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The macroeconomic implications of corruption in the choice to educate

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ABSTRACT

Educational corruption is a worldwide phenomenon, yet its macroeconomic implications are largely unknown. We formulate a fixed-price bribe model to explore the impact educational corruption may have on growth, income inequality and other factors. When using aggregate ability as our measure of growth, our model produces a v-shaped relationship between growth and corruption, suggesting that corruption is detrimental to growth at lower levels of bribery, but growth enhancing at greater levels. A cross-section of countries is used to empirically test our model and provides qualitative support for our modeling structure. Distributional analysis reveals that an increased prevalence of corruption leads to greater income inequality and reduces the ability of education to signal quality.

1. Introduction

Corruption in educational institutions is a global phenomenon, yet its implications on the macroeconomy have largely been omitted from economic studies. While a large number of studies focus on the relationship between general corruption and economic growth (Mauro, 1995; Dzhumashev, 2014; Marakbi and Villieu, 2020; Saha and Sen, 2021),[1] educational corruption has not been thoroughly investigated despite the fact that problematic levels of educational corruption have been reported in China, Colombia, Russia, Georgia, New Zealand, Nigeria, Thailand, Afghanistan, Kenya, and more recently in the United States. MacWilliams (2002) describes one instance where a professor at a Georgian school actually distributed a price list for various types of bribes to his students.[2] In this paper, we seek to fill this void in the literature by specifically exploring the relationship between corruption in schooling and key macroeconomic factors, such as the long-run economic growth rate. We build a two-period overlapping generations model with a fixed-price bribe, where agents have the ability to bribe to gain entry into educational institutions. We find a v-shaped relationship between educational corruption and economic growth when growth is measured using aggregate ability. We also find that increased levels of corruption reduce the ability of educational institutions to signal quality in the economy.

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[1] For a comprehensive survey of the literature on general corruption and economic growth, see Ugur (2014).

[2] For a review of cases of educational corruption around the world, see Rumyantseva (2004a).

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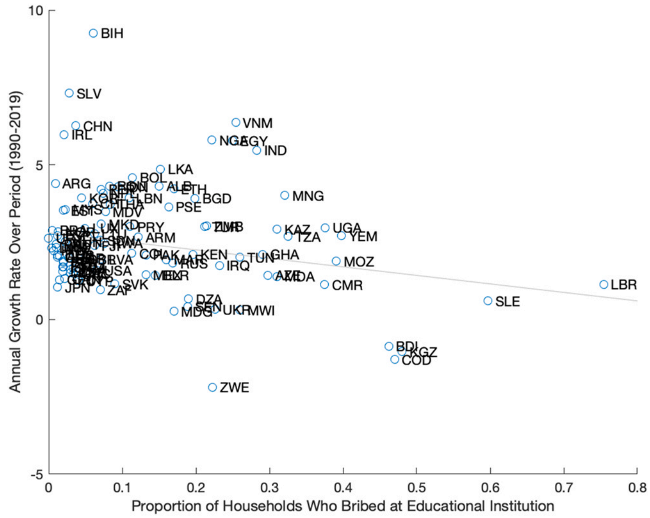


Fig. 1. Educational corruption across countries.

The literature often defines educational corruption as "the abuse of authority for personal as well as material gain" (Heyneman, 2004), suggesting that educational corruption is not solely for material gain as it also includes gains from personal advancement, such as an increase in social status. As such, students may bribe in order to avoid the selection mechanisms or quality measures in place to distinguish themselves from their fellow students with the expectations of some current or future gain. Rumyantseva (2005) further defines the "taxonomy" of educational corruption, arguing that two main types of educational corruption exist. One type involves students directly, with the potential to impact students' values, opportunities and beliefs. The other type of educational corruption does not directly involve students but indirectly affects their outcome. An example of this might be a school administrator embezzling funds from an educational institution, which reduces the resources available to students. In our study, we focus solely on educational corruption involving direct student interaction and specifically look at bribing for entrance into educational institutions.

Evidence showing the prevalence of bribery in educational institutions has been found in numerous studies. Shaw et al. (2015) find that approximately 56% of Ukrainian students bribed to enter their educational institution. Of those surveyed, women were approximately 6% more likely to have given a bribe than men. Those students who bribed on their final exams in high school were 16% more likely to bribe for entrance into college. A World Bank study revealed that in Kazakhstan, 69% percent of the students who bribed did so for entry into universities, while 10% bribed to obtain better grades (Rumyantseva, 2004b).

International data on educational corruption is available through Transparency International's Global Corruption Barometer. One component of this is particularly relevant, as it measures the proportion of households having reported bribes to educational institutions. This data is available for 100 countries and is presented in Fig. 1,[3] along with the respective average annual growth rate from 1990 through 2019. In the figure we also provide the resulting line estimated from the data using ordinary least squares, which shows that a negative association exists between the growth rate and the proportion of households bribing educational institutions.

While studies like Shaw et al. (2015) and Rumyantseva (2004b) shed some light as to the frequency and the potential determinants of educational corruption, they do not help identify the potential impact educational corruption has on economic growth, nor do they provide us with an analytical framework for studying corruption in education. It is therefore the goal of this paper to provide that framework, thus allowing us to say something about the economic impacts of educational corruption.

The potential hindrance that educational corruption poses on growth is that it allows students to bypass quality and selection metrics that are normally in place within educational institutions. The quality of education is important because it determines the quality of the labor force and therefore has impacts on productivity and innovation for a country. Hanushek and Kim (1995) explore the importance of the quality of the labor force and its impacts on economic growth and find a positive and significant relationship with economic growth for a cross-section of countries. Delgado et al. (2013) find in a nonparametric setting that educational achievement, measured by mean test scores, has a significant impact on growth. These results present evidence to support the important relationship between educational quality and economic performance.

Fershtman et al. (1996) explore the relationship between social status, education and economic growth and find that while social status plays an important role in the allocation of talent, it may lead to a decreased economic performance. Professions carrying high levels of status tend to draw people of all types of ability. Talent may be misallocated because people with high wealth levels have access to "high quality" institutions or specialized training that allow them to be employed in high status positions regardless of their ability. Furthermore, if those high wealth individuals are of low ability, then there may be a negative impact on economic growth if those high status industries are growth enhancing. The optimal distribution of talent would be allocating high ability individuals to growth-enhancing industries

[3] Further information regarding this data can be found in Section 4.

regardless of their wealth. Schools have the ability to achieve this if they are operating effectively. It is important to note that we do not state that the misallocation of talent does not occur in countries without educational corruption, only that this process is accelerated in countries that do have corruption in education. Thus, educational corruption inhibits the ability of educational establishments to act as a filter and allows high wealth low ability students to enter institutions that have better connections to positions of high status. The results of Fershtman et al. (1996) reveal another path in which educational corruption is detrimental to economic performance.

Heyneman (2004) supports the argument that educational corruption destroys the selection method that can be created by educational establishments. Klitgaard (1986) stresses the importance of basing selection into educational institutions on ability and discusses the impact of proper selection mechanisms on both efficiency and equity in educational outcomes. It is therefore easy to see how bribing the way into educational institutions can work to reduce the importance of ability in the admissions process. Pinera and Selowsky (1981) attempt to quantify the impacts of the misallocation of talent on economic performance, finding that developing countries could improve their per capita gross national product by five percentage points if they were to base their leadership on merit as opposed to gender or social status.

The purpose of this paper is to provide a theoretical framework to study the effects educational corruption has on economic growth, educational attainment, the education wage premium, and income inequality. Building on the framework developed by Fershtman et al. (1996), we develop an overlapping generations model with borrowing constraints explicitly modeling educational corruption. Educational corruption is introduced into the model by allowing agents to increase their entrance probabilities through a fixed-cost bribe. We find that as corruption becomes more prevalent, economic growth initially declines when measured using aggregate ability, before increasing with corruption. We also find that the share of income captured by skilled labor increases as corruption becomes more widespread in the economy. This is despite the overall population of skilled laborers remaining roughly constant and their average ability decreasing. Furthermore, as educational corruption increases, this leads to a convergence of average ability across occupations, thus reducing the ability of education to serve as a reliable signal of ability in the economy. We provide empirical evidence that qualitatively supports our modeling structure.

The remainder of the paper is structured as follows. In Section 2, we develop an overlapping generations model of educational corruption. Section 3 describes the simulation exercise and its results. We conduct an empirical verification of the model's implications in Section 4. Section 5 concludes.

2. Model

Here we formulate an overlapping generations model of educational corruption with fixed-price bribing. Our economy is populated by a continuum of households of mass 1, and a representative firm. The intuition and setup of the model is similar to Fershtman et al. (1996). In their model, they assume agents can choose to go to school or not, and if an agent decides to go to school, they automatically get in. In our model, agents do not know with certainty if they will join the educated workforce but instead face a probability of being accepted into the educational institution. Households not only give up wage earnings by going to school, but they can also bribe in order to increase their chance of entering an educational institution.

2.1. Households

Agents are assumed to live for two periods and are heterogeneous in two dimensions – innate ability, μ_t^t, and asset holdings (wealth), a_t^t. Thus, we denote the distribution of time t agents at time t by the density function $f_t^t(\mu_t^t, a_t^t)$. We assume that the distribution of time t agents is time invariant, such that each new generation is born identically distributed in terms of their asset holdings and innate ability.[4] When agents are born, they choose to pursue schooling, conditional upon their acceptance, or not to pursue schooling. If an agent decides not to go to school, he or she immediately joins the labor force and becomes a laborer (l), earning the market wage w_t^l for that period. We further assume that if they decide not to go to school, they remain laborers for the remainder of their life. If an agent decides to go to school they face a probability $\pi(m)$ of getting in and becoming a manager (m) in the second period of their life. If they become a manager, they will receive a wage of $w_{t+1}^m \mu_t^{t+1}$. Therefore, agents who become managers get paid the market wage as well as an ability premium. Modeling labor income in this way produces a positive relationship between labor income and ability, which is consistent with empirical labor market outcomes.

The way we model educational corruption is to allow students to pay a fixed-cost bribe z_t^t, which increases their probability of entry into school. Thus agents who decide to go to school face the probability $1 - \pi(m)$ of not getting in and becoming a laborer in the second period of their life. If an agent does not get into school, he or she receives a wage of w_{t+1}^l in the second period of life. Agents choose over current consumption c_t^t, future consumption c_t^{t+1}, and asset holdings a_t^{t+1}. The *gross* return on assets is defined endogenously as R_{t+1}. It is also assumed that agents receive status from their respective occupations, which we denote as S_s^{t+1} for $s \in [m, l]$.

