} d\varepsilon = \int_0^{\theta^2 V} \frac{\varepsilon}{\beta_l} d\varepsilon = \frac{\theta^4}{2\beta_l} V^2.$$

We replace β_l in this expression to obtain:

$$E(S = 1 | 0 \leq \beta \leq \beta_l) = \frac{\theta^3(1-\theta)V^2}{2k}$$

This expected success rate increases in the proportion of corrupt officials if $\theta \leq \frac{3}{4}$ and decreases otherwise, as

$$\frac{\partial E(S = 1 | 0 \leq |\beta \leq \beta_l)}{\partial \theta} = \frac{\theta^2(3 - 4\theta)V^2}{2k}.$$

Case 2: $\beta \in [\beta_l, \beta_h]$

In this case, $e^* = \frac{((1-\theta)\beta - k\theta)V}{1-k^2}$ and $b^* = \frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$.

Candidates in this interval use both effort and bribe. The probability of success given their type is $\frac{((1-\theta)\beta - k\theta)V}{1-k^2}$ when they encounter an honest official and $\frac{(\theta - k(1-\theta)\beta)V}{1-k^2}$ when they meet a corrupt official.

We expect a proportion θ of applicants to meet a corrupt official while a proportion $(1-\theta)$ will meet honest official. Therefore, the expected probability of success is given by $(1-\theta)\beta e^* + \theta b^*$ according to the encountered type of officials. And we obtain the expected level of success by aggregating over β:

$$E(S = 1 | \beta_l \leq \beta \leq \beta_h) = E(\varepsilon \leq (1-\theta)\beta e^* + \theta b^* | \beta_l \leq \beta \leq \beta_h)$$

$$= \int_0^{(1-\theta)\beta e^* + \theta b^*} \varepsilon \frac{f(\varepsilon, \beta_l \leq \beta \leq \beta_h)}{f(\beta_l \leq \beta \leq \beta_h)} d\varepsilon = \int_0^{(1-\theta)\beta e^* + \theta b^*} \frac{\varepsilon}{\beta_h - \beta_l} d\varepsilon$$

$$= \frac{\left((1-\theta)\beta e^* + \theta b^*\right)^2}{2(\beta_h - \beta_l)} = \frac{((1-\theta)^2\beta^2 - 2k(1-\theta)\theta\beta + \theta^2)^2 V^2}{2(1-k^2)^2(\beta_h - \beta_l)}.$$

We replace $\beta_l = \frac{k\theta}{(1-\theta)}$ and $\beta_h = \frac{\theta}{k(1-\theta)}$ in the expression above, we obtain:

$$E(S = 1 | \beta_l \leq \beta \leq \beta_h) = \frac{k(1-\theta)((1-\theta)^2\beta^2 - 2k(1-\theta)\theta\beta + \theta^2)^2 V^2}{2(1-k^2)^3\theta}$$

In this case, the evolution of the expected success rate with respect to the proportion of corrupt officials is undetermined.

Case 3: $\beta \in [\beta_h, 1]$

In the presence of corruption, this type resort only to effort. It is successful only when it meets an honest official. This is the second inefficiency result since such candidates will fail if a corrupt official is encountered. Conditional on meeting an honest official, the probability of success is given by $(1 - \theta)\beta^2 V$.

Taking into account the proportion of honest officials then the probability is given by: $\Pr(S = 1|\beta) = ((1 - \theta)\beta)^2 V$. In consequence, the average probability of success such as $\beta \geq \beta_h$ is given by:

$$E(S = 1|\beta_h \leq \beta \leq 1) = E(\varepsilon \leq ((1 - \theta)\beta)^2 V|\beta_h \leq \beta \leq 1)$$

$$= \int_0^{((1-\theta)\beta)^2 V} \varepsilon \frac{f(\varepsilon, \beta_h \leq \beta \leq 1)}{f(\beta_h \leq \beta \leq 1)} d\varepsilon = \int_0^{((1-\theta)\beta)^2 V} \frac{\varepsilon}{1 - \beta_h} d\varepsilon = \frac{((1 - \theta)\beta)^4 V^2}{2(1 - \beta_h)}$$

$$= \frac{k(1 - \theta)^5 \beta^4 V^2}{2(k - \theta(1 - k))}.$$

and:

$$\frac{\partial E(S = 1|\beta \geq \beta_h)}{\partial \theta} = \frac{k(1 - \theta)^4 \beta^4 V^2 (-8k + \theta(10 + 8k))}{4(k - \theta(1 - k))^2}.$$

This expected success rate increases in the proportion of corrupt officials if $\theta \geq \frac{8k}{10+8k}$, but decreases otherwise.

