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Cuong Le Van* and Mathilde Maurel†

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Abstract

Education is key in explaining growth, as emphasized recently by Krueger and Lindahl (2001). But for a given level of education, what can explain the missing growth in developing countries? Corruption, the poor enforcement of property rights, the government share of GDP, the regulations it imposes might influence the Total Factor Productivity (TFP thereafter) of a country's economic system. A number of empirical papers emphasize the consequences bad institutions have on growth, but few are examining the link between education, corruption (more generally bad institutions), and growth. Our model assumes that at low level of GDP per head and high level of corruption education spending has no impact on growth. The slope gets positive only at above critical size of corruption. The implications are tested using the data set of Xavier Sala-i-Martin, Gernot Doppelhofer, and Ronald I. Miller (2004), which is extended with the aggregate governance indicators of Kaufman et ali.

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1 Introduction

¿From Mankiw, Romer and Weil (1992: MRW thereafter), everybody will agree that education is key in explaining growth, and that differences in human capital can explain persistent differences in levels of national incomes between rich and poor countries. More recently, Krueger and Lindahl (2001) point out that education is one of the most salient explanatory variable in explaining either wages or growth. However, the magnitude of the effect of education continues to be clouded with uncertainty, as argued by Temple (2001). MRW (1992) has been criticized for having omitted important potentially concurrent explanatory variables, for having overestimated the true relationships between investment in education and private return on it, much smaller with micro-data, and for having selected a bad proxy for investment in human capital. But what omitted variables could explain the lack of growth in developing countries and the persistence of unequal trajectories, alongside with education? One possible answer lies in institutions, as defined by North (1990). The government enforcement of property rights, the government share of GDP, the regulations it imposes are likely to have an influence on the Total Factor Productivity (TFP thereafter) of a country's economic system.

A number of empirical papers emphasize the consequences bad institutions have on growth: Barro (1997), Hall and Jones (1999) Acemoglu and al. (2001) amongst others. But few are examining the link between education, corruption (more generally bad institutions), and growth. There is one interesting exception: Breton (2004), who argues that the distance of a representative worker from the maximum production possibility frontier depends upon corruption, which is itself a product of institutions. In his setting-up, the main ingredients for growth remain labor, unqualified and qualified, and capital. Bad institutions can push a country away from the best practice. Our growth theory model proceeds in a slightly different way. It assumes that at low level of GDP per head and high level of corruption education spending has no impact on growth. The slope gets positive only at above critical size of corruption. The implications are tested using the data set of Xavier Sala-i-Martin, Gernot Doppelhofer, and Ronald I. Miller (2004), which is extended with the aggregate governance indicators of Kaufman et al.

Several factors might explain the influence of poor institutions on TFP. First the amount of goods to be produced through a certain combination of factors can be lower than expected because resources are partially spent for paying bribes or for compensating defaulting institutions. Another reason is that the probability of having monopolistic structures might be higher where competition is hampered by low property rights; but those monopolistic structures imply that firms can operate far from the efficient frontier and that TFP is lower than what it would be with more competition. Third, as documented by Friedman et al. (2000), corrupt countries have higher underground economies, implying that output is likely to be underreported, but not labor and investment. More corrupt countries will report lower TFP for accounting reasons. If bribery affects investment data, then investment might be overestimated, which produces a downward bias again TFP. Finally an interesting argument is formalized in Breton (2004). The share of government spending contribution to TFP is positive up to a critical level, then it becomes negative. Indeed, the basic services like enforcing the rule of law, providing necessary infrastructure, providing education and health, can be produced by a relatively small state; above this critical level, the private sector is more efficient.

Our argument lies in the impact of corruption, not on TFP, but directly on the return to education. Empirical evidence exists. It emphasizes the weak link between expenditure and educational outcomes, like access to schooling and proportion of the school age population attending. Somehow paradoxically there is no consistent effect of resources on educational outcomes: "In the Lee and Barro (1997) study, for example, the pupil-teacher ratio has a negative and significant impact on achievement. Using similar data, the Hanushek and Kimko (2000) study reports a positive but insignificant result, while the Wobmann (2000) study, using class size as the resource variable, reports a positive and significant impact. These latter two suggest that larger class sizes are associated with better achievement and conversely, that the greater the level of resources available, the poorer the performance" (Samer Al-Samarrai (2002, page 3)). Using his own data, Samer Al-Samarrai (2002) show that more resources do not improve the primary gross and net enrolment ratios, nor the primary survival and completion rates. The missing link between resources and educational outcomes might have several explanations, including the relevance and quality of macro data for analyzing the efficiency of education, the effectiveness of the public expenditure management system, more particularly the budgetary process (Penrose (1993)), inefficient resources allocation within the education system (Pritchett and Filmer (1999), difficulty for implementing reforms to improve quality (Corrales (1999)).

But corruption and its corollary, bad institutions, are key for understanding the absent link between resources and outcomes. If the waste of the financial resources get misdirected, because of corruption, then one should not expect any link between those resources and what they are supposed to produce. Corruption indeed undermines the provision of health care and education services. Fighting against it might result in significant gains as measured by decreases in child and infant mortality rates and primary school dropout rates. "Countries with low corruption and high efficiency of government services tend to have about 26 percentage points fewer student dropouts than countries with high corruption and low efficiency of government services". It is worth noticing that according to the CIET social audit, the percentage of students paying extra charges for education range from 10 percent to 86 percent. Langseth and Stapenhurst (1997) report that parents do pay illegal stipends for enrolling their children in school. Corruption decreases the volume of public services, distorts the composition of public expenditures and decreases growth (De la Croix and Delavallade (2006)). It lowers the efficiency of public services by inducing higher dropout rates and low school enrolment (CIET (1999), Cockroft (1998)), by lowering the quality of public teachers (Chua (1999)). According to Ritva Reinikka and Jakob Svensson (2005) the newspaper campaign in Uganda which provides schools and parents with information to monitor local officials' handling of a large education grant program succeeded in reducing capture and on increasing enrolment and student learning.