An agent who decides to attempt to go to school must choose the following: a_t^{t+1}, c_t^t, z_t^t, and c_t^{t+1}. Thus an agent who attempts to attend school must choose over future contingent claims to consumption in addition to time t variables because his or her future is not known with certainty. The Bellman equation facing the agents in the economy can be expressed as follows:

$$V(a_t^t, \psi_t^t, \mu_t^t) = \max_{\chi_t^t \in \{0,1\}} [\max_{a_t^{t+1}, c_t^t} \{u(c_t^t, c_t^{t+1}, S_l^{t+1}) + \beta V(a_t^{t+1}, \psi_t^{t+1}, \mu_t^{t+1})\},$$

$$\max_{a_t^{t+1}, c_t^t, z_t^t} \{u(c_t^t, c_t^{t+1}, S_s^{t+1}) + E_t \beta V(a_t^{t+1}, \psi_t^{t+1}, \mu_t^{t+1})\}] \tag{2.1}$$

[4] It would be interesting to investigate the endogenous distribution of young agents, but this complicates the model and requires one to make an assumption about the evolution of ability across generations.

subject to:

$$u(c_t^t) = \frac{c_t^{t1-\eta}}{1-\eta} \tag{2.2}$$

$$u(c_t^{t+1}, S_s^{t+1}) = \frac{c_t^{t+11-\eta}}{1-\eta} + \frac{S_m^{t+11-\eta}}{1-\eta} I(\psi_t^{t+1} = m) + \frac{S_l^{t+11-\eta}}{1-\eta}(1 - I(\psi_t^{t+1} = m)) \tag{2.3}$$

$$c_t^t + a_t^{t+1} + z_t^t I(\chi_t^t = 1) \le R_t a_t^t + w_t^l (1 - I(\chi_t^t = 1)) \tag{2.4}$$

$$c_t^{t+1} \le R_{t+1} a_t^{t+1} + w_{t+1}^m \mu_t^{t+1} I(\psi_t^{t+1} = m) + w_{t+1}^l (1 - I(\psi_t^{t+1} = m)) + h_t^{t+1} I(\kappa) \text{w. p. } \pi(m) \tag{2.5}$$

$$a_{\min} \le a_t^{t+1} \tag{2.6}$$

where χ_t^t is the choice *not to attempt* ($\chi_t^t = 0$) or *to attempt* schooling at time t ($\chi_t^t = 1$). If $\kappa = 1$, then the aggregate bribes in the economy are evenly distributed to the old generation, who receive them as a gift (h_{t+1}). Solving the maximization problem above produces the policy functions $c_t^t(a, \psi, \mu)$, $a_t^{t+1}(a_t^t, \psi_t^t, \mu_t^t)$, $z_t^t(a_t^t, \psi_t^t, \mu_t^t)$, and $\chi_t^t(a_t^t, \psi_t^t, \mu_t^t)$. A key assumption of the model is the fact that attempting school comes with a fixed cost of foregone labor wages in addition to an extra expenditure in the form of a bribe.[5] This cost will be taken into consideration when agents decide to attempt schooling or not. Agents simply compare the indirect utility associated with both maximization problems and choose the one that yields the highest level of expected utility. We also introduce borrowing constraints through the variable $a_{\min}$ so that we can examine how the absence of financial markets impacts equilibrium outcomes.

Another variable that we introduce into our model is social status. As pointed out by Fershtman and Weiss (1993), social status plays an important role in the allocation of individuals across different occupations. The authors point out that people don't only consider the wages of a particular occupation when making choices, but also the level of social status that is attached to a particular profession. In their paper they introduce a two-sector general equilibrium model with production in which social status is defined to be a function of the average wage and average level of skill within a particular occupation. Agents in their model can give up the current period's wage income to obtain education and become skilled workers. They show that agents with higher non-wage incomes are more likely to sacrifice current period wage income to obtain a higher social status. The authors also show that economies with a higher emphasis on social status will have a lower level of aggregate output as well as experiencing higher levels of wage inequality between skilled and unskilled workers. In a later work, Fershtman et al. (1996) explore the impact of social status on economic growth. They show that social status can have a negative effect on economic growth if there is a "crowding out" effect in the sense that the low ability high non-wage income agents replace the high ability low non-wage income in the market for managers.

In light of these findings we consider social status to play an important role in the choice to educate and can therefore impact the determination of equilibrium wages and growth. Given this finding, we will include it in our formulation of the model. Following Fershtman et al. (1996) closely, we assume that status is measured in terms of the relative average ability of the profession. An educated worker receives the following level of social status:

$$S_m^{t+1} = \left(\frac{\bar{\mu}_m^{t+1}}{\bar{\mu}_l^{t+1}}\right)^{\delta}$$

where

$$\bar{\mu}_m^{t+1} = \frac{\int\int_{\Psi_{t,m}^{t+1}} \mu_t^{t+1} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1}}{\int\int_{\Psi_{t,m}^{t+1}} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1}}$$

and

$$\bar{\mu}_l^{t+1} = \left[\int\int_{\Upsilon_{t,l}^{t+1}} \mu_t^{t+1} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1} + \int\int_{\Theta_{t+1,l}^{t+1}} \mu_{t+1}^{t+1} f_{t+1}^{t+1}(\mu_{t+1}^{t+1}, a_{t+1}^{t+1}) d\mu_{t+1}^{t+1} da_{t+1}^{t+1}\right]$$
$$\left[\int\int_{\Upsilon_{t,l}^{t+1}} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1} + \int\int_{\Theta_{t+1,l}^{t+1}} f_{t+1}^{t+1}(\mu_{t+1}^{t+1}, a_{t+1}^{t+1}) d\mu_{t+1}^{t+1} da_{t+1}^{t+1}\right]$$

Social status of the uneducated is $S_l^{t+1} = \left(\frac{\bar{\mu}_l^{t+1}}{\bar{\mu}_m^{t+1}}\right)^{\delta}$. We denote the set of agents that attempted schooling in time t and were successful as $\Psi_{t,m}^{t+1}$, who are also referred to as managers. Let $\Theta_{t,l}^{t}$ denote the set of agents who did not attempt schooling and went directly into the workforce in time t and are referred to as *nonschooling laborers*. $\Delta_{t,l}^{t+1}$ is the set of agents that attempted schooling in time t but were *not* successful, who are referred to as *schooling laborers*. Therefore, the set of all time t laborers at time $t + 1$ is defined

[5] Given that this is a two period model, one could make the argument that a one-period wage sacrifice makes the cost of pursuing education too high. The model could allow for part-time work in the first period such that agents who attempt schooling get a fraction of their wage in period t. The simulation results under several levels of part-time work in the first period have shown little deviation from the main results of the study. The presence of part-time work in the first period is a pure income effect and has no impact on the comparative statics of the problem. The authors can provide the results of these simulations with part-time work upon request.

by $\Upsilon_{t,l}^{t+1} = \Theta_{t,l}^{t+1} \cup \Delta_{t,l}^{t+1}$. The set of time $t+1$ laborers at time $t+1$ is given by $\Theta_{t+1,l}^{t+1}$. Finally, denote the entire set of all laborers at time $t+1$ as $\Gamma_l^{t+1} = \Upsilon_{t,l}^{t+1} \cup \Theta_{t+1,l}^{t+1}$. The parameter δ represents the importance of social status as found in Fershtman et al. (1996).

An interesting feature of social status as pointed out by Fershtman et al. (1996) is the fact that it has a public good characteristic because each agent of a given profession shares the same level of social status. It is often difficult to observe the individual ability of each agent of a profession, and thus the best measure of a person's ability is the average ability of their cohort.

2.2. The probability of entry

If agents face a probability of receiving education and thus becoming a manager, it is natural to ask what should determine the probability. It seems that a reasonable place to start is the assumption that any agent's probability of being admitted to school and becoming a manager should be a function of ability (μ_t^t) and the amount they bribe (z_t^t). Also, the combination of an agent's ability level and the amount bribed are less important in *absolute* terms than they are in *relative* terms compared to the other agents in the economy. We model the interaction between ability and bribery as follows:

$$P = \mu_t^t \gamma + (1-\gamma) z_t^t \tag{2.7}$$

where $\gamma \in [0,1]$ and $\mu_t^t \in [1,2]$. Assuming a normal distribution gives the following probability function:

$$\pi(m) = \text{normcdf}(P, \bar{\mu}, \sigma_\mu) \tag{2.8}$$

where $\bar{\mu}$ and σ_μ are the mean and standard deviation of the ability distribution in the model economy. It can be seen from Eq. (2.7) that the parameter γ controls how influential bribery is in determining entry to school. More precisely, as $\gamma \to 1$ the probability of entrance is solely a function of an agent's ability, but when $\gamma \to 0$ the agent's probability of entry is only a function of the amount they bribe relative to the rest of the economy. This feature will be particularly useful when we examine the equilibrium outcomes of the model under the assumption of no educational corruption ($\gamma = 1$), or a maximum level of educational corruption ($\gamma = 0$).[6]

It is important to highlight that z_t^t in Eq. (2.7) should be interpreted strictly as a form of bribery and educational corruption and not some other form of private educational contribution. First, z_t^t differs from a simple entrance fee in that all agents who pursue schooling can choose the amount of z_t^t and must do so *prior* to knowing if they obtain entry. It should also not be perceived as an application cost. Application costs would also be a fixed cost that all agents have to pay, regardless of ability, and not directly influence the probability of entry. Furthermore, z_t^t should not be confused with other types of private educational contributions (e.g. tutors, entrance exam prep, etc.). The way in which z_t^t enters the probability of school entry function is additive, and does not have any multiplicative interaction with the agent's ability level. To put it another way, the bribery component of Eq. (2.7) is the same for all agents as both high and low ability agents receive an identical benefit for each level of z_t^t. This differs from how private education contributions are often modeled in the human capital literature. In studies such as Becker (1993) and Restuccia and Urrutia (2004), private contributions and ability interact in a multiplicative function, such that the marginal returns to educational investment are lower for low ability than for higher ability agents. Also, educational spending would likely increase an agent's human capital and thus directly impact their wage. In our model, z_t^t only influences the probability of school entry, and the agent's ability (μ_t^t) influences managerial wages, with private educational contributions being zero for all agents. While it would be interesting to examine how private educational contributions would behave in a model of educational corruption where agents could choose to allocate assets between private education and bribes, this unnecessarily complicates the presented framework and we leave it for future work.

2.3. The firm

The representative firm employs both types of workers and produces a single consumption good according to the following production function:

$$Y_t = A_t \left\{ a\left[bK_t^\theta + (1-b)NM_t^\theta\right]^{\frac{\rho}{\theta}} + (1-a)NL_t^\rho \right\}^{\frac{1}{\rho}} \tag{2.9}$$

where NL_t is the number of uneducated workers, NM_t is the efficiency units of educated labor, and K_t is the capital stock. A nice feature of this production technology is the fact that it is very flexible in terms of representing various levels of complementarity and substitutability in the three factors of production. Notice that if $\rho, \theta = 1$, then production is represented by perfect substitutability, and with $\rho, \theta = -\infty$, then production is represented by perfect complementarity. When $\rho, \theta = 0$, then production is of the Cobb-Douglas type. Another reason to use this type of production technology comes from the fact that there has been a line of literature focusing on the estimation of the parameters of this function.

The goal of the firm is to maximize each period's profits taking factor prices as given:

$$\max_{NL_t, NM_t, K_t} Y_t - w_t^l NL_t - w_t^m NM_t - K_t r_t \tag{2.10}$$

[6] Although we don't explicitly model the educational institution, Appendix D shows a simple model that fits within our fixed-price bribery framework and provides a consistent equilibrium in the larger framework of the model.

This yields the following factor demand curves:

$$r_t = A_t^{\rho} Y_t^{1-\rho} a [bK_t^{\theta} + (1-b)NM_t^{\theta}]^{\frac{\rho}{\theta}-1} bK_t^{\theta-1}$$

$$w_t^l = A_t^{\rho} Y_t^{1-\rho}(1-\alpha)NL_t^{\rho-1}$$

$$w_t^m = A_t^{\rho} Y_t^{1-\rho} a [bK_t^{\theta} + (1-b)NM_t^{\theta}]^{\frac{\rho}{\theta}-1}(1-b)NM_t^{\theta-1}$$

Note that we implicitly assume that labor is hired in efficiency units. The efficiency of managers depends on their ability, while the efficiency unit of laborers is simply equal to the total number of laborers employed. In other words, given two managers that differ by ability, the one with the higher ability will produce more. For laborers it is assumed that their productivity is independent of their ability.