The overall expected success rate in the presence of corruption is given by
$$E(S = 1) = E(S = 1|0 \leq \beta \leq \beta_l) + E(S = 1|\beta_l \leq \beta \leq \beta_h) + E(S = 1|\beta_h \leq \beta \leq 1)$$

$$= \frac{\theta^3(1 - \theta)V^2}{2k} + \frac{k(1 - \theta)((1 - \theta)^2 \beta^2 - 2k(1 - \theta)\theta\beta + \theta^2)^2 V^2}{2(1 - k^2)^3 \theta} + \frac{k(1 - \theta)^5 \beta^4 V^2}{2(k - \theta(1 - k))}.$$

The sign for the overall expected rate of success with regards to θ is uncertain. We therefore proceed to an empirical analysis in trying to examine the impact of corruption on success rate. In the case without corruption (Benchmark case), we have $\theta = 0$ and this implies that $\beta_l = 0$ and $\beta_h = 0$. In this case $E(S = 1) = E(S = 1|0 \leq \beta \leq 1) = \frac{\beta^4 V^2}{2}$ (The result obtained above in the part without corruption).

Although for simplicity, we have presented the case where V is independent of the proportion of corrupt official, this needs not to be the case. For instance, it is believable that the value of a diploma obtained in a very corrupt country may be lower than one obtained in a less corrupt country, both at the national and international level. Rumyantseva (2005) reports cases where many employers in Russia and Ukraine explicitly state in job advertisements that only graduates from certain universities are welcome to apply. The locals explain that this is because they do not trust other institutions due to corruption. Allowing V to depend on θ changes only the result regarding candidates' probability of success. The expected rate of success at the societal level may be positive or negative. Indeed, an increase in corruption produces two opposite effects. It increases the returns to bribery, but decreases the value of the qualification, leaving the net effect undetermined.

6.   Some Empirical Evidence

In this section, we empirically investigate the central implication of our model regarding the macro-economic effects of individual decisions about corruption, through the education channel. More precisely, we first examine whether higher levels of corruption are associated with low education quality, as a higher proportion of corrupt officials lowers aggregate learning effort. Then, we test whether education quantity is positively related to corruption as it may increase the chances of obtaining a degree or passing an exam.

The main challenge facing the empirical investigation is the data constraint. Providing an evidence-based relationship between our education outcomes and corruption requires appropriate measures of the variables of interest, namely corruption in the education sector, as well as measures of the quality and quantity of education. The following sub-section describes how we deal with this challenge, and the ensuing limitations and implications of our findings.

6.1. Data and Sample

Corruption

Despite many reported cases of corruption in the educational system of countries, our search for data on bribery in the education sector has been inconclusive. In the absence of the preferred data, we resort to three common measures of corruption used in literature: the corruption component of the political risk rating of the International Country Risk Guide (ICRG), the

Control of Corruption estimates from the World Wide Governance Indicators (WGI), and the Corruption Perception Index (CPI) from Transparency International (TI).

The ICRG measure is an assessment of corruption within the political system. It ranges from 0 to 6. The Control of Corruption indicator from the WGI captures perceptions of the extent to which public power serves for private gain by the means of corruption. The values range between -2.5 and 2.5. The CPI index from the TI captures perceptions of people on how corrupt their public sectors are, within a range from 0 to 100.

None of these measures is exclusively related to education. Consequently, the estimation results implicitly assume that bribery in the educational system largely reflects corruption in the public sector overall. For each measure, the higher the score, the lower the level of corruption (the lower the score, the higher the level of corruption). To ensure consistency and for ease of interpretation, we transform the values so that high scores indicate high levels of bribery.

Education quality

We proxy the quality of education using harmonized test scores (HTS) from the Human Capital Index database. The data are obtained by harmonizing test scores from major international student achievement testing programs, where 300 is minimal attainment and 625 is advanced attainment. Using HTS data allow us to have the most expansive cross-country dataset on the quality of education. However, most of the testing programs included in the HTS measure achievements on early-grade students. The preferred dataset should have been comprehensive measures of education quality (at all levels).