This paper is structured as followed. Section 2 proposes a model where corruption produces negative externalities and undermines the efficiency of education[1]. Section 3 exposes the data and methodology used to test the implications of the model, and computes how much growth can be gained from improving the institutional environment and from reducing corruption. The last section summarizes.

2 The One Period Model

We first consider the one period model with a developing country which produces a consumption good using the physical capital and the efficient labor as inputs. This country has an initial endowment S. We assume that the human capital of the workers has a positive externality effect on the total productivity. More precisely, we have

$$y = h^{\gamma} k^{\alpha} (h\bar{N})^{1-\alpha},$$

where y denotes the output, k the physical capital, h the human capital, $\bar{N}$ the number of workers. The term h^{γ} with $\gamma > 0$ is the productivity. We assume $0 < \alpha < 1$.

The human capital formation is obtained by an education technology Φ. Explicitly $h = \Phi_{a,\widehat{S}}(S^1)h_0$ defined as follows:

$$\Phi_{a,\widehat{S}}(S^1) = 1, \text{ if } S^1 \leq \widehat{S}, \tag{1}$$

[1]This model belongs to the class of models initiated by Shleifer and Vishny (1993) in the sense that corruption is seen as a negative phenomenon. In contrast, there exists a class of models that define bribes as a mechanism for overcoming an overly centralized and extended bureaucracy, red tape, and delays. Corruption is "efficient-grease", bribe reflects an individual's opportunity cost. As emphasized earlier, this efficient-grease hypothesis runs counter to empirical studies and surveys.

$$\Phi_{a,\widehat{S}}(S^1) = 1 + a(S^1 - \widehat{S}),\ a > 0,\ \text{if } S^1 \geq \widehat{S}. \tag{2}$$

The threshold $\widehat{S}$ represents the fixed cost due to the corruption in the education sector. For simplicity, we normalize by putting $\bar{N} = 1$ and $h_0 = 1$.

The objective is to maximize the output $y = h^\gamma k^\alpha (h\bar{N})^{1-\alpha}$, under the constraints $h = \Phi_{a,\widehat{S}}(S^1)$ and $k + S^1 = S$.
Let θ denotes the share of S between k and S^1, i.e. $S^1 = \theta S$, $k = (1-\theta)S$. It is easy to see that the problem becomes

$$\max\{F_{a,\widehat{S},\gamma}(\theta, S) : \theta \in [0,1]\}$$

where $F_{a,\widehat{S},\gamma}(\theta, S) = (1-\theta)^\alpha [\Phi_{a,\widehat{S}}(\theta S)]^{1+\gamma-\alpha}$. Let

$$G_{a,\widehat{S},\gamma}(S) = \max\{F_{a,\widehat{S},\gamma}(\theta, S) : \theta \in [0,1]\},$$

$$\Gamma_{a,\widehat{S},\gamma}(S) = argmax\{F_{a,\widehat{S},\gamma}(\theta, S) : \theta \in [0,1]\},$$

i.e. $\theta^* \in \Gamma_{a,\widehat{S},\gamma}(S)$ iff $G_{a,\widehat{S},\gamma}(S) = F_{a,\widehat{S},\gamma}(\theta^*, S)$, and finally,

$$H_{a,\widehat{S},\gamma}(S) = G_{a,\widehat{S},\gamma}(S) S^\alpha \text{ the maximal output} \tag{3}$$

We now give some preliminary results.

Lemma 1 *If $S \leq \widehat{S}$ then the optimal share of S for the human capital $\theta^* = 0$ (the country does not invest in education).*

Proof: Indeed, if $S \leq \widehat{S}$, then for any $\theta \in [0,1]$, $\Phi_{a,\widehat{S}}(\theta S) = 1$. Thus $F_{a,\widehat{S},\gamma}(\theta, S) = (1-\theta)^\alpha$ and the maximum is reached with $\theta = 0$. This solution is obviously unique. ■

Lemma 2 *If S is high enough, then $\theta^* \in \Gamma_{a,\widehat{S},\gamma}(S) \Longrightarrow \theta^* > 0$ (i.e. the country will invest in education).*

Proof: Take some $\theta \in (0,1)$. For S such that $\theta S > \widehat{S}$, then $F_{a,\widehat{S},\gamma}(\theta, S) = (1-\theta)^\alpha (1 + a(\theta S - \widehat{S}))^{1+\gamma-\alpha}$. Therefore, for S sufficiently large we have $F_{a,\widehat{S},\gamma}(\theta, S) > F_{a,\widehat{S},\gamma}(0, S) = 1$. Hence $\theta^* \in \Gamma_{a,\widehat{S},\gamma}(S) \Longrightarrow \theta^* > 0$. ■