2.4. Learning technology

We model the evolution of the technological parameter A_t following Fershtman and Weiss (1993), who assume that only the educated can add to the stock of knowledge. When managers attend school they not only gain access to the current stock of knowledge, but add to it by utilizing their ability in school and adding to the total stock of available knowledge in the second period of their life. Thus, technology evolves as follows:

$$A_{t+1} = (1 + g_{t+1})A_t,$$

where

$$g_{t+1} = \tau \int \int_{\Psi_{t,m}^{t+1}} \mu_t^{t+1} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1} = \tau NM_{t+1} \text{ and } \tau > 0.$$

Thus the growth rate of technological progress at any given time is solely a function of the aggregate ability of the educated agents. Alternatively, we could also define the growth rate g_{t+1} as the average ability level of educated agents in the model as follows:

$$g_{t+1} = \tau \frac{\int \int_{\Psi_{t,m}^{t+1}} \mu_t^{t+1} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1}}{\int \int_{\Psi_{t,m}^{t+1}} f_t^{t+1}(\mu_t^{t+1}, a_t^{t+1}) d\mu_t^{t+1} da_t^{t+1}} = \tau \bar{\mu}_m \text{ and } \tau > 0.$$

2.5. Equilibrium

In this section we focus on the characteristics of a stationary equilibrium. Each period, agents form expectations over future wages and the status of each occupation as well as future interest rates. Given their expectations, they make their decisions appropriately. In a rational expectations equilibrium the expectations of each agent must be confirmed. Since the distribution of characteristics $f_t^t(\mu_t^t, a_t^t)$ is invariant over time we only need to find a stationary distribution of laborers and managers. The definition of a stationary rational expectations equilibrium is as follows:

Definition 1. *A stationary equilibrium is defined by (i) an invariant distribution of young agents* $f_t^t(\mu_t^t, a_t^t)$, (ii) a known probability function $p(z_t^t, \mu_t^t)$, and (iii) individual household decision rules z_t^t, a_t^{t+1}, χ_t^t, c_t^t, and c_t^{t+1} such that:

1) *Individual household consumption, savings, schooling and bribery rules solve the household problem given in* Eq. (2.1) *subject to* Eqs. (2.2) through (2.5).
2) *Given the probability function,* $P(z_t^t, \mu_t^t)$, the set of managers and laborers is time invariant: $\Psi_{t,m}^t = \Psi_{t,m}^{t+1}$ *and* $\Gamma_l^t = \Gamma_l^{t+1}$.
3) Aggregate consistency conditions hold:

i) $NM_t = \int \int_{\Psi_{t,m}^t} \mu_t^t f_t^t(\mu_t^t, a_t^t) d\mu_t^t da_t^t$

ii) $NL_t = \int \int_{\Upsilon_{t,l}^t} f_t^t(\mu_t^t, a_t^t) d\mu_t^t da_t^t + \int \int_{\Theta_{t,l}^t} f_t^t(\mu_t^t, a_t^t) d\mu_t^t da_t^t$

i) $K_t = \int \int_{\Psi_{t,m}^t} a_t^t f_t^t(\mu_t^t, a_t^t) d\mu_t^t da_t^t + \int \int_{\Gamma_l^t} a_t^t f_t^t(\mu_t^t, a_t^t) d\mu_t^t da_t^t$

4) NL_t, NM_t *and* K_t *solve the firm's maximization problem given in* Eq. (2.10).

3. Simulation

Since there is no closed form solution of the model we have to resort to numerical methods. The model is solved using the standard algorithm for a perfect foresight rational expectations equilibrium.[7]

[7] A more detailed explanation of our solution method can be found in Appendix B. Furthermore, we present the accuracy of our solution method in Appendix C using measures presented Gaspar and Judd (1997).

3.1. Parametrization

3.1.1. Production function

For the parametrization of the production function we turn to the literature. Duffy et al. (2004) estimate the equation for a panel of countries using three different forms of nonlinear estimation, including non-linear least squares (NLLS), NLLS with fixed effects (NLLS-FE), and generalized method of moments with fixed effects (GMM-IV). Their results suggest that under Monte Carlo simulations, NLLS has the lowest absolute median bias in the estimation of ρ over different Monte Carlo specifications, while GMM-IV produces the lower absolute median bias in the estimation of θ. Duffy et al. (2004) show estimates of between.23861 and 1.25 for ρ and estimates ranging from 0.03832 to 0.56737 for θ. Krusell et al. (2000) and Polgreen and Silos (2005) also focus on the estimation of ρ and θ; however, their specifications include both capital structures and capital equipment, which is not applicable to our model specification. Furthermore, they estimate the parameters of their model using only U.S. data, unlike the 73 country panel used by Duffy et al. (2004). We adopt the estimation methods outlined in Duffy et al. (2004), and, using updated data from Feenstra et al. (2015), estimate values for a, b, ρ and θ. These values can be found in Table 1.

3.1.2. Distribution of young

Due to the fact that the distribution of the young agents $f_t^t(\mu_t^t, a_t^t)$ is fixed over time, the results of the model could vary depending on how the distribution of ability (μ) and assets (a) is defined. If agents born with high levels of wealth are also of high ability, then the impact educational corruption has on growth may be very small, as it will be the highest ability agents who decide to go to school and pay the highest bribes, because they are also the agents who can afford to take the risky investment in schooling. However, if wealth and ability are negatively correlated, the impact of educational corruption may be expected to be very large – wealthy lowest ability agents may be the ones who obtain schooling due to the higher probability of entry. To address this ambiguity, we vary the distribution of the young to see how the results vary across different specifications.

Rather than just guess what the distribution of wealth and ability looks like at the aggregate level, we draw on recent literature for some hints. A study by Zagorsky (2007) shows that while ability is a strong predictor of income, it has no statistical relationship with initial wealth after controlling for other factors. Because the study is limited to the U.S., we still vary the distribution of wealth and ability, restricting our analysis to two cases only: one in which the correlation between ability and wealth is 0.85 (Distribution I) and another in which the correlation between ability and wealth is zero (Distribution II).

3.1.3. Other parameters

Table 1 shows the values assigned for each of the respective parameters.

Since it is unclear what value γ should take we try a broad range of values. More specifically, we vary γ over the interval [0,1] to see how educational corruption, as defined in this model, impacts economic growth as well as the education wage premium and the choice to educate or not. We also simulate the model for a variety of different specifications, which are provided in Appendix Table A.1.[8]

3.2. Aggregate simulation results

In this section we discuss the aggregate numerical results generated by the model. In Section 3.2.1, we provide results when the distribution of wealth across agents is correlated with ability. Section 3.2.2 provides results when wealth and ability are not correlated. Figs. 2–3 provide the policy functions and Figs. 4–6 show the results of the model in terms of the impact varying degrees of educational corruption have on economic growth, the education wage premium, and the proportion of agents who obtain education for both Distribution I and Distribution II. Note that rather than present these variables across various levels of γ, we plot them against the proportion of households who bribe under various levels of γ.[9]

3.2.1. Correlated ability and wealth

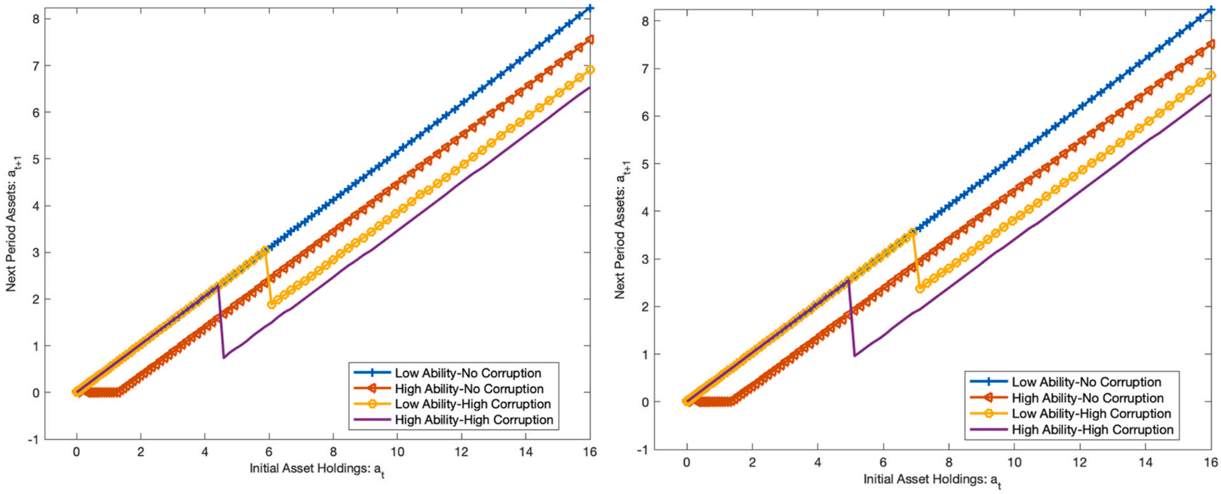
Figs. 2a and 3a provide the policy functions for a subset of the model's agents under Distribution I. More precisely, this figure shows decisions over next period assets (a_{t+1}) and, more importantly, the schooling decision for the highest and lowest ability agents under two regimes; no corruption and high corruption. If we examine the policy function for the high ability agent under no corruption, we can see that relatively few agents are constrained and the majority of high ability agents choose schooling. Similarly, we see that low ability agents are higher savers and never choose schooling when no educational corruption exits. Comparing this with a high corruption regime, we see that the decisions for high and low ability agents of lower initial assets in regard to saving are in line with low ability agents under no corruption. These agents also choose not to pursue schooling. However, those with higher asset levels ($a_t \geq 4.5$) eventually choose schooling. Low ability agents who are born with a larger asset allocation ($a_t \geq 6$) also eventually choose schooling. The existence of corruption therefore forces high ability agents with no assets to forgo schooling and become laborers. Meanwhile, low ability agents who are wealthier opt to pursue schooling when they wouldn't otherwise if corruption was nonexistent.

[8] It is important to note that the key findings from the main parameterization were also found under the specifications listed in Appendix Table A.1. Output from these model specifications can be provided upon request.

[9] Although not necessarily the case theoretically, our simulation results show that the proportion of households who bribe monotonically decreases as γ approaches 1.

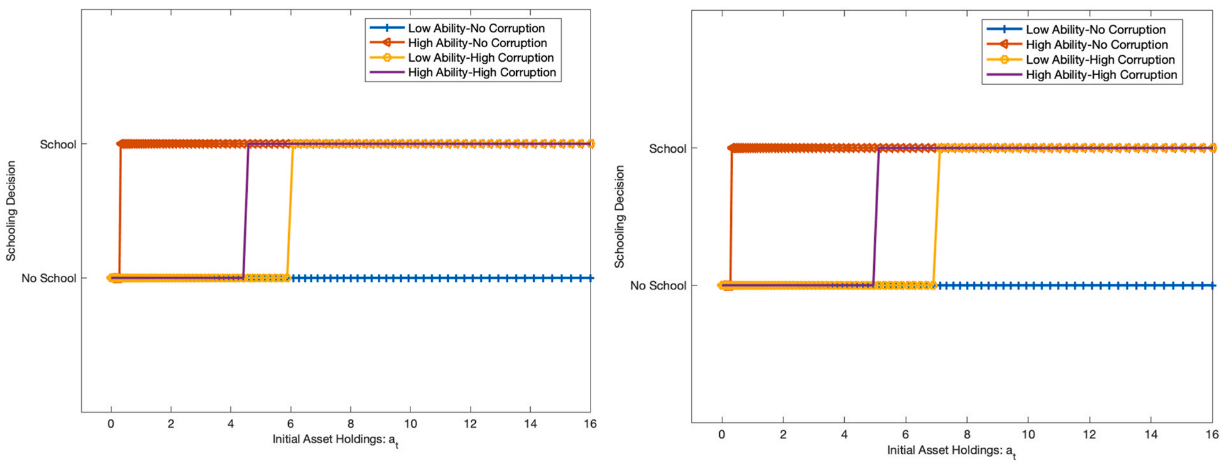
Table 1
Parametrization.