At least two considerations can justify the use of the HTS data to test the predictions of our model. First, we cannot rule out the possibility that parents engage in any form or bribery to have their children pass exams. As such, corruption is at play at all levels of education including primary education. Second, early-grade students' performance is highly correlated with performance of students at higher levels. Early education is the foundation upon which advanced education is built. Accordingly, a student with good achievements at early stages is expected to perform well at advanced stages. In short, the quality of education at early stages can reflect education quality overall.

Education quantity

Education quantity is captured through two alternative education outcomes: the proportion of graduates from tertiary education in total population; and the gross enrolment ratio in tertiary education. Data are from the WDI and from the UNESCO Statistics.

6.2. Econometric estimations

To examine the prediction of our model, we adopt the following specification:

$$\log(education_{it}) = \alpha + \beta\ corruption_{it} + \log(GDPPC_{it}) + Expenditure_{it} + \varepsilon_{it}$$

Where $i = 1, \dots, n$ represent countries and $t = 1, \dots, T$ years, $\log(education)$ is the natural log of one of our variables of education, $corruption$ is one of the corruption indicators; $\log(GDPPC)$ represents the natural log of the per capita GDP; $Expenditure$ is the government expenditure per student as a percent of GDP per capita (we consider primary and secondary education for education quality, and tertiary education for education quantity); α is a constant, and ε denotes the error term. We estimate the equation using OLS and Poisson regressions.

Corruption and Education quality

The education quality data is available for 2017. However, the rounds of the tests from which HTS scores are come from earlier years. For instance, the years for the Early Grade Reading Assessment (EGRA) test scores are 2007 onwards. Consequently, we estimate the equation using average values of corruption and control variables over the period 2010-2017. We consider all countries for which data are available. Depending on the variables included, the sample countries range from 92 to 157[8]. Tables 1.a, 1.b and 1.c give the OLS and Poisson estimates using respectively the ICRG, TI and WGI measures of corruption. Columns (1) and (5) report the coefficient of corruption without the control variables from the OLS and Poisson regressions respectively. In columns (2) and (3), we add the two controls one at a time for the OLS regressions. We do the same thing in columns (6) and (7) for the Poisson regressions. Columns (4) and (8) include both controls in the OLS and Poisson regressions respectively.

We find evidence that higher corruption correlates negatively with the quality of education. The coefficient of corruption is negative and statistically significant in all specifications, except for some including (log) per capita GDP, no matter the measure of corruption used, or the

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[8] The full list of the countries is reported in appendix, Table A.1

Table 1.a. Corruption and Education quality: OLS and Poisson estimates using ICRG measure of corruption

	Harmonized Test Scores (HTS) in logarithm							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	Poisson	Poisson	Poisson	Poisson
Corruption	-0.0926***	-0.0872***	-0.0149	-0.00214	-0.0892***	-0.0827***	-0.0128	-6.93e-05
	(0.00747)	(0.0109)	(0.0115)	(0.0133)	(0.00716)	(0.0101)	(0.0114)	(0.0130)
Expenditure		0.00220*		0.00153*		0.00227**		0.00161**
		(0.00113)		(0.000801)		(0.00106)		(0.000783)
Log GDPPC			0.0788***	0.0845***			0.0792***	0.0848***
			(0.00985)	(0.0118)			(0.0101)	(0.0115)
Constant	6.371***	6.272***	5.425***	5.280***	6.368***	6.263***	5.420***	5.272***
	(0.0219)	(0.0647)	(0.118)	(0.136)	(0.0204)	(0.0604)	(0.121)	(0.133)
Observations	127	92	127	92	127	92	127	92
R-squared	0.410	0.483	0.626	0.703				

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors (in parenthesis) are heteroskedasticity robust. Corruption is measured with the corruption variable of the ICRG and transformed so that higher values reflect more corruption. The estimates are based on the natural logarithm of HTS, with data available for 2017. The explanatory variables values are mean averages over the period 2010-2017.

regression method adopted. These results align with the prediction of our theoretical model that corruption negatively affects the quality of education as it increases the proportion of students choosing to exert no learning effort at all. The highest decrease is obtained in Table 1.c when corruption is measured with the WGI corruption index: on average, one unit increase in corruption is associated with about 11% decrease in the quality of education in the models without controls (columns (1) and (5)). Regarding the controls, they are statistically significant at conventional levels in almost all estimations and have the expected signs. Support from the government through education expenditure helps build good education quality. Increasing income per capita enables people to invest in education and improve its quality.