We will show that there exists a critical value S^c, i;e, a value with the following property:

$$S < S^c \Longrightarrow \theta^* = 0,$$

and

$$S > S^c \Longrightarrow \theta^* \in (0,1).$$

Proposition 1 *The critical value S^c exists.*

Proof: Let $B = \{S \geq 0 : G_{a,\widehat{S},\gamma}(S) = \Phi(0)^{1+\gamma-\alpha} = 1\}$. It is easy to check that B is compact and non empty(0 and $\widehat{S}$ belong to B). Let $S^c = \max\{S : S \in B\}$. We claim that S^c is the critical value.
Let $\widehat{S} < S < S^c$. Observe that $G_{a,\widehat{S},\gamma}(S) \geq 1$ for all S. Since $F_{a,\widehat{S},\gamma}(\theta, S) \leq F_{a,\widehat{S},\gamma}(\theta, S^c)$, we have $G_{a,\widehat{S},\gamma}(S) \leq G_{a,\widehat{S},\gamma}(S^c) = 1$, hence $G_{a,\widehat{S},\gamma}(S) = 1$ and $0 \in \Gamma_{a,\widehat{S},\gamma}(S)$. Assume there exists another $\theta_1 \in \Gamma_{a,\widehat{S},\gamma}(S)$. Since $G_{a,\widehat{S},\gamma}(S) = F_{a,\widehat{S},\gamma}(\theta_1, S)$, θ_1 must be greater than $\frac{\widehat{S}}{S}$ (see Lemma 1). Let $S < S' < S^c$. Then we have a contradiction

$$1 = G_{a,\widehat{S},\gamma}(S') \geq F_{a,\widehat{S},\gamma}(\theta_1, S') > F_{a,\widehat{S},\gamma}(\theta_1, S) = G_{a,\widehat{S},\gamma}(S) = 1.$$

Thus $\theta_1 = 0$. We have shown there exists a unique solution θ^* which equals 0. Now consider the case $S > S^c$. From the very definition of S^c, we have $\theta^* > 0$. Obviously, $\theta^* < 1$ (if not the output equals 0!) ■

The following proposition shows that the critical value decreases when the threshold $\widehat{S}$ decreases or/and if the quality of the education technology measured by a increases or/and the externality parameter γ increases.

Proposition 2 *(a) If $\widehat{S}$ decreases then S^c decreases*
(b) If a increases then S^c decreases.
(c) If γ increases then S^c decreases.

Proof: (a) The function $\Phi_{a,\widehat{S}}$ increases when $\widehat{S}$ decreases. That implies, $\forall S$, $G_{a,\widehat{S}',\gamma}(S) \geq G_{a,\widehat{S},\gamma}(S)$ if $\widehat{S}' < \widehat{S}$. If S'^c, S^c are the critical values associated with $\widehat{S}'$ and $\widehat{S}$, then $1 = G_{a,\widehat{S}',\gamma}(S'c) = G_{a,\widehat{S},\gamma}(S^c)$. Now, if $S'^c > S^c$ then we have a contradiction

$$1 = G_{a,\widehat{S}',\gamma}(S'c) \geq G_{a,\widehat{S},\gamma}(S'c) > G_{a,\widehat{S},\gamma}(S^c) = 1.$$

(b) We have $\Phi_{a,\widehat{S}}(S) \geq \Phi_{a',\widehat{S}}(S)$ if $a > a'$. By the same argument we find that $S^c < S'^c$ if $a > a'$.
(c) Since $F_{a,\widehat{S},\gamma}$ increases in γ, $G_{a,\widehat{S},\gamma}$ also increases in γ. The same argument as in (a) applies to have: γ increases $\Longrightarrow S^c$ decreases. ■

Remark 1 *Obviously, when $\widehat{S} = 0$, then S^c disappears. The country always invest in education.*

3 Corruption in Education and Economic Growth

We will now explore whether we may have growth in presence of corruption in the education sector. For this, we consider an intertemporal optimal growth model with a representative consumer. She has a utility function given by the quantity $\sum_{t=0}^{+\infty} \beta^t u(c_t)$ where c_t is her consumption at date t. At each period t, she saves S_{t+1} to invest, for the next period $t+1$, in physical capital k_{t+1} and in expenditures S^1_{t+1} for the human capital. The education technology is given by a function Φ (from now on, we will drop the superscripts in the function Φ, F, G, H...) defined by relations (1), (2), (3). Formally, we want to solve

$$\max \sum_{t=0}^{+\infty} \beta^t u(c_t), \text{ with } 0 < \beta < 1,$$

under the constraints

$$\text{for any period } t, \ c_t + S_{t+1} \leq h_t^\gamma k_t^\alpha (h_t)^{1-\alpha},$$

$$k_t + S_t^1 = S_t; \ h_t = \Phi(S_t^1)$$

and $S_0 > 0$ is given.

This problem actually is equivalent to

$$\max \sum_{t=0}^{+\infty} \beta^t u(c_t)$$

under the constraints

$$\text{for any period } t, \ c_t + S_{t+1} \leq H(S_t) \text{ and } S_0 > 0 \text{ is given .}$$

The function H is defined by relation (3).
For the remaining of the paper we will assume u strictly concave, $u'(0) = +\infty$. Let S^s be defined by $\alpha(S^s)^{\alpha-1} = \frac{1}{\beta}$. We have the following proposition.

Proposition 3 *(a) Assume $S^c > S^s$. Then if $S_0 < S^c$ then the optimal path $\{S_t^*\}_{t=0,\ldots,+\infty}$ converges to S^s and the country will never invest in education.*

(b) Assume $S^c < S^s$. Then the optimal path $\{S_t^*\}$ is increasing and there exists some T such that for any $t \geq T$ the country will invest in education.

(c) Assume $S^c < S^s$ and $\gamma > \alpha$. Then, when a is high enough (good quality of education technology), the optimal $\{S_t^*\}$ will converge to $+\infty$ (the economy grows without bound).

(d) Let a be fixed. Assume $S^c < S^s$ and $\gamma > \alpha$. Then when γ is high enough, the optimal $\{S_t^*\}$ will converge to $+\infty$. In other words, even in presence of corruption, the country takes off if the externality effect of the human capital is high.

Proof: (a) For $S \leq S^c$ we have $H(s) = S^\alpha$. In this case, if $S_0 < S^c$, the optimal path will converge to the steady state S^s (see Le Van and Dana, 2005).

