Human Capital and Sectoral Labor Allocation[*]

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Abstract: This paper argues that the public education policies, which affect schooling years and education quality, are important to understand sectoral employment and productivity. We build a general equilibrium multi-sector heterogeneous-agent life-cycle model, which features both education investment, in terms of schooling years and expenditure, and sectoral employment choices. Disciplining the stock of human capital using schooling years and return data, we perform counterfactual experiments and show that eliminating public education policies would increase agricultural employment by 46% while endowing the country with U.S. public education policies would reduce the agricultural employment by 13% even when assuming constant years of schooling.

JEL codes: E24, I25, J24, O11, O41

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1 Introduction

Structural transformation is a distinctive feature of economic growth that occurs when a sustained period of rising income is accompanied with reallocation of economic activities from agricultural to non-agricultural sector. The literature has emphasized two channels to explain the pattern: the increase in income reduce the demand of food and the relative technological progress in the agricultural sector. Both of these channels reduce the demand for agricultural workers and make the agricultural sector shrinks over time.

In this paper, we argue that human capital is also important to determine the structural transformation. As shown in Figure 1, economies with more years of schooling and better education quality are also the ones that have smaller agricultural sector in terms of employment share.[1] How does human capital accumulation affect structural transformation? As human capital is relatively more valuable in the non-agricultural sector, people who accumulate more human capital choose to work in the non-agricultural sector. How does human capital accumulation varies systemically across different countries? We proposed that public education system plays an important role in understanding the human capital accumulation process. The places with better education systems reduce the marginal cost of education and induce agents to accumulate more human capital.

Figure 1: Sectoral Allocation, Years of Schooling and Return to Schooling

This paper considers both quantity and quality of education. The quantity of education refers to the years of schooling while the quality of education considers how much human capital can be imparted per year of schooling, which can be inferred from the Mincer return (see, e.g., Hendricks, 2002; Schoellman, 2012). There are two dimensions of education policies that we are interested in: years of government subsidized schooling and government expenditure on public education, both of which are important to determine the quantity and quality of education.

The two dimensions of education policies are also important to the sectoral labor productivity. The quantity and quality of education augment one's efficiency in production in both agricultural and non-agricultural sectors.[2] Mincer regression confirms that additional years of schooling increase

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[1]The return to education is from Schoellman (2012) that uses the wage of U.S. immigrant workers to back out the quality of education from their mother countries.

[2]It is less controversial that education augments the non-agricultural sector production efficiency. Goldin and Katz

one's earning by increase one's human capital or production efficiency. We show that, even controlling for the years of schooling, the sectoral labor productivity increases with the education policies mentioned.

It is also shown that in economies with better education policies, the sectoral difference in education level is smaller. Since the education policies augment one's efficiency in production, their sectoral composition is also important to understand the sectoral productivity. We find that better education policies also reduce the agricultural productivity gap between agricultural and non-agricultural sectors. This is complement to the study of Gollin, Lagakos and Waugh (2014).

With all these evidence, we build on Córdoba and Ripoll (2013) and develop a general equilibrium version of life-cycle framework to study the role of human capital accumulation in determining the process of structural transformation. In the model, different households have different endowment and choose different schooling and, based on these, sectoral employment. There are two main differences between our model and that of Córdoba and Ripoll (2013). First, our model is a general equilibrium model. Adding the production sector not only allow our model to have prediction on the sectoral allocation of labor, but also the endogenous productivity difference due to the composition of worker with different human capital. Second, relatedly, we add household heterogeneity into the model. This is because we want different households to choose different years of schooling and education investment based on their own endowment. So, household difference in endowment leads to different human capital accumulation and hence different sectoral employment.

Human capital accumulation depends on both the duration of schooling and education investment during the schooling period. The two dimensions of education policies, which are average government education subsidy and its duration, play important role in human capital accumulation and hence structural transformation. The education subsidy lowers the marginal cost of education investment and induces more human capital investment, while the increase in the duration of subsidy strengthens this effect. As households acquire more human capital, they self-select themselves into the non-agricultural sector. As a result, the model is able to generate the fact that economies with better education policies having more years of schooling and smaller agricultural sector.

We first calibrate the model using the U.S. data. The model is able to generate cross-sectional distribution of years of schooling in both agricultural and non-agricultural sectors that match the data well. Counterfactual analysis shows that education policies, like the duration of government subsidized schooling and government public education expenditure, are as important as the productivity progress in explaining the decline in agricultural employment share.