Corruption and Education quantity

We take advantage of panel data on the proportion of graduates from tertiary education in total population, and the gross enrolment ratio in tertiary education to empirically investigate the association between corruption and education quantity. We keep the same time period as before (2010-2017) for consistency. Here again, we resort to OLS and Poisson estimations with country fixed effects (FE) to control for country-specific constant unobservables that might affect both corruption and education. Some regressions also include year FE to control for common shocks that might have affected education quantity across years. The results are contained in Tables 2 and 3.

Table 1.b. Corruption and Education quality: OLS and Poisson estimates using the CPI index of TI

	Harmonized Test Scores (HTS) in logarithm							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	Poisson	Poisson	Poisson	Poisson
Corruption	-0.00593***	-0.00602***	-0.00173**	-0.00129	-0.00580***	-0.00582***	-0.00165**	-0.00124
	(0.000375)	(0.000542)	(0.000753)	(0.000899)	(0.000365)	(0.000511)	(0.000744)	(0.000890)
Expenditure		0.00141		0.00154**		0.00154*		0.00160**
		(0.000981)		(0.000768)		(0.000920)		(0.000742)
Log GDPPC			0.0648***	0.0694***			0.0650***	0.0690***
			(0.0105)	(0.0124)			(0.0105)	(0.0121)
Constant	6.386***	6.335***	5.596***	5.475***	6.385***	6.325***	5.594***	5.478***
	(0.0199)	(0.0560)	(0.127)	(0.149)	(0.0187)	(0.0523)	(0.127)	(0.147)
Observations	152	108	151	107	152	108	151	107
R-squared	0.489	0.583	0.608	0.708				

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors (in parenthesis) are heteroskedasticity robust. Corruption is measured with the Corruption Perception Index (CPI) of Transparency International and transformed so that higher values reflect more corruption. The estimates are based on the natural logarithm of HTS, with data available for 2017. The explanatory variables values are mean averages over the period 2010-2017

Table 1.c. Corruption and Education quality: OLS and Poisson estimates using the WGI Control of Corruption index

	Harmonized Test Scores (HTS) in logarithm							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	Poisson	Poisson	Poisson	Poisson
Corruption	-0.113***	-0.112***	-0.0280*	-0.0175	-0.110***	-0.108***	-0.0257*	-0.0159
	(0.00741)	(0.0108)	(0.0145)	(0.0177)	(0.00716)	(0.0101)	(0.0144)	(0.0177)
Expenditure		0.00151		0.00163**		0.00164*		0.00169**
		(0.00101)		(0.000770)		(0.000948)		(0.000744)
Log GDPPC			0.0681***	0.0730***			0.0690***	0.0731***
			(0.0103)	(0.0126)			(0.0104)	(0.0125)
Constant	6.058***	5.998***	5.471***	5.370***	6.065***	6.000***	5.469***	5.372***
	(0.00925)	(0.0343)	(0.0882)	(0.105)	(0.00933)	(0.0329)	(0.0888)	(0.105)
Observations	157	108	156	107	157	108	156	107
R-squared	0.476	0.567	0.610	0.705				

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors (in parenthesis) are heteroskedasticity robust. Corruption is measured with the control of corruption index of the WGI and transformed so that higher values reflect more corruption. The estimates are based on the natural logarithm of HTS, with data available for 2017. The explanatory variables values are mean averages over the period 2010-2017

They tend to confirm the predictions of our theoretical model as corruption is found to be positively associated with the expected rate of success, whether measured by the proportion of graduates (Table 2) or the gross enrolment ratio in tertiary education (Table 3). The coefficients of corruption in Table 2 are all positive and significant at 1% or 5% levels, no matter the measure of bribery or the regression type used. These results are confirmed in Table 3 when using the ICRG measure of bribery in columns 1 to 4. No statistically significant link is detected with the TI and WGI measures. Unlike GDP per capita which has the expected sign when it is significant, government expenditure in tertiary education is found to be negatively associated with education quantity in some of the regressions.