(b) Since when $S < S^c$, $H(S) = S^\alpha$, the optimal path cannot converge to zero (see Le Van and Dana, 2005) and hence is increasing. Since $S^c < S^s$, it cannot converge to S^s and will pass over S^c at some date T. Thus for any $t > T$, the economy will invest in education (see Proposition 1).

(c) When $S > S^c$, one can check that $\theta^* = \frac{(1+\gamma-\alpha)aS+(a\widehat{S}-1)\alpha}{aS(1+\gamma)}$. Using the envelope theorem, we find

$$H'(S) = (\frac{\alpha}{1+\gamma})^\alpha(1+\gamma-\alpha)a^{1-\alpha}[1+a\theta^*S-a\widehat{S})]^{\gamma-\alpha}\ [1+aS-a\widehat{S})]^\alpha$$

for any $S > S^c$. Then $H'(S) \geq (\frac{\alpha}{1+\gamma})^\alpha(1+\gamma-\alpha)a^{1-\alpha}$, since $\theta^* \leq 1$ and $\theta^*S - \widehat{S} > 0$. If the optimal sequence $\{S_t^*\}$ which is increasing, converges to a steady state $\bar{S}$ then $H'(\bar{S}) = \frac{1}{\beta}$. But when a converges to $+\infty$, $H'(\bar{S})$ goes also to infinity: a contradiction. Hence, the optimal sequence $\{S_t^*\}$ will converge to $+\infty$ when a is large enough.

(d) Since $H'(S) \geq (\frac{\alpha}{1+\gamma})^\alpha(1+\gamma-\alpha)a^{1-\alpha}$, $H'(S)$ converges to infinity if γ does too. Apply the argument in (c). ■

Remark 2 *Observe that if* $1 - a\widehat{S} > 0$ *then* θ^* *is an increasing function of* S. *In the long term,* θ^* *will converge to* $\frac{(1+\gamma-\alpha)}{(1+\gamma)}$ *which is larger than the share devoted to physical capital* $1-\theta^* = \frac{\alpha}{1+\gamma}$ *if* $2\alpha < 1+\gamma$. *This condition must be satisfied with empirical data because usually* α *is around* $\frac{1}{3}$.

4 To Fight the Corruption and Economic Growth

In this section we suppose the country wants to fight the corruption. The expenses for this task is S^2. We have the budget constraint $k + S^1 + S^2 = S$. We assume that the threshold is described by the function $\widehat{S} = \Psi(S, S^2)$, where Ψ is a decreasing function in S^2 and in S (given S, the level of corruption diminishes if we devote more S^2; given S^2, it decreases if the country is richer, i.e. S is high). We assume that $\Psi(S, .)$ is convex, $\Psi(S,0) > 0, \Psi(S,+\infty) = 0$, the derivative with respect to S^2, $\Psi_2(S,S^2)$ is increasing in S. And finally, $\Psi_2(S,0) < -1$, given $\sigma > 0$,$\lim_{S\to+\infty}\Psi_2(S,\sigma) > -1$ (such a function exists, e.g., $\Psi(S,\sigma) = \frac{1}{S+\sigma^\mu+1}$, $0 < \mu < 1$).

Let $\Phi_S(S^1, S^2)$ be defined as follows:

$$\Phi_S(S^1,S^2) = 1,\ \text{if}\ S^1 \leq \Psi(S,S^2),\ \text{and}$$

$$\Phi_S(S^1,S^2) = 1 + a(S^1 - \Psi(S,S^2)),\ \text{if}\ S^1 \geq \Psi(S,S^2).$$

Let $\Delta = \{(x,y) \geq 0 : x + y \leq 1\}$. Given S, S^1, S^2 with $S^1 + S^2 \leq S$, define $(\theta^1, \theta^2) \in \Delta$ by $S^1 = \theta^1 S$, , $S^2 = \theta^2 S$. Our problem is to find $\theta^1(S), \theta^2(S)$ which maximize $(1-\theta^1-\theta^2)^\alpha\Phi_S(\theta^1 S, \theta^2 S)^{1+\gamma-\alpha}$, under the constraint $(\theta^1,\theta^2) \in \Delta$.

Lemma 3 *There exists S^c such that*

$$S < S^c \Rightarrow \theta^1(S) = \theta^2(S) = 0,$$

$$S > S^c \Rightarrow \theta^1(S) > 0,\ \theta^2(S) > 0.$$

Proof: The function $S \to \Psi(S,S)$ decreases from $\Psi(0,0)$ to 0 when S goes from 0 to $+\infty$. Let $\underline{S}$ be the unique solution to $S = \Psi(S,S)$. We claim that $S < \underline{S}$ implies $\theta^1(S) = \theta^2(S) = 0$. Indeed, if $S < \underline{S}$, then

$$\Psi(S, \theta^2 S) \geq \Psi(S,S) > S \geq \theta^1 S \text{ and } \Phi_S(\theta^1 S, \theta^2 S) = 1.$$

The optimal values $\theta^1(S), \theta^2(S)$ must equal 0.
Now, fix $(\widetilde{\theta}^1, \widetilde{\theta}^2)$ in the interior of Δ. Let $\widetilde{S}^1 = \widetilde{\theta}^1 S$, $\widetilde{S}^2 = \widetilde{\theta}^2 S$. Then $\Phi_S(\widetilde{S}^1, \widetilde{S}^2)$ converges to $+\infty$ when S converges to $+\infty$. Hence

$$\max_{(\theta^1,\theta^2)\in\Delta} (1-\theta^1-\theta^2)^\alpha \Phi_S(\widetilde{\theta}^1 S, \widetilde{\theta}^2 S)^{1+\gamma-\alpha} \geq (1-\widetilde{\theta}^1-\widetilde{\theta}^2)^\alpha \Phi_S(\widetilde{S}^1, \widetilde{S}^2)^{1+\gamma-\alpha} > 1$$

for any S large enough. This excludes $\theta^1(S) = 0$.