Then we recalibrate a set of country-specific parameters to cross-country data and test the model prediction on cross-country differences in agricultural employment share and sectoral productivity. The model produces some variables that have clear data counterparts: sectoral years of schooling and return to education. So, we discipline our model using two different dataset. The first dataset is from Gollin, Lagakos and Waugh (2014) that document the sectoral years of schooling in both agricultural and non-agricultural sectors. The other dataset is from Schoellman (2012) that uses

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(2010) argue that it is also the case in the agricultural sector as people with more years of schooling earns higher income, but smaller Mincer return compared to the non-agricultural sector.

immigrants' return to education to derive the quality of education in other countries.[3] The calibrated model is able to generate some key features in cross-country sectoral productivity differences.

The counterfactual exercise shows that developing countries, like Bangladesh, would experience 46% increase in agricultural employment share if the public education policies are removed. If Bangladesh is endowed with the public education policies in the U.S., however, and assume that the years of schooling remains unchanged (but the quality of education increased for each additional year of schooling), the agricultural employment share would reduced by 13%.

Related Literature. We build on the Roy (1951) model of self-selection based on comparative advantage. The framework is similar to that of Lagakos and Waugh (2013) and Porzio, Rossi and Santangelo (2021), that individuals with heterogeneous human capital choose their sector of employment. Porzio, Rossi and Santangelo (2021) argue that human capital is valued higher outside of the agricultural sector, higher human capital individuals will self-select to non-agricultural sector. In their framework, however, human capital is determined exogenously. So, their models are unable to shed light on the macroeconomic response of change in education policy. Our contribution is to endogenize the process of human capital accumulation, link that to changes in education policy, and quantify their impact on both sectoral employment choice and aggregate productivity. Moreover, our work consider both the years of schooling and the quality of education in determining the structural transformation.[4] To our best knowledge, we are the first to quantify the effect of quality of education on structural transformation.

Our work is also related to works studying human capital accumulation. Our model is built on the one in Córdoba and Ripoll (2013) and Manuelli and Seshadri (2014). The current paper is similar to Córdoba and Ripoll (2013) that both of us consider how the differences in education policies and productivity, among other factors, affect individuals' schooling and human capital choices. We add production side and self-selection based on heterogeneous human capital in order to study structural transformation. In additional, the current work also talks to the human capital literature by incorporating both quality and quantity of education into a life-cycle model to account for the quality-adjusted human capital stock.

To our best knowledge, Caselli and Coleman (2001) is the seminal paper studying the effect of education on sectoral allocation of labor. The current work is different from theirs in the way the human capital accumulated through education is used. In Caselli and Coleman (2001), education served as a pre-requisite for individuals who wish to join the non-agricultural sector and education does not augment the individuals' production efficiency. However, the current work treats human capital as a productive factor input. So, align with Manuelli and Seshadri (2014), different quantity

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[3] We do not use return to education data derived from the country's own census or survey data like in ones in Psacharopoulos (1985, 1994). This is because the return to education not only depends on the quality of education, but also the total human capital stock. In places with lower education attainment, secondary school completion is considered high education and individuals with such degree earn premium wage. For example, some of the less developed countries documented in Bils and Klenow (2000) had higher return to education when compared to the U.S. So, as argued in Schoellman (2012), it is desirable to control for the stock of human capital.

[4] The current work use the method proposed in Hendricks (2002) and Schoellman (2012) to use the immigrants' earning in the U.S. to assess the education quality in their original countries. There are other works that directly estimate the human capital stock using the international testing score (for example, Hanushek and Kimko, 2000; Hanushek and Woessmann, 2012; Hanushek, Ruhose and Woessmann, 2017).

and quality of (sectoral) human capital affect (sectoral) productivity in the economy. This allows us to use the measured sectoral human capital stock in the model to understand the problem of agricultural productivity gap.

Finally, our model also answers to a large literature of structural transformation.[5] The current work is mostly related to Acemoglu and Guerrieri (2008) that built on the insight of Rybczynski (1955) and formalize a model that endogenous changes in the supply of different inputs may lead to structural transformation if sectors vary by their factor intensity. Our contribution is to build a model that endogenizes the formation of human capital, and link it to structural transformation.

The subsequent discussion will be organized as follows. Section 2 discusses the empirical evidence. Section 3 presents a model with education and sectoral employment choice. Section 4 is to calibrate the model and establish the credibility of the model. Section 5 presents some counterfactual exercise. Section 6 concludes.

2 Empirical Evidence

In this section, we argue for the importance of education policies on years of schooling, sectoral employment, and sectoral labor productivity. We review the evidence that differences in education policies play an important role in understanding the cross-country years of schooling and sectoral labor allocation differences. Economies with longer years of compulsory education and government education expenditure have more years of schooling and have relatively fewer employment in agricultural sector. The education policies also affects human capital quality (measured in sectoral labor productivity) even if the years of schooling is controlled. In addition, the sectoral allocation of human capital also has implication on the sectoral labor productivity.

