Education, Corruption and Growth in developing countries *

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Abstract

Krueger and Lindahl (2001) has emphasized that education is the key factor in explaining growth. But what can explain the fact that the growth might still be missing in developing countries with a certain level of education? Corruption, poor enforcement of property rights, share of government spending in GDP and government's regulations might affect the Total Factor Productivity (TFP) of a country's economy. A number of empirical papers emphasize the consequences that bad institutions have on the growth, but few are examining the link between education, corruption (more generally bad institutions) and growth. Because of corruption, our model assumes that when the education spendings are below some critical value, education has no impact on the growth of human capital. We also assume that this critical value increases with the level of corruption. We test the infuences of the main factors, i.e. human capital investments and corruption level, by using the data set of Xavier Sala-i-Martin et al. (2004) which is extended with the aggregate governance indicators of Kaufman et al. (2006).

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1 Introduction

From Mankiw, Romer and Weil (1992, MRW thereafter), everybody will agree that education is the key factor in explaining growth, and that differences in human capital can explain persistent differences in level of national income 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 undecided, as argued by Temple (2001). MRW (1992) has been criticized for : (i) to omit potentially important concurrent explanatory variables, (ii) to overestimate the relationship between investment in education and private returns on it which might be much smaller when using micro-data, and (ii) to have selected a bad proxy for investment in human capital. But what are the omitted variables that could explain the lack of growth in developing countries and the persistence of unequal trajectories, even in presence with education? A possible answer relies on institutions, as defined by North (1990): the government enforcement of property rights, the share of public spendings in GDP, the regulations the goverment imposes are likely to influence the Total Factor Productivity (TFP thereafter) of the economy.

A number of empirical papers emphasize the consequences that bad institutions have on growth: ee e.g. Barro (1997), Hall and Jones (1999) Acemoglu and al. (2001). 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 how far is a representative worker from the maximum production possibility frontier depends upon corruption, which is itself a product of institutions. In his setting, the main ingredients of growth remain capital and unqualified and qualified labor. Bad institutions prevent a country from implementing the best policy. Our growth theory model proceeds in a slightly different way. Because of corruption, it assumes that when the education spendings are below some critical value, education has no impact on the growth of human capital. We also assume that this critical value increases with the level of corruption. We test the infuences of the main factors, i.e. human capital investments and corruption level, by using the data set of Xavier Sala-i-Martin et al. (2004) which is extended with the aggregate governance indicators of Kaufman et al. (2006).

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 away 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 larger underground economies, implying that output is likely to be underestimated, but not labor and investment. In these countries, the official TFP are lower that what they should be because of accounting reasons. Investment data might be overestimated because of bribery. This induces a downward bias against TFP. Finally an interesting argument is formalized in Breton (2004). The contribution to TFP of the share of government spending is positive up to a critical level, then becomes negative afterwards. Indeed, the basic services like enforcing the rule of law, providing necessary infrastructure, providing education and health, can be efficiently produced when the public sector is small. If not, the private sector is more efficient.

Our argument relies on the impact of corruption, not on TFP, but directly on the returns to education. Empirical investigation emphasizes the weak link between expenditure and educational outcomes, such as access to schooling and proportion of the attending schooling age population. 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 two latter 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, neither 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 the key for understanding the absent link between resources and outcomes. If the weight of the financial resources is misdirected, because of corruption, then one could expect no link between those resources and what they are supposed to produce. Corruption indeed undermines the provision of health care and education services. Fighting it might result in significant gains measured in 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 actually 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 Reinikka and Svensson (2005), the newspaper campaign in Uganda which provides schools and parents with information helping them to monitor local officials' management of a large education grant program has succeeded to reduce the money loss and to increase the enrolment and the quality of learning.

This paper is organized as followed. Sections 2, 3 and 4 propose models where corruption produces negative externalities and undermines the efficiency of education[1]. Section 5 presents the data and the 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 the corruption. The last section summarizes.

2 The One Period Model

We first consider the one period model of a developing country that produces a consumption good by using the physical capital and the efficient labor as inputs. This country has an initial endowment S. We assume that the human capital of 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. Ex-

[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.

plicitly $h = \Phi_{a,\widehat{S}}(S^1)h_0$ defined as follows:

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

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

The threshold $\widehat{S}$ represents the fixed cost due to the corruption in the education sector. For simplicity, we normalize by letting $\bar{N} = 1$ 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 invests 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. To do 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, in 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 $\Phi, F, G, H...$) 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 rest 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 Fighting 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 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 the reader to 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 asymptotically 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 $\{S_t^{2*}\}$ also converges to infinity and hence $\widehat{S}$ goes to zero (see Lemma 4). ■

5 Empirical Evidence

The data are provided in Xavier Sala-i-Martin et al. (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 are 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, i.e. 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, a higher value indicating a better institutional situation. Corruption has many definitions, which can be related to those indicators. According to Reinikka and Svensson (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. In the previous section, we gave our own definition of corruption which 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, which likely to lower the quality in delivering education services.

As can be seen from the interacted variables in tables 4 to 6 and tables 7 to 12, good institutions enhance growth by increasing the positive return to education (public spending on education or primary schooling). Table 1 shows increases in the average rate of growth induced by an improvement in the institutional variable when it changes 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-country 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

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

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). Efficient 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.

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-versa. Variables such as the share of Protestants and former British colonies identified by Treisman (2000) are used as instruments. We also use other variables that are correlated with the endogenously explanatory variable but not with the residual of the equation, like the degree of ethnolinguistic fractionalization, fraction buddhist, fraction catholic, landlockedness, 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 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 indicating that institutions are exogeneous[3] . Therefore we rest on the previous results.

6 Conclusion

This paper provides an endogenous 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 data set collected by Xavier Sala-i-Martin et al. (2004). Empirical analysis supports the idea that corruption decreases the returns to education.

[3] Stata results and tests are available upon request

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

Institution	Column A	Column 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%

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 are selected according to the corresponding figures in Table 1 column A.

Table 3: *Impact of Institutions on Growth: Cross-country 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.

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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

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

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

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

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 5: *Growth, Education, Rule of Law*

Table 6: *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 7: *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 8: *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 9: *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 10: *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 11: *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 12: *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