Let

$$\Gamma(S) = \max_{(\theta^1,\theta^2)\in\Delta} (1-\theta^1-\theta^2)^\alpha \Phi_S(\theta^1 S, \theta^2 S)^{1+\gamma-\alpha}$$

and

$$S_* = \sup\{\underline{S} : S < \underline{S} \Rightarrow \Gamma(S) = 1\},$$

$$S^* = \inf\{\bar{S} : S \geq \bar{S} \Rightarrow \Gamma(S) > 1\}.$$

One can check that $S_* = S^*$. Take $S^c = S_* = S^*$.

We now prove that $\theta^2(S) > 0$ if $S > S^c$. For short, write θ^1, θ^2 instead of $\theta^1(S)$, $\theta^2(S)$. If $\theta^2 = 0$, we the have the following First-Order Conditions (FOC):

$$\begin{aligned} \frac{(1+\gamma-\alpha)aS}{1+a(\theta^1 S - \widetilde{S})} - \frac{\alpha}{1-\theta^1} &= 0 \\ -\frac{(1+\gamma-\alpha)aS\Psi_2(S,0)}{1+a(\theta^1 S - \widetilde{S})} - \frac{\alpha}{1-\theta^1} &\leq 0. \end{aligned}$$

This implies $\Psi_2(S,0) \geq -1$: a contradiction with our assumptions. Hence $\theta^2 > 0$. ■

Lemma 4 *Let $S > S^c$. The optimal value for S^2 is given by the equation $\Psi_2(S, S^2) = -1$. It is an increasing function in S. The optimal values for k and S^1 are also increasing functions in S. When S goes to infinity, $S^2(S)$ goes to infinity too and hence $\widehat{S}$ goes to zero, where $S^2(S)$ denotes the optimal value for S^2, given S.*

Proof: The FOC conditions will be:

$$\begin{aligned}\frac{(1+\gamma-\alpha)aS}{1+a(\theta^1 S-\Psi_2(S,\theta^2 S))}-\frac{\alpha}{1-\theta^1-\theta^2} &= 0\\ -\frac{(1+\gamma-\alpha)aS\Psi_2(S,\theta^2 S)}{1+a(\theta^1 S-\Psi_2(S,\theta^2 S))}-\frac{\alpha}{1-\theta^1-\theta^2} &= 0.\end{aligned}$$

This implies $\Psi_2(S,\theta^2 S)=-1$, i.e. $\Psi_2(S,S^2(S))=-1$. It is easy to check that the optimal value $S^2(S)$ increases with S. The optimal value $k(S)$ is given by the problem $\max_k\{k^\alpha[\Phi(\zeta(S)-k]^{1+\gamma-\alpha}\}$ under the constraint $0\leq k\leq\zeta(S)$, with $\zeta(S)=S-S^2(S)-\Psi(S,S^2(S))$ which is increasing in S. In view of the form of the function Φ, one can check that the function $\{k^\alpha[\Phi(\zeta(S)-k]^{1+\gamma-\alpha}$ is supermodular in k,S. Using an argument in Amir (1996), we obtain that $k(S)$ is increasing in S ($k(S)$ denotes the optimal value of k. We let to the reader check that the optimal value $S^1(S)$ is also increasing in S.

We now prove that the optimal value $S^2(S)$ converges to $+\infty$ when S converges to infinity. Indeed, if it is not the case, since $S^2(S)$ is increasing in S, we can suppose that it converges to some $\bar{S}<+\infty$. Since $\Psi_2(S,S^2(S))=-1$ for any S, if $\varepsilon>0$ is small enough, we obtain $\lim_{S\to+\infty}\Psi_2(S,\bar{S}-\varepsilon)\leq-1$ which contradicts the assumption that $\lim_{S\to+\infty}\Psi_2(S,\sigma)>-1$ for any $\sigma>0$. ■

Let $L(S)=\max_{k,S^1,S^2}\{k^\alpha[1+\Phi(S^1)]^{1+\gamma-\alpha}\}$ under the constraints $k+S^1+S^2=S$ and $\widehat{S}=\Psi(S,S^2)$. $L(S)$ is the maximum output obtained from S. The optimal growth model is:

$$\max\sum_{t=0}^{+\infty}\beta^t u(c_t)$$

under the constraint : for any period t, $c_t+S_{t+1}\leq L(S_t)$, and $S_0>0$ is given. We can define as in Section 2 the critical value S^c as

$$S^c=\max\{S: L(S)S^\alpha\}.$$

Let us recall S^s which is defined in Section 2: $\alpha(S^s)^{\alpha-1}=\frac{1}{\beta}$. We now give the main result of this section

Proposition 4 *Assume $S^c<S^s$ and $\gamma>\alpha$. If either a or γ is high enough then the optimal S_t^* (which is increasing) will converge to infinity and the threshold $\widehat{S}$ converges to zero (the corruption disappears in the long term.*

Proof: As in Proposition 3 (b), the optimal path is increasing since $S^c<S^s$. Computing the derivative of the function L, one can show, as in Proposition 3 (d), that $L'(S)$ is uniformly bounded from below by a quantity which converges to $+\infty$ if either a or γ converges to infinity too. Therefore, when these parameters are high enough, the optimal path $\{S_t^*\}$ converges to infinity. In particular, the optimal sequence $\{S_t^{2*}\}$ converges also to infinity and hence $\widehat{S}$ goes to zero (see Lemma 4). ■