Fact 1. Education policies affect both the years of schooling and quality of education
The education policies, namely, years of compulsory education and government education expenditure, varies largely across different countries. For example, in the year 2005, the compulsory education in Bangladesh is 5 years and government spent 2.11% of GDP on education; in the USA, however, the numbers were 12 years and 4.94%, respectively.

Not only does this difference in education policies have implication on years of schooling, such difference also affect the return to education as documented in Schoellman (2012). In economies with better education policies, i.e., government provides longer years of compulsory education and larger amount of public education expenditure, the economies are likely to have more years of schooling. This is not very surprising because the improvement of the education policies reduce the marginal cost of individuals who receive an education, and lead to increase schooling in general.

In addition, in countries with better education policies, more human capital is imparted per year of schooling, which in turn is associated with a larger wage income per an addition year of schooling. Two lower panels in Figure 2 shows that the return to education correlated with education policies.

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[5]For literature review, consult Herrendorf, Rogerson and Valentinyi (2014)
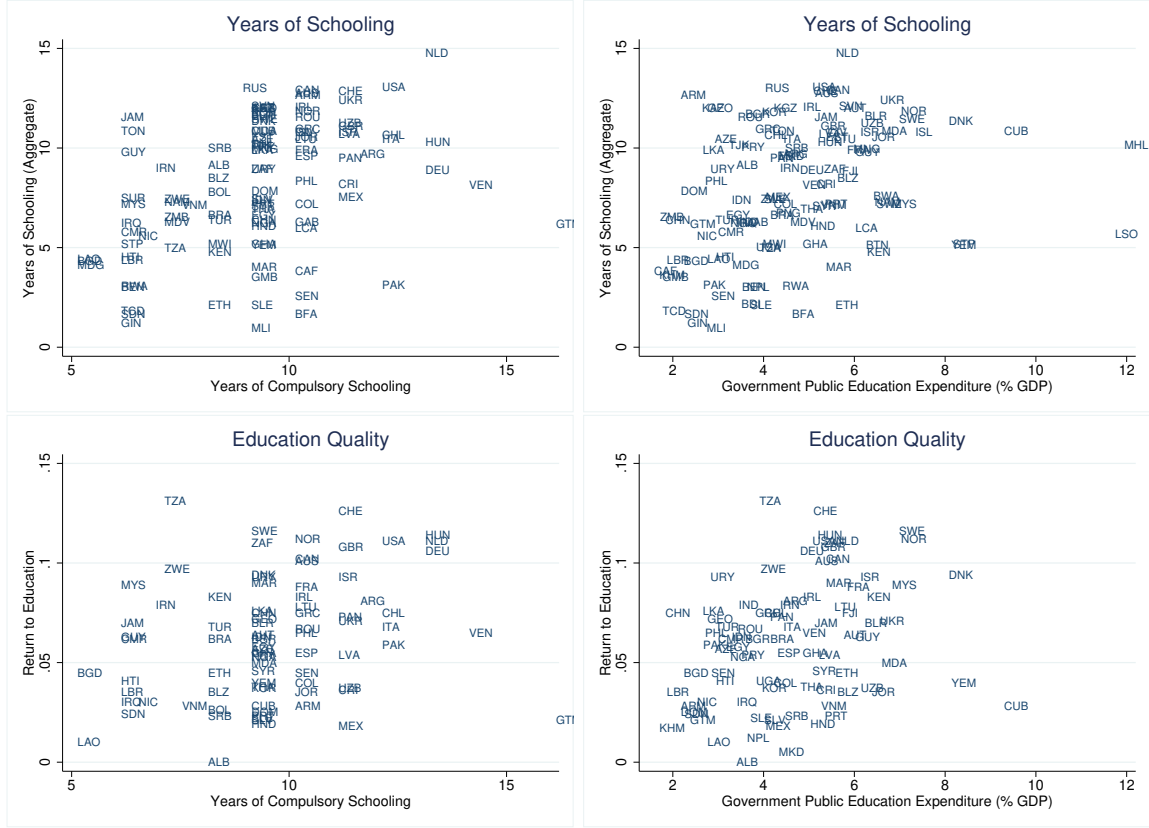
Figure 2: Education Policies on Quality and Quantity of Education

Fact 2. Education policies are correlated with sectoral labor productivity controlling years of schooling

Sectoral labor productivity provides us a sectoral measure of efficiency unit of labor. We define sectoral labor productivity as the sectoral share of output divided by sectoral employment share:

$$\frac{Y_i/Y}{N_i/N} = \frac{Y_i}{N_i} \times \frac{N}{Y} \iff \frac{Y_i}{N_i} = \frac{Y_i/Y}{N_i/N} \times \frac{Y}{N}$$

where Y_i/N_i is sectoral labor productivity, Y/N is GDP per worker, Y_i/Y is sectoral value added share and N_i/N is sectoral employment share. By using the data from the World Bank and Gollin, Lagakos and Waugh (2014), we can construct a measure for sectoral labor productivity. Then, we regress sectoral labor productivity on years of schooling to remove the effect of years of schooling on sectoral labor productivity.