Table 2. Corruption and Education quantity: OLS and Poisson estimates using the proportion of tertiary graduates in total population as proxy for education quantity

	Proportion of graduates from tertiary education in total population (in logarithm)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	OLS	Poisson	Poisson	OLS	OLS	Poisson	Poisson	OLS	OLS	Poisson	Poisson
Corrup_ICRG	0.157***	0.153***	0.123**	0.125**								
	(0.0514)	(0.0513)	(0.0537)	(0.0551)								
Corrup_TI					0.00969**	0.0110**	0.00992**	0.0102**				
					(0.00449)	(0.00500)	(0.00390)	(0.00458)				
Corrup_WGI									0.184**	0.210**	0.236***	0.252***
									(0.0926)	(0.0867)	(0.0837)	(0.0790)
Log GDPPC	0.506	-0.0378	0.195	-0.0995	0.742**	0.357	0.429	0.383	0.342	-0.0660	0.0469	-0.191
	(0.315)	(0.319)	(0.287)	(0.270)	(0.332)	(0.336)	(0.298)	(0.274)	(0.262)	(0.237)	(0.206)	(0.177)
Expenditure	-0.00316*	-0.00296*	-0.00452**	-0.00432***	-0.000525	-0.000508	-0.00171	-0.00152	-0.00362**	-0.00357**	-0.00518***	-0.00498***
	(0.00175)	(0.00150)	(0.00182)	(0.00166)	(0.00101)	(0.000926)	(0.00201)	(0.00179)	(0.00167)	(0.00146)	(0.00162)	(0.00152)
Constant	-5.412*	-0.493			-7.626**	-4.270			-3.436	0.194		
	(2.975)	(2.979)			(3.092)	(3.080)			(2.367)	(2.121)		
Observations	354	354	343	343	282	282	262	262	419	419	400	400
R-squared	0.216	0.290			0.059	0.081			0.145	0.201		
Countries	85	85	74	74	96	96	76	76	109	109	90	90
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors (in parenthesis) are heteroskedasticity robust. Corrup_ICRG: WGI measure of corruption; Corrup_TI: Corruption perception index of TI; Corrup_WGI: control of corruption index of the WGI. All corruption variables are transformed so that higher values reflect more corruption. Education is measured with the proportion of graduates from tertiary education in total population. The estimates are based on yearly data over the period 2010-2017

Table 3. Corruption and education quantity: OLS and Poisson estimates using the gross enrolment ratio in tertiary education as proxy for education quantity

	Gross enrolment ratio in tertiary education (in logarithm)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	OLS	Poisson	Poisson	OLS	OLS	Poisson	Poisson	OLS	OLS	Poisson	Poisson
Corrup_ICRG	0.0666***	0.0539**	0.0771***	0.0735***								
	(0.0242)	(0.0262)	(0.0263)	(0.0269)								
Corrup_TI					-0.00150	-0.00140	0.00260	0.00364				
					(0.00303)	(0.00329)	(0.00210)	(0.00228)				
Corrup_WGI									-0.0992	-0.0981	-0.0233	-0.0216
									(0.0958)	(0.0795)	(0.0788)	(0.0636)
Log GDPPC	0.625***	0.189	0.468***	0.182	0.723***	0.407**	0.573***	0.359**	0.630***	0.157	0.350**	0.0328
	(0.129)	(0.189)	(0.136)	(0.163)	(0.199)	(0.205)	(0.181)	(0.168)	(0.168)	(0.174)	(0.168)	(0.175)
Expenditure	-0.00191***	-0.00185***	-0.00222***	-0.00211***	-0.00171**	-0.00168**	-0.00162**	-0.00163**	-0.00198***	-0.00190***	-0.00287***	-0.00270***
	(0.000589)	(0.000582)	(0.000575)	(0.000568)	(0.000783)	(0.000723)	(0.000708)	(0.000673)	(0.000558)	(0.000536)	(0.000941)	(0.000933)
Constant	-2.102*	1.762			-2.656	0.0655			-1.982	2.074		
	(1.163)	(1.684)			(1.709)	(1.780)			(1.474)	(1.508)		
Observations	449	449	434	434	363	363	340	340	555	555	534	534
R-squared	0.365	0.443			0.230	0.264			0.201	0.269		
Number of id	102	102	87	87	116	116	93	93	132	132	111	111
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors (in parenthesis) are heteroskedasticity robust. Corrup_ICRG: WGI measure of corruption; Corrup_TI: Corruption Perception Index of TI; Corrup_WGI: control of corruption index of the WGI. All corruption variables are transformed so that higher values reflect more corruption. Education is measured with the gross enrolment ratio in tertiary education. The estimates are based on yearly data over the period 2010-2017

7. Conclusion

A simple model is developed in the context of the education sector, to highlight individuals' heterogeneous behaviours in presence of bribery, as well as the effects of corruption on the quality and quantity of education at the societal level.