5 Empirical Evidence

The data are provided in Xavier Sala-i-Martin, Gernot Doppelhofer, and Ronald I. Miller (2004). They examine the robustness of a wide range of 67 explanatory variables in cross-country economic growth regressions. We take a basic specification where average growth rate of GDP per capita between 1960 and 1996 is explained by the most robust explanatory variables according to their analysis, that is the relative price of investment *iprice1*, the logarithm of the initial level of real GDP per capita *gdpch60l*, and primary school enrolment *p60*. A alternative specification is the same growth equation with public education spending share in GDP in 1960s *geerec1* replacing primary school enrolment *p60*. For testing the implication of the model, namely that the return of the investment in education can be cancelled by corruption up to a critical size, we interact primary school enrolment *p60* and public education spending *geerec1* with corruption or with the following governance indicators (see Kaufman *et alii*) for the year 1996:

- *Va96*: Voice and Accountability - measuring political, civil and human rights;
- *Pol96*: Political Instability and Violence - measuring the likelihood of violent threats to, or changes in, government, including terrorism;
- *Gov96*: Government Effectiveness - measuring the competence of the bureaucracy and the quality of public service delivery;
- *Reg96*: Regulatory Burden - measuring the incidence of market-unfriendly policies;
- *Rul96*: Rule of Law - measuring the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence;
- *Corr96*: Control of Corruption - measuring the exercise of public power for private gain, including both petty and grand corruption and state capture.

$$gr6095_i = b_1 + b_2\ iprice1_i + b_3\ p60_i + b_4\ (p60 * inst96)_i + b_5\ gdpch60l_i + \varepsilon_i \quad (4)$$

$$gr6095_i = b_1 + b_2\ iprice1_i + b_3\ geerec1_i + b_4\ (geerec1 * inst96)_i + b_5\ gdpch60l_i + \varepsilon_i \quad (5)$$

The value of each indicator[2] varies from -2.5 to 2.5, an higher value indicating a better institutional situation. Corruption has many definitions, which can be related to those indicators. According to Ritva Reinikka and Jakob Svensson

[2]As explained in Kaufmann, Kraay, and Mastruzzi (2004)

(2005), corruption is defined as the lack of information and transparency in delivering education services. The lack of information and transparency can be proxied by the quality of the service delivered (*Gov96*) and the quality of contract enforcement (*Rul96*). De la Croix and Delavallade (2006) emphasize how corruption can distort the composition of public spending, by favoring sectors where rent seeking can be achieved more easily. Government effectiveness (*Gov96*) and regulatory burden (*Reg96*) can be used for measuring the extent of this distorsion due to rent seeking and corruption. Our own definition of corruption in the previous section is the negative externality on growth, which can be explained either by the variable control of corruption (*Corr96*) or by any dimension of public and private governance in the educational system, likely to lower the quality in delivering education services.

As can be seen from the interacted variables in tables 4 to 9, and tables 10 to 15, good institutions enhance growth by increasing the positive return to education (public spending on education or primary schooling). Table 1 reports the increase in the average rate of growth induced by an improvement in the institutional variable from its average value to the average value plus twice the standard error. All variables are taken at their mean value. Figures in the first (second) column are calculated using coefficients from equation 4 (respectively equation 5). Finally tables 2 and 3 provide cross countries comparisons. What would have been growth in country x if the quality of a given institution had augmented by the average value plus twice the standard error, and in which developed country y do we observe the rate of growth implied by such an institutional improvement?

According to Tables 1 and 2, column A, an improvement in the *Voice and Accountability* variable implies an increase in the rate of growth from 1,58% - which is the rate of growth of Nepal, where the score of *Voice and Accountability* is relatively low (0,14) - to 2,23%, which is close to the rate of growth of Canada and that of the United States, where the scores of *Voice and Accountability* reflect an higher level of political, human and civil rights (respectively 1,44 and 1,53). The implied increase in growth 0,65% would have allowed Senegal to get a non-negative rate of growth. Table 1, column B, tells that an improvement in *Political Instability and Violence* induces an increase in growth from 1,58% (Nepal) to 2,55% (West Germany). In Nepal *Political Instability* is -0,35, in West Germany the score stands at 1,31. The economy of Liberia, which declined over the period at -0.87%, would have stagnated.

A better control of corruption doubles the rate of growth *via* a better return to education, from 1,56% to 2,92% according to equation 4 (column A in Table 1), and 3,56% to 4,82% according to equation 5 (column B in Table 1). Efficiently fighting against corruption would have allowed Ecuador to reach the same rate of growth as Austria (Table 2), and Greece or Spain to reach the same rate of growth as Japan.

Table 1: *Impact of Institutions on Growth corresponding growth computed with 4:(column A) corresponding growth computed with 5: (column B)*

Institution	Colunm A	Colunm B
Voice and Accountability		
average value	1,58%	1,75%
average value plus twice the standard error	2,23%	1,75%
implied increase in growth	0,65%	0,00%
Political Instability and Violence		
average value	1,55%	1,58%
average value plus twice the standard error	2,60%	2,55%
implied increase in growth	1,05%	0,97%
Government Effectiveness		
average value	1,42%	1,13%
average value plus twice the standard error	3,02%	2,77%
implied increase in growth	1,60%	1,64%
Regulatory Burden		
average value	1,44%	3,46%
average value plus twice the standard error	2,87%	4,91%
implied increase in growth	1,43%	1,45%
Rule of Law		
average value	1,47%	1,04%
average value plus twice the standard error	3,01%	2,60%
implied increase in growth	1,54%	1,56%
Control of Corruption		
average value	1,56%	3,56%
average value plus twice the standard error	2,92%	4,82%
implied increase in growth	1,36%	1,26%