Production Function		Free Parameters	
θ	0.39	δ	0.1
ρ	0.59	γ	[0,1]
a	0.67	$a_{\min}$	0
b	0.17	κ	0
		η	2



(a) Distribution I (b) Distribution II

Fig. 2. Policy Function over Next Period Assets ($\mathbf{a_{t+1}}$) for the Lowest and Highest Ability Agents.



(a) Distribution I (b) Distribution II

Fig. 3. Policy Function over Schooling Decision for the Lowest and Highest Ability Agents.

The implication of these decision rules across aggregate measures of economic performance are provided in Figs. 4a, 5a and 6a under the assumption that wealth and ability are strongly positively correlated. Notice that in Fig. 4a we find a somewhat surprising v-shape when growth is measured using aggregate ability, indicating that as bribery becomes more prevalent, annual equilibrium growth rates decline up to a certain point, then increase as the proportion of households that bribe increases. The equilibrium growth rate when no agents bribe ($\gamma = 1$) is equal to 2.06%, and when about 22% of agents bribe ($\gamma = 0$) the growth rate is about 1.94%. Since growth is linked to the number of managerial efficiency units, this implies that similar agents are becoming managers under the two extreme types of corruption regimes. There is little variation in the growth rate across various corruption regimes when growth is dependent upon the average ability of managers, with the growth rate hovering between 2.05% and 2.10%.

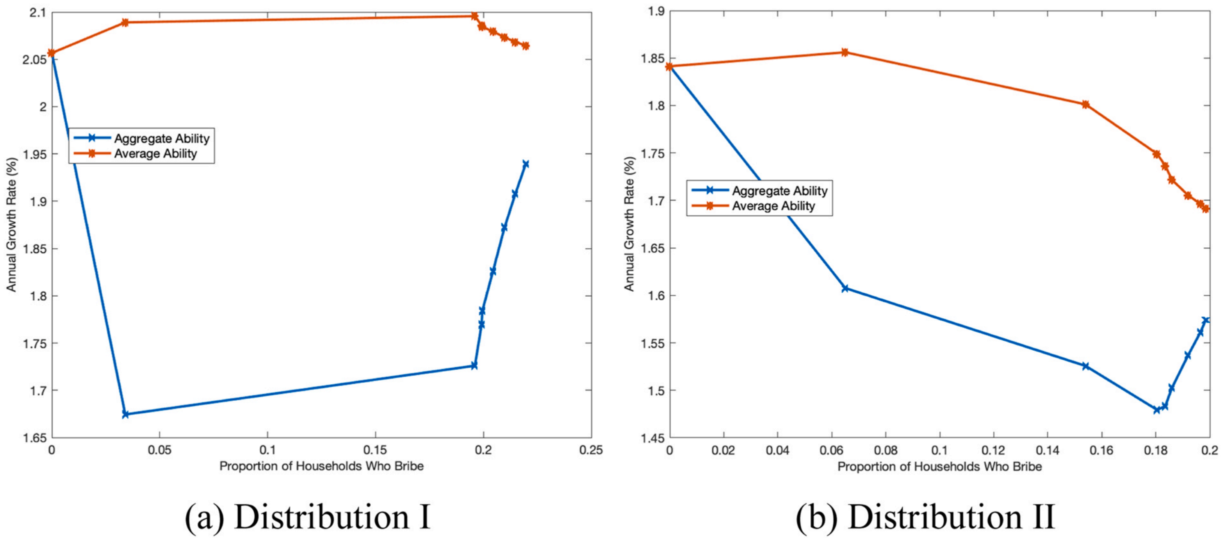


Fig. 4. Educational Corruption versus Annual Economic Growth.

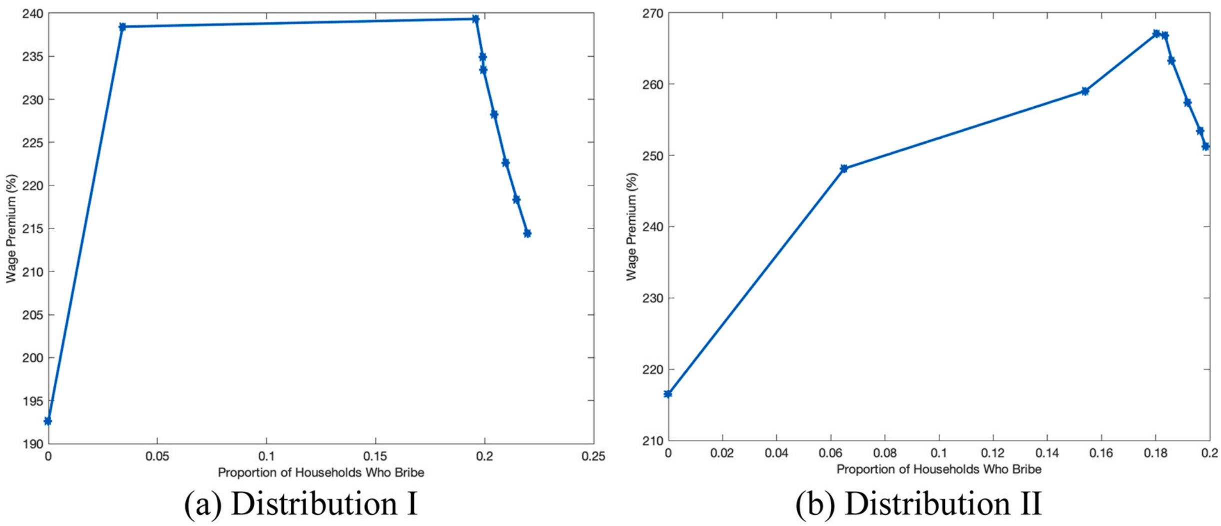


Fig. 5. Educational Corruption versus Wage Premium.

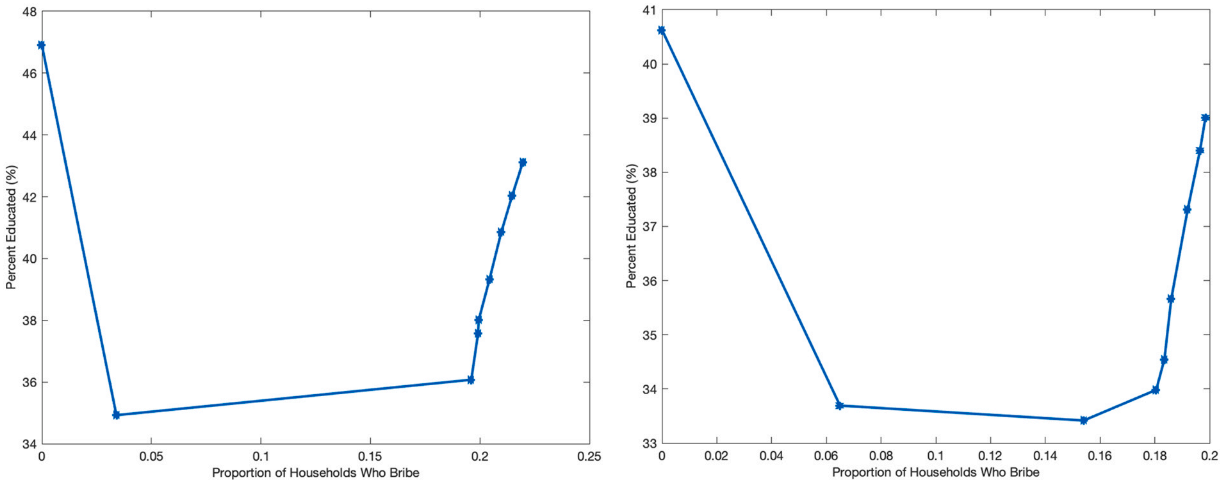
Fig. 5a presents the results for the education wage premium as we vary the degree of corruption. Again, note that we obtain an inverted v-shaped relationship between the proportion of households that bribe and the education wage premium. When bribery is the most prevalent, we obtain an education wage premium of 214.47% and a wage premium of 192.63% when there is no corruption.

The results for the proportion of educated agents are found in Fig. 6a. As is to be expected given previous findings, we observe a v-shaped pattern similar to the relationship between educational corruption and economic growth. In the model economy exhibiting no corruption, a total of 46.91% of agents obtain schooling. When corruption is most prevalent, 43.12% of agents obtain schooling and become managers. This number drops to a low 34.93% when three percent of households bribe.

Fig. 7a provides the Gini coefficient obtained under each corruption regime. Interestingly, the level of income inequality monotonically *decreases* as the prevalence of educational corruption increases. The Gini coefficient is 0.55 when there is no educational corruption in the economy and 0.5 when 22% of households bribed. Overall, we find that when using Distribution I, growth and educational attainment are highest and the education wage premium is lowest when there is no educational corruption in the economy. Income inequality, however, is at its highest.

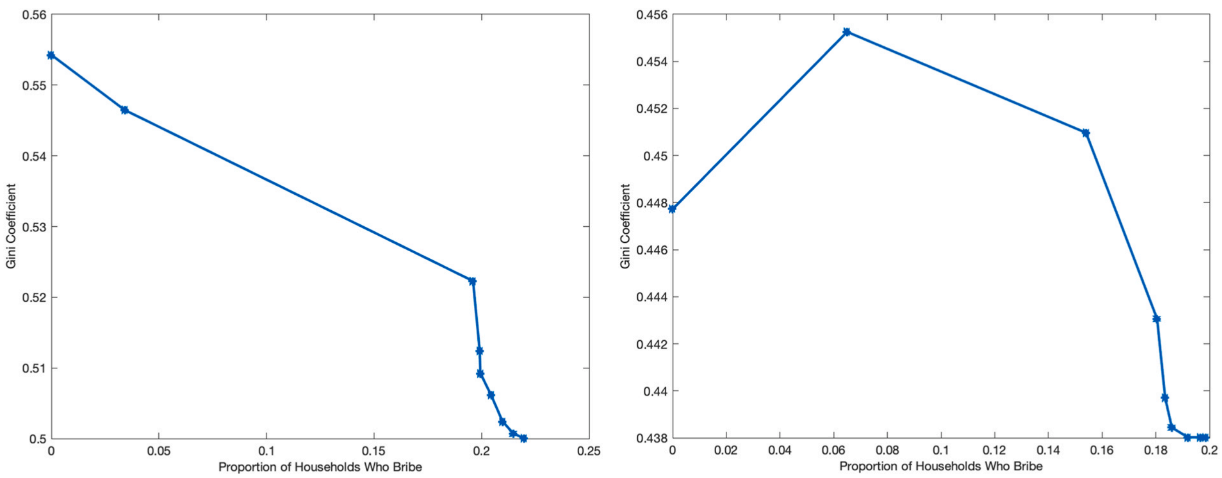
3.2.2. Uncorrelated ability and wealth

Figs. 2b and 3b provide the policy functions for a subset of the model's agents where there is no correlation between assets and ability. A similar story is observed under Distribution II as in Figs. 2a and 3a under Distribution I, that being the greater presence of corruption leading to agents of lower ability and higher assets attending school when they would not otherwise under lower



(a) Distribution I (b) Distribution II

Fig. 6. Educational corruption versus education rates.