To obtain a qualification or pass an exam, heterogeneous applicants have to pass a test, choosing between productive effort and corrupt effort (i.e. bribery). Applicants' heterogeneity is modelled as a difference in innate ability. There are two types of officials: honest or corrupt. Honest officials take only learning effort into account in measuring the candidate performance, while corrupt officials care only about the bribe size. Both effort and bribery positively contribute to the candidate's probability of success but are costly. In case of success, the candidate obtains a degree, whose value decreases with the proportion of corrupt officials in the economy. The key assumption of our model is that effort and bribe are explicitly modelled as strategic substitutes.

We find that "strong" candidates rely only on effort; "medium" candidates choose positive levels of both bribe and effort, while "weak" candidates rely only on bribery. In the presence of corruption, such differences in behaviour result in inefficiencies in a simple way. The best candidates have a 0 probability of getting the degree when they encounter a corrupt official, while weak candidates may still get the degree without exerting any effort.

Individual decisions also translate into aggregate effort level in the economy or aggregate expected rate of success among applicants. Here, aggregate effort level may be interpreted as education quality, while aggregate expected rate of success may be a proxy of education quantity. In this analysis, aggregation is useful as it allows investigating the macro-economic effects of individual decisions about corruption, highlighting in particular a channel (education), through which corruption may impact growth. The results suggest that corruption may decrease education quality, as a higher proportion of corrupt officials lowers aggregate effort level, and increases the proportion of candidates choosing to exert no effort at all. On the other hand, corruption may increase education quantity by increasing the chances of obtaining a degree. The empirical evidence supports these conclusions: corruption appears to be positively correlated to both education quality (proxied with HTS scores) and education quantity (as measured by the proportion of graduates from tertiary education in total population; and the gross enrolment ratio in tertiary education).

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Appendix

Table A.1. Countries entering the regression analysis

Albania	Cyprus	Iraq	Mozambique	Singapore
Algeria	Czech Republic	Ireland	Myanmar	Slovak Republic
Angola	Denmark	Israel	Namibia	Slovenia
Argentina	Dominican Republic	Italy	Netherlands	South Africa
Armenia	Ecuador	Jamaica	New Zealand	Spain
Australia	Egypt, Arab Rep.	Japan	Nicaragua	Sri Lanka
Austria	El Salvador	Jordan	Niger	Sudan
Azerbaijan	Estonia	Kazakhstan	Nigeria	Sweden
Bahrain	Ethiopia	Kenya	Norway	Switzerland
Bangladesh	Finland	Korea, Rep.	Oman	Tanzania
Belgium	Gambia, The	Kuwait	Pakistan	Thailand
Botswana	Germany	Latvia	Panama	Togo
Brazil	Ghana	Lebanon	Papua New Guinea	Trinidad and Tobago
Bulgaria	Greece	Liberia	Paraguay	Tunisia
Burkina Faso	Guatemala	Lithuania	Peru	Turkey
Cameroon	Guinea	Luxembourg	Philippines	Uganda
Canada	Guyana	Madagascar	Poland	Ukraine
Chile	Haiti	Malawi	Portugal	United Arab Emirates
China	Honduras	Malaysia	Qatar	United Kingdom
Colombia	Hong Kong SAR, China	Mali	Romania	United States
Congo, Dem. Rep.	Hungary	Malta	Russian Federation	Uruguay
Congo, Rep.	Iceland	Mexico	Saudi Arabia	Vietnam
Costa Rica	India	Moldova	Senegal	Yemen, Rep.
Cote d'Ivoire	Indonesia	Mongolia	Serbia	Zambia
Croatia	Iran, Islamic Rep.	Morocco	Sierra Leone	Zimbabwe

Table A.2. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log (HTS)	1413	6.052145	0.1613995	5.720057	6.364519
Log (tertiary graduates, % pop)	778	-0.6454133	0.8439206	-4.290663	0.7786503
Log (gross enrolment ratio)	961	3.387359	0.9505207	-0.3928797	4.839314
Corruption (ICRG)	1104	3.342089	1.178687	0	5.625
Corruption (TI)	1222	57.16367	19.56328	8	92
Corruption (WGI)	1624	0.0293827	0.9991876	-2.404901	1.82574
Log (GDPPC)	1954	8.659834	1.423839	5.363194	12.1631
Expenditure	545	36.97322	14.65778	6.44574	101.8884

Notes: The statistics are based on the panel data