The next step of this empirical study is to instrument the institutional variables for addressing the double causality running from institutions to growth and vice et versa. Variables such as the share of Protestants and former British colonies identified by Treisman (2000) are used as instruments. We use as well other variables correlated with the endogeneous explanatory variable but not with the residual of the equation, like the degree of ethnolinguistic fractionalization, fraction buddhist, fraction catholic, landlockness, oil producing country dummy, the extent of political rights, the share of primary exports in 1970. The results are mixed, while the coefficients of either public education spending or

Table 2: *Impact of Institutions on Growth: Cross countries Comparisons*

COUNTRY	GR6096	**VA96**	**Pol96**	**Gov96**	**Reg96**	**Rul96**	**Corr96**
Ecuador	1,54%	**0,06**	*-0,61*	*-0,65*	*-0,05*	*-0,39*	*-0,75*
Nepal	1,58%	**0,14**	*-0,35*	*-0,38*	*-0,22*	*-0,36*	*-0,28*
Canada	2,21%	**1,44**	*1,02*	*1,92*	*1,37*	*1,87*	*2,14*
United States	2,27%	**1,53**	*1,06*	*2,02*	*1,56*	*1,79*	*1,71*
Senegal	-0,67%	**-0,17**	*-0,67*	*-0,40*	*-0,45*	*-0,17*	*-0,39*
Ecuador	1,54%	*0,06*	**-0,61**	*-0,65*	*-0,05*	*-0,39*	*-0,75*
France	2,63%	*1,50*	**1,03**	*1,75*	*1,18*	*1,65*	*1,39*
Liberia	-1,01%	*-1,40*	**-2,42**	*-2,19*	*-2,91*	*-2,15*	*-1,66*
Jordan	1,40%	*-0,16*	*0,40*	**0,18**	*0,06*	*0,20*	*-0,10*
Israel	3,03%	*1,07*	*-0,50*	**1,32**	*1,24*	*1,18*	*1,48*
Madagascar	-1,61%	*0,26*	*0,23*	**-0,64**	*-0,07*	*-0,85*	*0,37*
Angola	-1,51%	*-1,42*	*-2,17*	*-1,13*	**-1,60**	*-1,44*	*-1,00*
Uganda	1,37%	*-0,63*	*-1,19*	*-0,37*	**0,10**	*-0,88*	*-0,52*
Austria	2,89%	*1,43*	*1,38*	*1,92*	**1,51**	*1,98*	*1,66*
Congo	1,51%	*-1,23*	*-0,70*	*-1,24*	*-0,70*	**-1,27**	*-0,81*
Israel	3,03%	*1,07*	*-0,50*	*1,32*	*1,24*	**1,18**	*1,48*
Angola	-1,51%	*-1,42*	*-2,17*	*-1,13*	*-1,60*	**-1,44**	*-1,00*
Ecuador	1,54%	*0,06*	*-0,61*	*-0,65*	*-0,05*	*-0,39*	**-0,75**
Austria	2,89%	*1,43*	*1,38*	*1,92*	*1,51*	*1,98*	**1,66**
Angola	-1,51%	*-1,42*	*-2,17*	*-1,13*	*-1,60*	*-1,44*	**-1,00**

Note: Growth rates of countries selected according to the corresponding figures in Table 1 column 1.

Table 3: *Impact of Institutions on Growth: Cross countries Comparisons*

COUNTRY	GR6096	**VA96**	**Pol96**	**Gov96**	**Reg96**	**Rul96**	**Corr96**
Nepal	1,58%	*0,14*	**-0,35**	*-0,38*	*-0,22*	*-0,36*	*-0,28*
Germany, West	2,57%	*1,55*	**1,31**	*1,91*	*1,54*	*1,90*	*1,76*
Liberia	-1,01%	*-1,40*	**-2,42**	*-2,19*	*-2,91*	*-2,15*	*-1,66*
Haiti	-0,87%	*-0,46*	**-0,21**	*-1,42*	*-1,23*	*-1,23*	*-0,98*
Bangladesh	1,10%	*-0,33*	*-0,53*	**-0,67**	*-0,54*	*-0,68*	*-0,47*
Jamaica	1,13%	*0,55*	*0,64*	**-0,41**	*0,54*	*-0,21*	*-0,33*
Finland	2,72%	*1,71*	*1,45*	**1,89**	*1,50*	*2,08*	*2,23*
Madagascar	-1,61%	*0,26*	*0,23*	**-0,64**	*-0,07*	*-0,85*	*0,37*
Tunisia	3,28%	*-0,53*	*0,24*	*0,49*	**0,05**	*0,07*	*-0,05*
Japan	4,67%	*1,08*	*1,08*	*1,36*	**0,84**	*1,60*	*1,22*
Angola	-1,51%	*-1,42*	*-2,17*	*-1,13*	**-1,60**	*-1,44*	*-1,00*
Argentina	1,02%	*0,60*	*0,47*	*0,45*	*0,82*	**0,28**	*-0,12*
Costa Rica	1,02%	*1,37*	*0,89*	*0,16*	*0,68*	**0,64**	*0,76*
Sierra Leone	1,02%	*-1,37*	*-2,25*	*-0,24*	*-0,45*	**-1,02**	*-1,66*
Kenya	1,06%	*-0,48*	*-0,38*	*-0,60*	*-0,48*	**-0,77**	*-1,05*
France	2,63%	*1,50*	*1,03*	*1,75*	*1,18*	**1,65**	*1,39*
Madagascar	-1,61%	*0,26*	*0,23*	*-0,64*	*-0,07*	**-0,85**	*0,37*
Angola	-1,51%	*-1,42*	*-2,17*	*-1,13*	*-1,60*	**-1,44**	*-1,00*
Greece	3,43%	*0,98*	*0,42*	*0,76*	*0,80*	*0,78*	**0,37**
Spain	3,55%	*1,15*	*0,64*	*1,59*	*1,16*	*1,23*	**0,77**
Japan	4,67%	*1,08*	*1,08*	*1,36*	*0,84*	*1,60*	**1,22**
Nicaragua	-1,14%	*-0,22*	*-0,66*	*-0,46*	*-0,21*	*-0,68*	**-0,15**

Note: Growth rates of countries selected according to the corresponding figures in Table 1 column 2.

primary schooling in 1960 are no more significant, institutions interacted with education still matter. More importantly, the Hausman tests do not reject the null hypothesis telling that institutions are exogeneous[3] . Therefore we rest on the previous results.