(a) Distribution I (b) Distribution II

Fig. 7. Educational Corruption versus Gini Coefficient.

corruption regimes, with the opposite holding true for high ability and low asset agents. The main difference comes when comparing these policy functions across distributions. If we examine high ability agents under no corruption ($\gamma = 1$), there is little difference in behavior across distributions. However, these high ability agents, who possess a lower amount of initial assets, behave differently. More precisely, high ability agents only attend schooling if they have $a_t \geq 5$, a higher minimum asset level than under Distribution I. Agents with low ability also choose schooling at a higher asset level than under Distribution I ($a_t \geq 7$ versus $a_t \geq 6$); however, since there is no correlation between wealth and ability under Distribution II, these individuals make up a larger fraction of the population than under Distribution I.

Figs. 4b, 5b and 6b show the results under the assumption that there is no correlation between wealth and ability, as suggested by Zagorsky (2007). Fig. 4b shows that while we obtain a similar v-shaped relationship to the distribution where assets and ability are correlated, the effects of educational corruption on the annual growth rates are more severe at higher levels of corruption when growth is measured using aggregate ability. Economic growth is highest when there is no corruption at 1.84% annually. When just 7% of households bribe any amount this drops to 1.64%. When corruption is highest, 20% of households bribe to pursue education and the economy grows at 1.57% annually. When annual growth rates are measured using the average ability level, we find that in the absence of corruption the growth rate is 1.84%. When bribery is introduced into the economy, there is a minor increase in the growth rate to 1.86%; however, this decreases with corruption afterwards. When 20% of households bribe, the annual growth rate is 1.69%. Comparing these results with those obtained with Distribution I, it is clear that the impact of corruption is much greater in magnitude under both measures of growth.

Fig. 5b shows the impact educational corruption has on the education wage premium. When there is no corruption, the education wage premium is 216.51%. This increases to 251.24% when corruption is most abundant. Examining the overall trend of corruption on the education premium, we find that the education premium reaches a maximum of 267.08% when about 18% of households bribe to gain access to education. After that, the premium starts to fall as bribery becomes popular. However, this decline is more gradual and less severe than in Distribution I.

Finally, we plot the relationship between educational corruption and the proportion of educated agents in Fig. 6b. When there is no bribery in equilibrium, the number of educated workers is highest at 40.62%. When 20% of households bribe, only 39.01% of the agents are educated. Comparing the overall relationship between corruption and education rates, we find a U-shaped relationship between the two. Initially, corruption leads to a fall in the number of educated individuals before it gradually increases. When comparing this relationship to that of corruption on growth and the wage premium, a clearer picture starts to emerge. As corruption is introduced to the economy, the number of agents seeking education starts to fall. In turn, this leads to a lower amount of economic growth. At the same time, since the number of managerial efficiency units starts to fall, the education wage premium starts to rise. As corruption becomes more widespread, the number of educated individuals slowly starts to rise. This increase in managerial efficiency units causes an increase in the equilibrium growth rate and reduces the education wage premium. The main results of aggregate economic measurements suggest that the distribution of wealth and ability certainly changes the size of the effect educational corruption has on growth, the wage premium and the proportion of educated, but for the most part leaves the trends unaffected.

3.3. Distributional simulation results

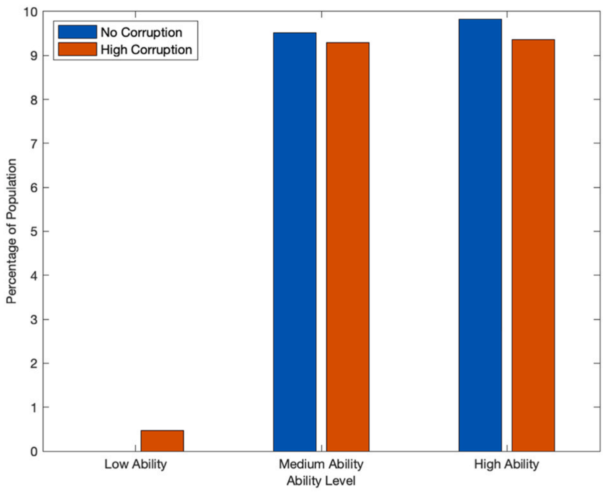
The competitive equilibrium found for our simulated economy provides us with the ability to exploit the heterogeneity of the underlying distribution rather than simply rely on aggregate level analysis. We analyze the underlying distributions for Distribution I and II in Sections 3.3.1 and 3.3.2, respectively.

3.3.1. Correlated ability and wealth

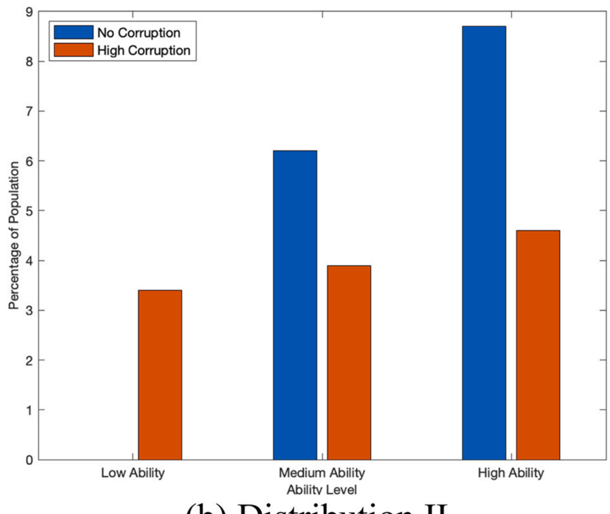
Fig. 8a provides a breakdown of the types of agents who pursue schooling as a fraction of each generation, for the lowest, medium and highest ability agents across corruption regimes for Distribution I. When examining these populations it can be seen that there are minimal differences under no corruption and high corruption regimes. In both scenarios, medium and high ability agents make up between 9% and 10% of the schooling population respectively. We do find that a minimal amount of low ability agents pursue schooling under high corruption regimes, whereas none of these agents opt for schooling under no corruption. These results are not entirely surprising given that this distribution contains a high correlation between wealth and ability.

Figs. 9a and 10a further investigate the distribution of schooling agents and present the population and income share by occupation under various corruption regimes for Distribution I. The population of managers mirrors the education rates obtained in Fig. 6a. In regard to their income share, managers earn between 70% and 80% of the economy's total income, which is the lion's share, despite only making up roughly 40% of the population. Laborers who do not attend school earn the second greatest share, with the smallest portion going to laborers who attempted schooling in the first period but failed.

Fig. 11a provides the average ability level for each occupation across various levels of γ for Distribution I. We find that when ability and wealth are correlated, the average ability level for managers is fairly consistent, ranging between 1.8 and 1.9 under a variety of corruption regimes. The average ability of laborers who attempted schooling but failed increases from about 1.5–1.75 as the proportion of households who bribe increases from zero to 0.2. After this 20% threshold, average ability falls, similar to that of

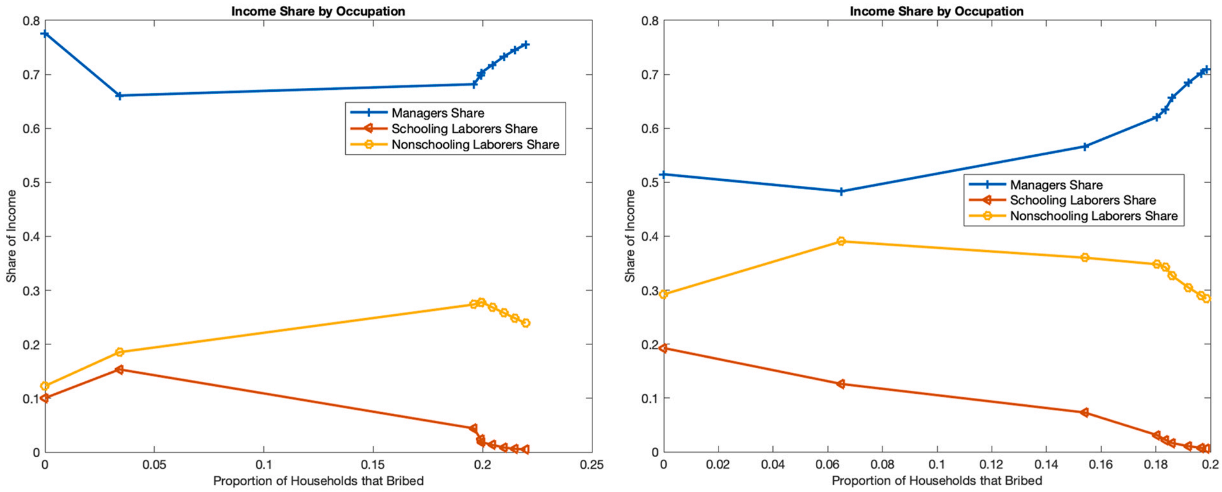


(a) Distribution I



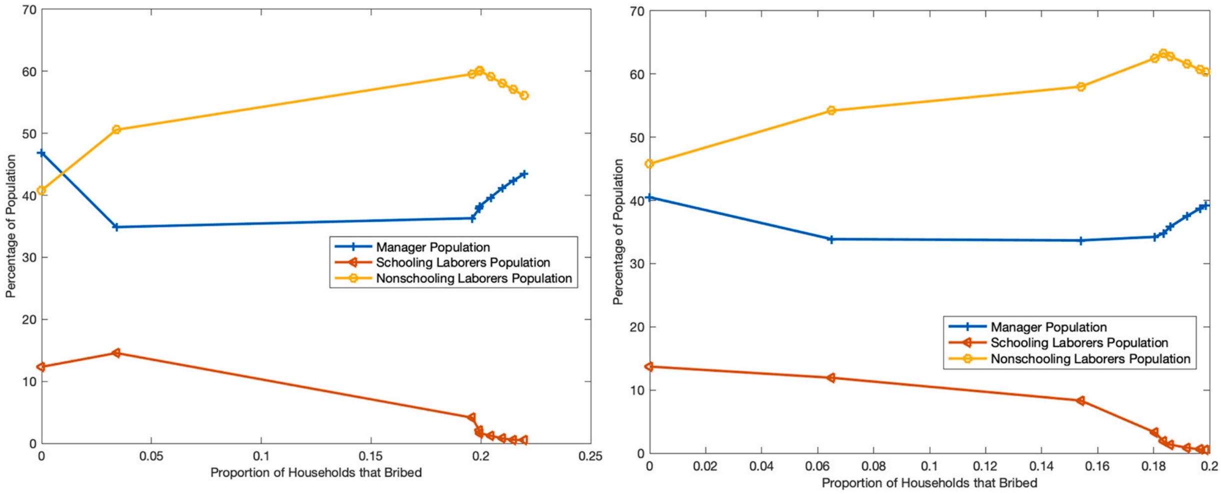
(b) Distribution II

Fig. 8. Schooling Population as a Percentage of Each Generation, by Ability Level.



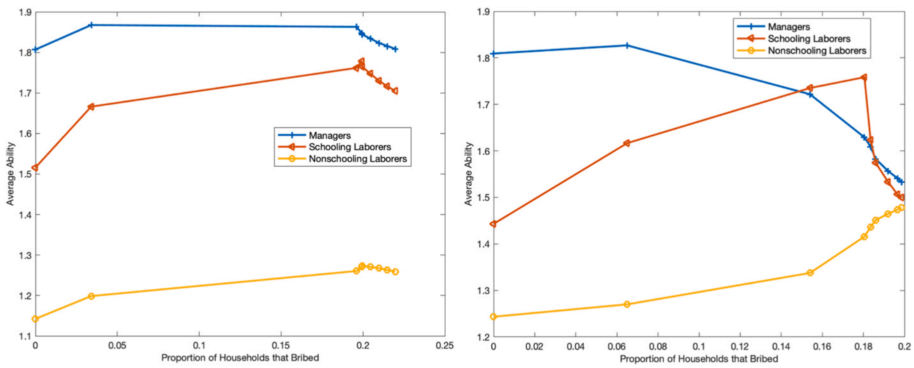
(a) Distribution I (b) Distribution II

Fig. 9. Share of Income by Occupation under Various Corruption Regimes.