6 Conclusion

This paper provides an endogeneous optimal growth model for explaining the impact of corruption within the education sector. Human capital is produced through a non-linear education technology. The non-linearity is due to a fixed cost, above which investment in education yields a positive return. Below the threshold, investment in human capital does not produce any return. While a great deal of models emphasizes the consequences of corruption and more generally of low quality institutions on total factor productivity, our model focuses on the effect of corruption on the return to education. Its implication is tested using the dataset collected by Xavier Sala-i-Martin, Gernot Doppelhofer, and Ronald I. Miller (2004). Empirical analysis supports the idea that corruption decreases the return to education.

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[3] stata results and tests are available upon request

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Table 4: *Growth, Education,Voice and Accountability*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000992	0,0000341	-2,91	0,004
p60	0,0353232	0,0081749	4,32	0
p60*va96	0,004709	0,0027339	1,72	0,088
gdpch60l	-0,0063468	0,0037929	-1,67	0,097
cons	0,0469749	0,0243959	1,93	0,057

Table 5: *Growth, Education,Political Instability*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000943	0,0000327	-2,89	0,005
p60	0,0341149	0,0080684	4,23	0
p60*pol96	0,0073202	0,0021288	3,44	0,001
gdpch60l	-0,0063931	0,0030804	-2,08	0,04
cons	0,0477959	0,019669	2,43	0,017

Table 6: *Growth, Education,Government Effectiveness*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000814	0,0000316	-2,58	0,011
p60	0,0339602	0,008182	4,15	0
p60*gov96	0,0108602	0,0019763	5,5	0
gdpch60l	-0,0107624	0,0035889	-3	0,003
cons	0,0764289	0,0225627	3,39	0,001

Table 7: *Growth, Education,Regulatory Framework*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000763	0,0000314	-2,43	0,017
p60	0,0321337	0,0079129	4,06	0
p60*reg96	0,0105224	0,002637	3,99	0
gdpch60l	-0,0082551	0,0032012	-2,58	0,011
cons	0,0590293	0,0201235	2,93	0,004

Table 8: *Growth, Education,Rule of Law*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000853	0,000031	-2,76	0,007
p60	0,0352735	0,0083265	4,24	0
p60*rul96	0,0104869	0,0021306	4,92	0
gdpch60l	-0,0104191	0,003617	-2,88	0,005
cons	0,0738549	0,0227306	3,25	0,002

Table 9: *Growth, Education,Corruption*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0000969	0,0000347	-2,79	0,006
p60	0,037631	0,0103372	3,64	0
p60*cor96	0,009314	0,0022544	4,13	0
gdpch60l	-0,0108246	0,0044067	-2,46	0,016
cons	0,0771738	0,0272839	2,83	0,006

Table 10: *Growth, Education,Voice and Accountability*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0001292	0,0000292	-4,43	0
geerec1	0,3490316	0,1867135	1,87	0,064
geerec1*va96	0,1385323	0,1002374	1,38	0,17
gdpch60l	-0,000103	0,0027416	-0,04	0,97
cons	0,0211327	0,021211	1	0,321

Table 11: *Growth, Education,Political Instability*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0001257	0,0000288	-4,36	0
geerec1	0,3336531	0,1766379	1,89	0,062
geerec1*pol96	0,1899536	0,0653656	2,91	0,004
gdpch60l	0,0001036	0,001982	0,05	0,958
cons	0,0197635	0,0154056	1,28	0,202

Table 12: *Growth, Education,Government Effectiveness*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,000104	0,0000278	-3,74	0
geerec1	0,1816014	0,1690278	1,07	0,285
geerec1*gov96	0,3162868	0,074646	4,24	0
gdpch60l	-0,0041113	0,0023364	-1,76	0,081
cons	0,0504734	0,0182065	2,77	0,007

Table 13: *Growth, Education,Regulatory Framework*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0001066	0,0000277	-3,86	0
geerec1	0,3006736	0,1621821	1,85	0,067
geerec1*reg96	0,301736	0,0693875	4,35	0
gdpch60l	-0,0025102	0,0021683	-1,16	0,25
cons	0,0365615	0,0163639	2,23	0,028

Table 14: *Growth, Education,Rule of Law*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0001181	0,0000247	-4,79	0
geerec1	0,2317087	0,1652191	1,4	0,164
geerec1*rul96	0,3022762	0,0723724	4,18	0
gdpch60l	-0,0036263	0,0022362	-1,62	0,108
cons	0,0472594	0,0173093	2,73	0,007

Table 15: *Growth, Education,Corruption*

gr6096	Coefficient	Std Err	T-Stat	P> $\|t\|$
iprice1	-0,0001201	0,0000308	-3,9	0
geerec1	0,2547736	0,2022274	1,26	0,211
geerec1*cor96	0,2449854	0,0845091	2,9	0,005
gdpch60l	-0,0033518	0,0027593	-1,21	0,228
cons	0,0462569	0,0211743	2,18	0,031