(a) Distribution I (b) Distribution II

Fig. 10. Population by Occupation under Various Corruption Regimes.



(a) Distribution I (b) Distribution II

Fig. 11. Average ability by occupation under various corruption regimes.

managers. The average ability of non-schooling laborers trends upwards with increases in bribery, bringing about a minor convergence in ability levels when there are high levels of corruption.

3.3.2. Uncorrelated ability and wealth

Fig. 8b examines the schooling population for Distribution II under different corruption regimes in greater detail. Comparing Fig. 8b to the corresponding figure for Distribution I reveals dramatically different results. Namely, we find that there is a clear monotonically increasing relationship between ability level and the schooling decision when there is no corruption, as one would expect. When no corruption is present in the economy, the highest ability makes up the largest fraction of agents attempting schooling, followed by medium ability. No low ability agents pursue schooling. However, when corruption is greatest ($\gamma = 0$), the distribution of the schooling population is more evenly spread across ability levels. Under the highest corruption regime, there are almost identical proportions of low, medium and high ability agents involved in schooling.

Figs. 9b and 10b present the income and population information for Distribution II. The managers' population again makes up around 40% of the population across the various levels of a. As with Distribution I, managers capture the largest share of income. However, when there is no correlation between wealth and ability, the share of income captured by managers increases dramatically from about 50% when there is no corruption to 75% when bribery is most abundant. Non-schooling laborers comprise 45–60% of the population and about 30% of income. Comparing these results to those obtained for Distribution I reveals that in both scenarios managers make up a similar proportion of the population, but the behavior of the income captured by this occupation varies substantially. If there is a correlation between wealth and ability, as in Distribution I, then educated labor captures the majority of income, regardless of corruption level. If there is no correlation between wealth and ability, as in Distribution II, corruption heavily influences income shares, and when it is most prevalent leads to a divergence across occupation.

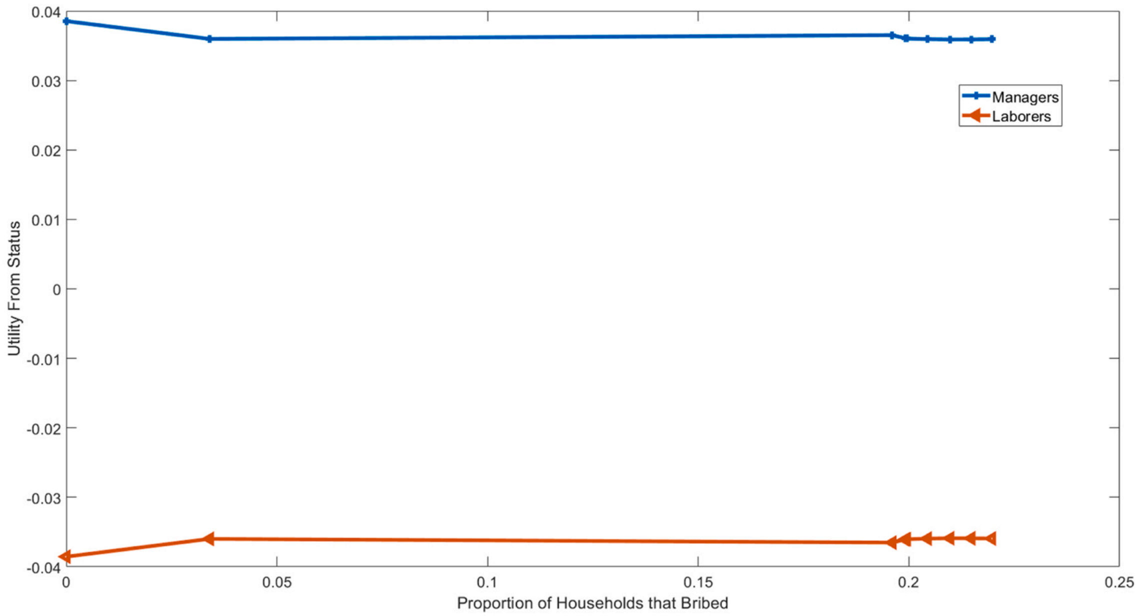
Fig. 11b examines the average ability level for each occupation across various levels of corruption in Distribution II. When no households bribe, there is a clear hierarchy with respect to occupation and ability level; managers have an average ability of 1.81, laborers who attempt schooling but fail have an average ability of 1.4, and non-schooling laborers have an average ability level of 1.24. As bribery plays a greater role in the education decision, the average ability level across occupations begins to converge. This trend was observed slightly in Distribution I, but is much more pronounced in Distribution II. When the economy has the greatest level of corruption, there is virtually no distinction with regard to occupation and ability level. This suggests that one of the greatest consequences attributed to educational corruption is that it diminishes the role of educational institutions to act as a signal of talent and ability.

As a direct consequence of converging average abilities under Distribution II, the value of status from obtaining education also converges as corruption becomes more prevalent in educational institutions. As presented in Fig. 12b, when corruption increases, the status value of laborers approaches that of managers. Therefore the relative value of education, as measured by status, becomes irrelevant. Thus, in countries with high levels of corruption in education we should find little additional value to education outside of the market wage. This is in contrast to the role social status plays in the equilibrium outcomes in the model under Distribution I. In this case, the relative value of social status remains constant across different levels of corruption. This result is clearly demonstrated in Fig. 12a.

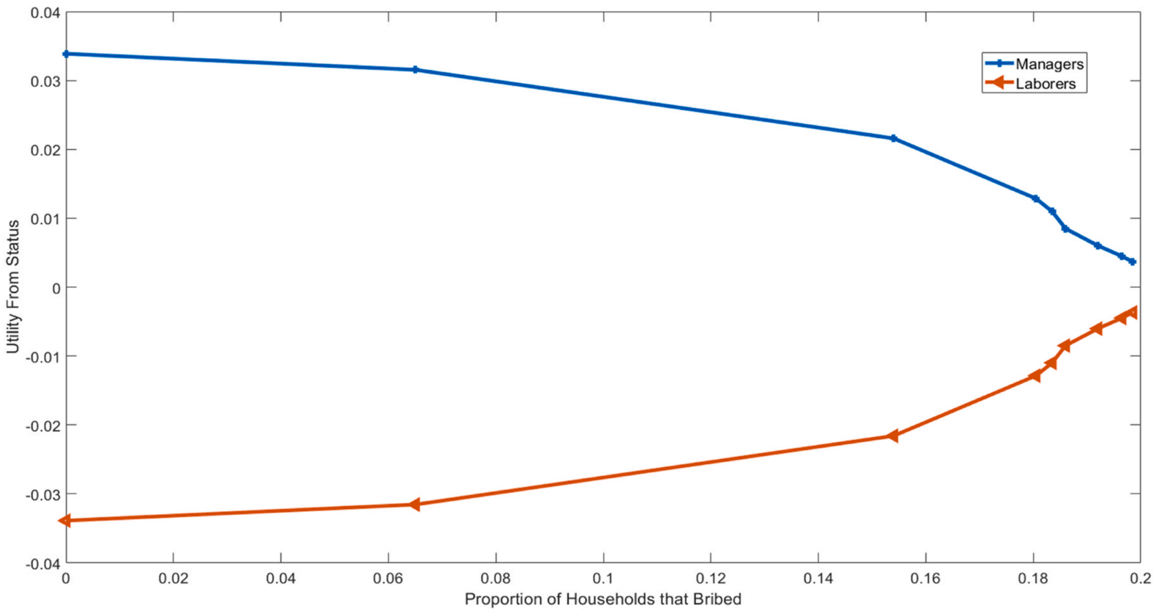
3.3.3. Unpacking the relationship between educational corruption and growth

Taking the distributional results presented in Figs. 8–11 into account, along with our previous discussion of the aggregate results, we can better understand the complicated relationship that exists between educational corruption and growth in our fixed-price bribing model. The relationship between the two depends on two factors: the underlying distributional correlation between wealth and innate ability and how economic growth is measured (aggregate ability vs. average ability). When there is a positive correlation between existing wealth and ability, the impact of educational corruption on economic growth is less pronounced if growth is viewed as being a measure of the average ability of educated labor. In fact, under these conditions there is almost no effect on growth. These results intuitively make sense, since under the no corruption and high corruption regimes the highest ability agents also have the greatest amount of wealth, and thus roughly the same agents will become managers. This changes when the underlying distribution moves towards one with no correlation between assets and wealth. Under these circumstances, if growth is measured using average ability, corruption has a monotonically decreasing effect as educational institutions become less of a signal of quality. Under no corruption only the highest ability agents become managers, hence the high average ability seen in Fig. 11b. While the managerial wage premium may continue to draw high ability agents, under high corruption schooling selection draws more high wealth agents irrespective of ability since it depends more on bribes.

If growth is viewed as a composition of the aggregate ability of educated labor in the economy, the relationship between corruption and growth becomes more complicated. Under both distributions, we obtain a V-shaped relationship, suggesting that, at a certain level, corruption may be growth enhancing. This resulting relationship has been found in previous studies examining overall corruption (Marakbi and Villieu, 2020; Saha and Sen, 2021), but the mechanism at work here requires further explanation. Initially, under a strict no corruption regime, schooling depends entirely on ability and we obtain the highest aggregate ability level. As bribery is introduced into the model, fewer high ability-low wealth agents become managers, and thus the aggregate ability level begins to fall. However, as γ increases and bribery becomes a greater factor, the schooling selection decision, education rates and aggregate ability of managers increase. At these low levels of educational attainment and aggregate ability, the education wage premium becomes quite high. Eventually, this allows high ability-low wealth individuals to earn enough in the second period that they are willing to attempt schooling, even when the probability of entry is mainly based on bribes. This also explains why the inflection



(a) Distribution I



(b) Distribution II

Fig. 12. Importance of social status under various corruption regimes.

points in Figs. 4a and 4b vary. When there is a correlation between wealth and ability, corruption becomes growth enhancing at lower levels of corruption because the threshold wage premium for high ability agents is lower given their greater level of assets. Under Distribution II, high ability agents are less likely to be wealthy, and thus the threshold wage premium needs to be higher and with lower education rates.

4. Empirical verification

In order to strengthen some of the findings from the theoretical model, we estimate the relationships between the aggregate variables measuring economic performance and corruption. These regressions control for three additional factors: initial real GDP per capita, a degree of openness to international trade, and population growth. We control for these variables in these regressions since in every simulation of the model, the economy is closed, starts with the same initial level of output, and there is no population growth. It is important to note that the goal of this section is not to prove empirical causality between corruption and macroeconomic factors, but instead to estimate reduced form relationships that compare most directly to those obtained in the theoretical model presented here. As such, we do not attempt to match precise magnitudes of empirical counterparts. Our aim in this section is to provide empirical evidence for the main trends obtained in our simulation and offer qualitative support for our modeling structure.

4.1. Data

In order to measure educational corruption we use Transparency International's Global Corruption Barometer (GCB). The GCB uses survey data to measure the degree of corruption, both actual and perceived, by the general public across country, asking a variety of questions regarding bribery and corruption across various institutional levels.[10] In particular, the GCB provides information on the proportion of households who have paid bribes to educational institutions.[11] This specific variable is available from surveys performed in 2007, 2010 and 2013. In order to maximize the number of observations, we take a multi-year average across the three survey years.

We calculate annual growth rates over a 29 year period from 1990 through 2019 using data from the Penn World Tables (PWT v.10).[12] Initial RGDP per capita is taken from 1990. We also use the PWT v.10 to calculate population growth and a country's degree of openness to international trade. Tertiary completion rates from 2010 are obtained from the Barro-Lee dataset on educational attainment as found in Barro and Lee (2013). We directly calculate the returns to education across three skill levels using our production function, Eq. 2.9. Parameter values from Table 1 are used, along with data on capital stock and labor obtained from the PWT v.10. Skilled and unskilled labor is calculated using Barro-Lee estimates on educational attainment. Gini coefficients are collected from the World Bank for the most recent year available for each country. The final dataset consists of 100 countries. Summary statistics for these variables can be found in Table 2. Given these variables we now turn to our estimation procedure.

4.2. Estimation

To estimate the relationship between growth, the education wage premium and tertiary completion rates, we turn to semiparametric estimation.[13] Following Li and Racine (2007), we estimate the following semiparametric model using Robinson's Estimator:

$$Y = X'\gamma_0 + g(Z) + U$$

where X is a matrix of the explanatory variables initial RGDP, average annual population growth and openness. Z is educational corruption. Y is RGDP growth, tertiary completion rates, or the college wage premium. This functional form assumes that the explanatory X variables enter the equation linearly, while educational corruption is modeled non-parametrically. An estimator for β is obtained in the following manner:

$$\hat{\gamma}_0 = (\widetilde{X}'\widetilde{X})^{-1}\widetilde{X}'\widetilde{Y} \tag{4.1}$$

where $\widetilde{X} = X - E(X|Z)$ and $\widetilde{Y} = Y - E(Y|Z)$. $E(Y|Z)$ and $E(X|Z)$ are estimated nonparametrically.[14]

4.3. Specification testing

In order to test the statistical significance of the relationship between our dependent variables and educational corruption, we utilize a modified nonparametric specification test developed by Li (1994) and Zheng (1996).[15] The null hypothesis under consideration is as follows:

$$\mathrm{H}_0^a\text{: } \mathrm{E}(\mathrm{Y}|\mathrm{z}, \mathrm{x}) = \mathrm{m}(\mathrm{x}, \mathrm{z}, \gamma_0), \text{ for almost all x, z and for some} \gamma_0 \in \Gamma \tag{4.2}$$

[10] For a complete description of the methodology, please go to http://www.transparency.org/

[11] The correlation coefficient ranges from.66 to.93 across various other types of bribes including judiciary, medical, police, registry, utilities, tax, land, and customs.

[12] Ideally, we would examine growth over a 30 year period to align with our model specification. However, examining growth in this period allows us to maximize our number of observations to 100 versus 82. It is also worth noting that in the model, corruption influences growth afterwards; however, data limitations prohibit us from studying a strictly post-bribery period. This drawback highlights the importance of our model and why this empirical addition is simply meant to provide some initial support for a topic that will require further research in the future.

[13] Due to the small number of observations, performing a fully nonparametric estimation is not feasible.

[14] See Li and Racine (2007) for a more formal presentation of Robinson's estimator and semiparametric estimation.

[15] A similar test is presented by Härdle and Mammen (1993).

Table 2
Summary Statistics.

Variable	Mean	S.D.	Max	Min
Annual RGDP pc Growth, 1990–2019	2.42	2.25	9.26	-11.43
Proportion of Households Engaged in Educational Corruption, 2007–2013	0.14	0.14	0.75	0.00
RGDP pc 1990	11,416.16	10,752.67	42,263.76	714.23
Population Growth, 1990–2019	1.17	1.17	3.28	-1.15
Openness, 1990–2019	-5.65	11.59	25.11	-41.12
Tertiary Completion Rates, 2010	10.81	8.17	30.56	0.21
Skill Wage Premium (S1)	106.62	62.44	499.97	31.07
Skill Wage Premium (S2)	44.88	23.21	132.31	12.58
Skill Wage Premium (S3)	27.37	15.52	62.10	4.91
Gini Coefficient	0.36	0.07	0.63	0.17

Source: Authors' Calculations, Feenstra et al. (2015), and the World Bank.

where $m(x, z, \gamma_0)$ is a known function with γ_0 being a parameter vector. To test conditional independence between our dependent variable Y and our measure of educational corruption Z, we replace $m(x, z, \gamma_0)$ with the unconditional mean for Y, $\bar{Y}$. That is, we test the following null hypothesis:

$$H_0^a\text{: } E(Y - X'\gamma_0|z) = g(z) = \bar{Y}, \text{ for almost all z and for some } \gamma_0 \in \Gamma \tag{4.3}$$

A rejection of H_0^a suggests that Y is *not* mean independent of educational corruption, after controlling for our independent variables contained in X. The results of these specification tests can be found in Table 3. We fail to reject the null hypothesis for growth, tertiary completion rates, and various levels of the skill premium. As such, we conclude that they are mean independent of educational corruption. We reject the null hypothesis for tertiary total rates and the Gini coefficient, and find that they are not mean independent of educational corruption.

4.4. Empirical results

Fig. 13a shows the results for the semiparametric estimate of annual growth on the Global Corruption Barometer (GCB). An inspection of this figure reveals an interesting relationship between corruption and annual growth. When zero to 20 households bribe, there is a negative effect on economic growth. However, after this range, growth is monotonically increasing as corruption becomes more prevalent. This suggests that corruption has a negative impact on growth in countries that experience low levels of corruption, but a positive impact on growth in countries experiencing higher levels of corruption.

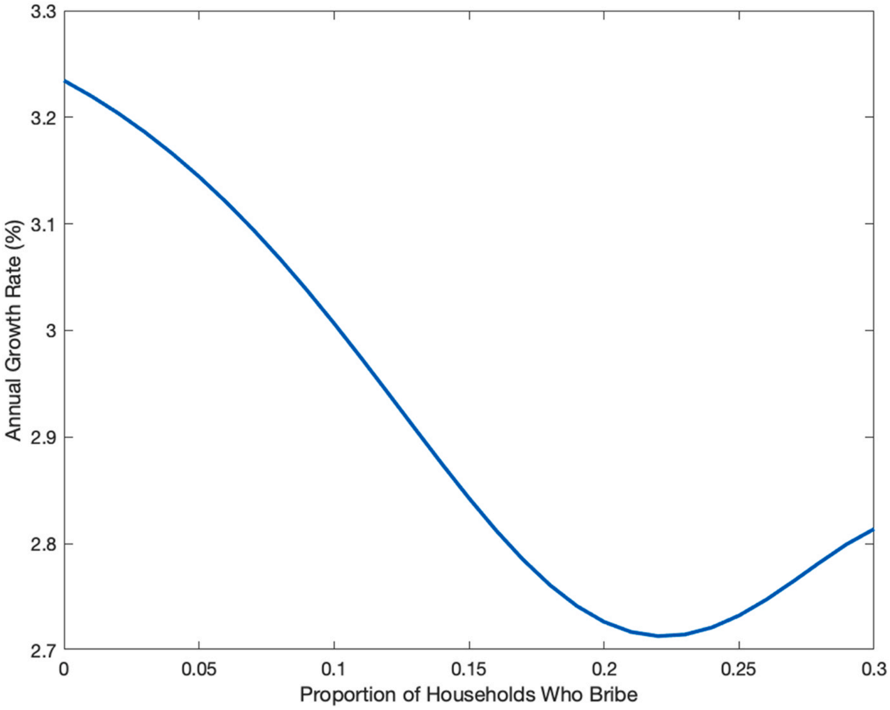
When we compare this result to those obtained from the model found in Fig. 13b, we see that both distributions of varying asset-ability correlations exhibit a similar relationship to that found in the data when growth is measured at the aggregate and the average level of ability. In both distributions, low levels of bribery have a negative impact on growth, and as corruption becomes more prevalent it has a positive impact on growth. A further comparison of the two figures shows that when growth is measured using aggregate ability we also find higher levels of corruption to be growth enhancing, albeit not to the same degree that the data implies.

Turning to the wage premium and educational corruption, Fig. 14a through d compare the results from our estimation to the results produced by the model. It is important to point out that in our model there is only one level of education, and, if admitted, the agent completes schooling to become a manager in the sense that there are two main skills levels, managers or educated workers, and laborers or uneducated workers. In reality we know that there are various levels of education and thus various skill premiums. We estimate the impact of corruption on the skill premium across three levels, $S1$, $S2$ and $S3$. $S1$ is the skill level defined as skilled workers that have at least some tertiary level of education. $S2$ is defined so that skilled workers have completed secondary school, and $S3$ is defined so that skilled workers have at least some secondary education.

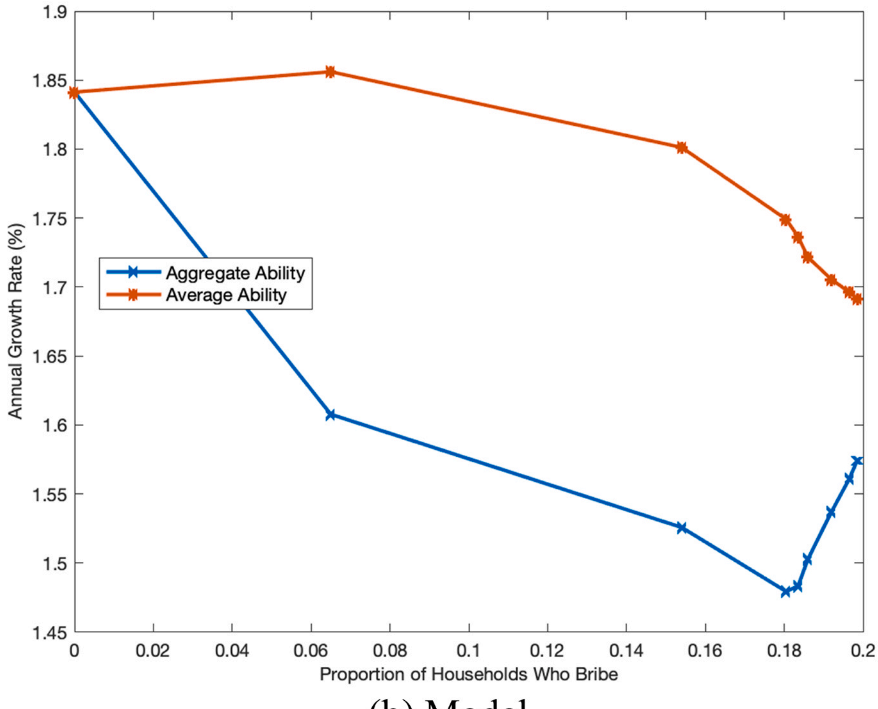
Table 3
Specification Test Results.

Test Under H_0^a: $E(Y - X'\gamma_0 \mid z) = g(z) = \bar{Y}$	
Dependent Variable	P-value
Average Growth Rate	0.2932
Tertiary Completion Rates	0.2957
Tertiary Total Rates	0.0175
Wage Premium S0	0.8471
Wage Premium S1	0.1253
Wage Premium S2	0.5539
Wage Premium S3	0.8496
Gini Coefficient	0.0025

Source: Authors' Calculations.



(a) Data



(b) Model

Fig. 13. Empirical Comparison of Bribery and Growth.

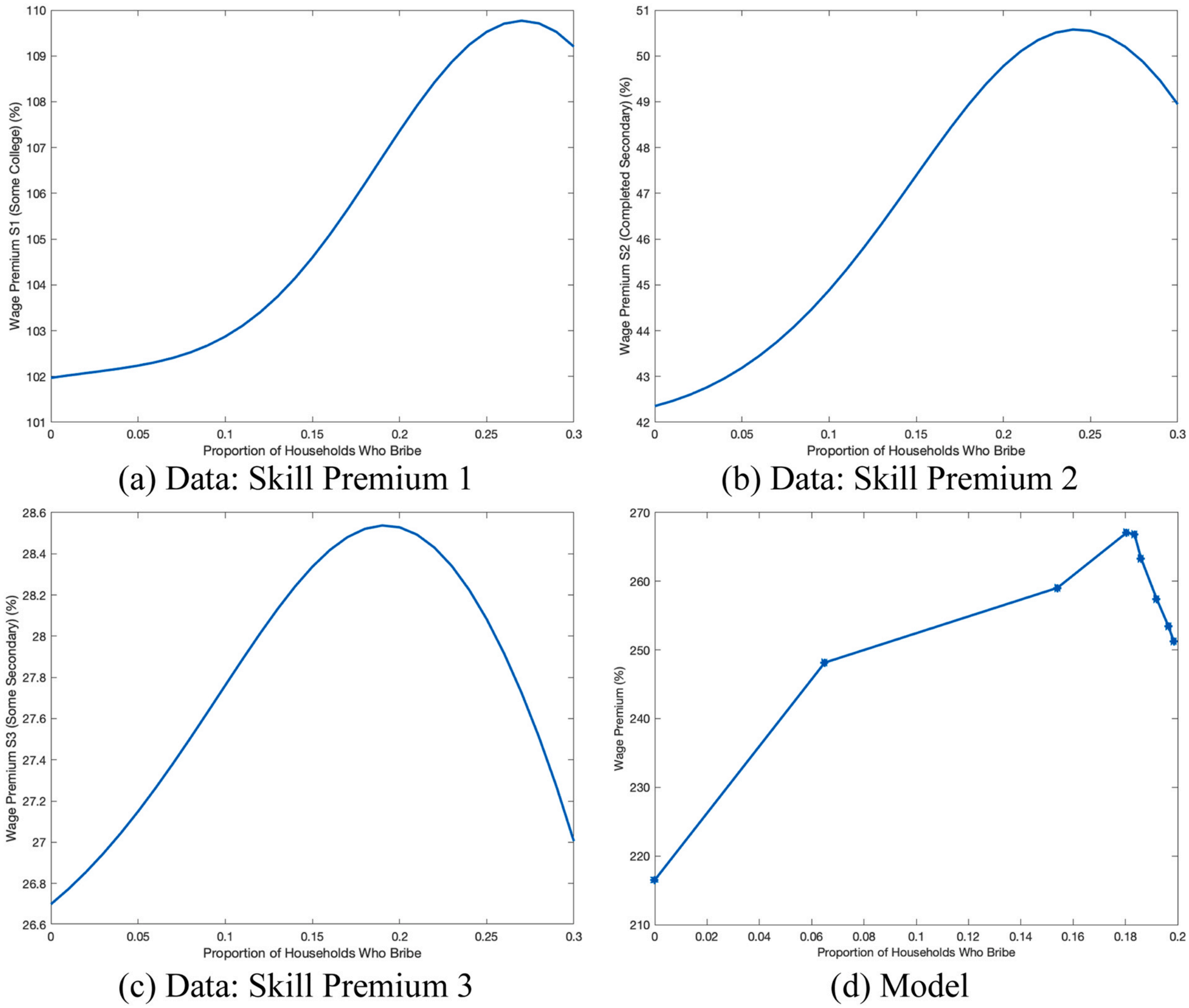


Fig. 14. Empirical comparison of bribery and the wage premium.

Fig. 14a shows the impact of corruption on the wage premium with skill level $S1$. We find that that the skill premium is fairly constant until around 10% of households begin to bribe, after which the skill premium strictly increases until about 25% of households bribe, where it begins to fall again. A similar relationship is found for skill premium $S2$. Moving on to $S3$, we find a more pronounced inverse u-shaped relationship between corruption and the wage premium. The wage premiums found using our model are shown again in Fig. 14d. Overall, the relationship between corruption and the wage premium match the data fairly well. In the data, as in all three measures of the skill premium, we find that the education wage premium increases as corruption increases, before turning negative at greater levels of corruption.

In Fig. 15a and b we present the estimation results for the impact of corruption and education using the data and our model, respectively. The semiparametric analysis suggests that when zero to 23% of households engage in some form of bribery, the expected tertiary completion rate declines, with a minor increase initially, from a little under 9–7.8%. After this range, however, as bribery begins to increase so do tertiary completion rates. Our model produces similar qualitative results. Initially, corruption has a negative impact on education, followed by a positive one after corruption becomes more widespread.

Finally, Fig. 16 presents the estimated relationship between corruption and the Gini coefficient using the data and the model. In regard to the data, we find that inequality declines over the range where between zero and 30% of households report bribing. This is only partially captured in the model, where we find an initial increase in the Gini coefficient as corruption rises before declining as bribery becomes more prevalent. Overall, taking Figs. 13a through 16b into account, we find strong qualitative evidence that broadly supports our modeling structure.

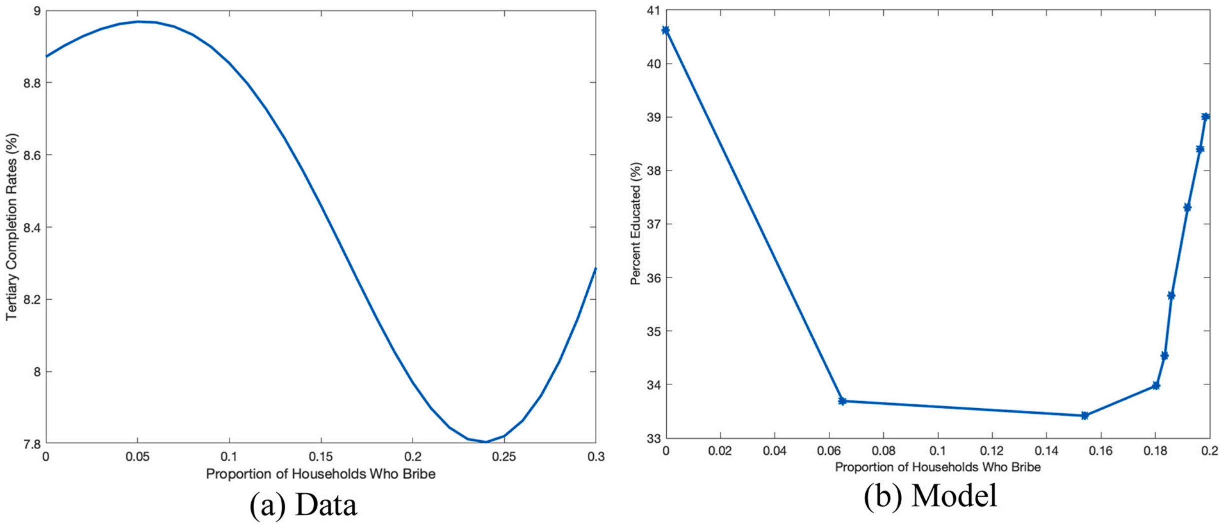


Fig. 15. Empirical comparison of bribery and tertiary completion rates.

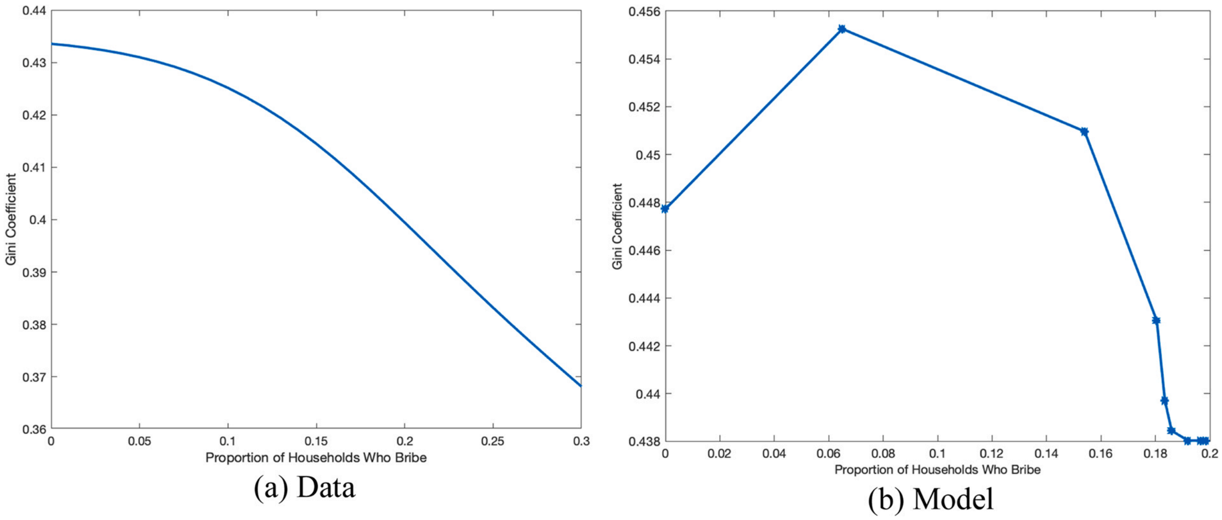


Fig. 16. Empirical comparison of bribery and gini coefficient.

5. Conclusions

This paper provides an analytical framework for studying the macroeconomic implications of educational corruption. We develop an overlapping generations model of educational corruption and show that it has a complicated relationship with economic growth rates, educational attainment and the education wage premium. At lower levels of household bribery, corruption has a negative effect on educational attainment, leading to lower equilibrium growth rates and higher skill premiums. However, as corruption becomes more widespread, this relationship becomes inverted. At higher levels of household bribery, the level of educational attainment and economic growth begins to increase, depending on how growth is measured. As this happens, the wage premium begins to fall. It is important to note that the rates of economic growth and educational attainment are highest when there is no corruption in the economy. The skill premium is also lowest when there is no bribery. In this case, the allocation of workers across occupations is purely driven by ability, i.e. only the highest ability agents pursue schooling and become managers. As expected, when corruption is introduced this is no longer the case. Distributional analysis provides strong evidence for this. As corruption becomes more prevalent, the schooling population is split more evenly across ability as agents with higher asset levels are able to bribe their way into schooling. There are two major distributional outcomes. First, as corruption increases, the share of income going to managers increases despite maintaining a relatively constant population. Second, ability across occupation converges as corruption increases. As such, educational institutions cease to be a reliable signal of quality and ability to the economy.

We use semiparametric estimation to examine how our model's aggregate results do vis-à-vis the data. Using data from Transparency International, the PWT v.10 and Barro and Lee (2013), we construct a cross-section of 100 countries to perform our analysis. We find a negative correlation between corruption and economic growth and educational attainment in countries where there is relatively little bribery. However, in countries where corruption is more common, this correlation becomes positive. We also use this cross-section of countries to examine the impact of corruption on the wage premium across three skill levels, where we find a predominantly positive relationship between corruption and the education skill premium. Lastly, we find a negative relationship between bribery and the Gini coefficient, indicating that corrupt economies also experience higher levels of inequality. These findings provide broad qualitative support for our modeling structure and highlight educational corruption as an important growth determinant.

Declarations of Interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ecosys.2023.101074.

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