The residual productivity is then plotted against different education policies. It is evident that the sectoral labor productivity is positively (and robustly) correlated with education policies. Longer duration of compulsory schooling and larger amount of government spending on public education lead to higher sectoral labor productivity, even when the years of schooling is controlled. This shows that public education policies have positive effect on the efficiency unit of labor in each sector.
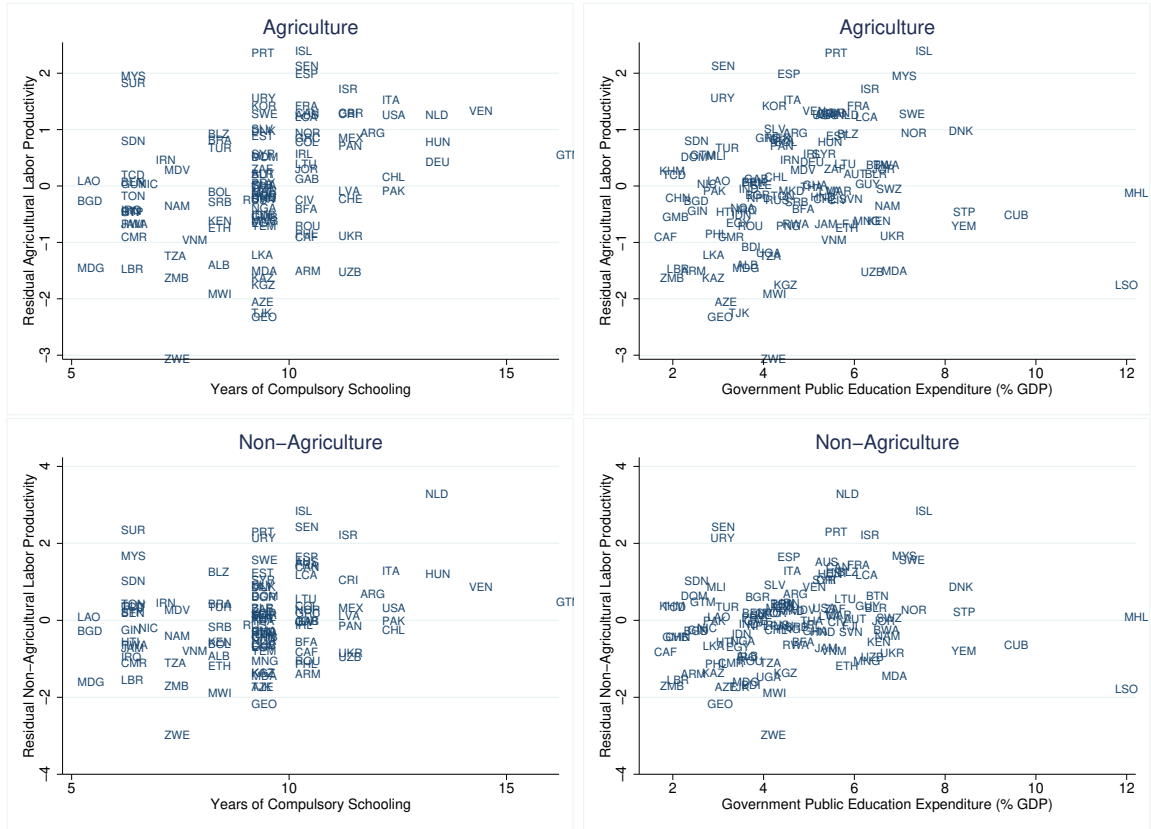
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Figure 3: Residual Sectoral Productivity and Education Policies

Fact 3. Education policies reduce sectoral difference in education and agricultural productivity gap

Education policies also lead to less inequality in sectoral distribution of years of schooling. Figure 4 shows that in economies with higher years of schooling, the discrepancies in sectoral years of schooling is substantially lower.

Since human capital augments the efficiency unit of production in both the agricultural and non-agricultural sectors, the equalization of the sectoral schooling difference will induce the reduction in the agricultural productivity gap as shown in Figure 4. As noted by Gollin, Lagakos and Waugh (2014), the sectoral years of schooling cannot fully explain all the agricultural productivity gap. This is also true in the current analysis, since the relation between the agricultural productivity gap and education policies is not as tight as that with schooling gap.

2.1 Summary

In this section, we show that the reason behind the negative correlation observed in Figure 1 can be understood in two dimensions. First, better education policies induce more years of schooling and better education quality. As the non-agricultural sector is more human capital intensive, increase in (quality-adjusted) human capital leads to relative expansion in non-agricultural sector and relative
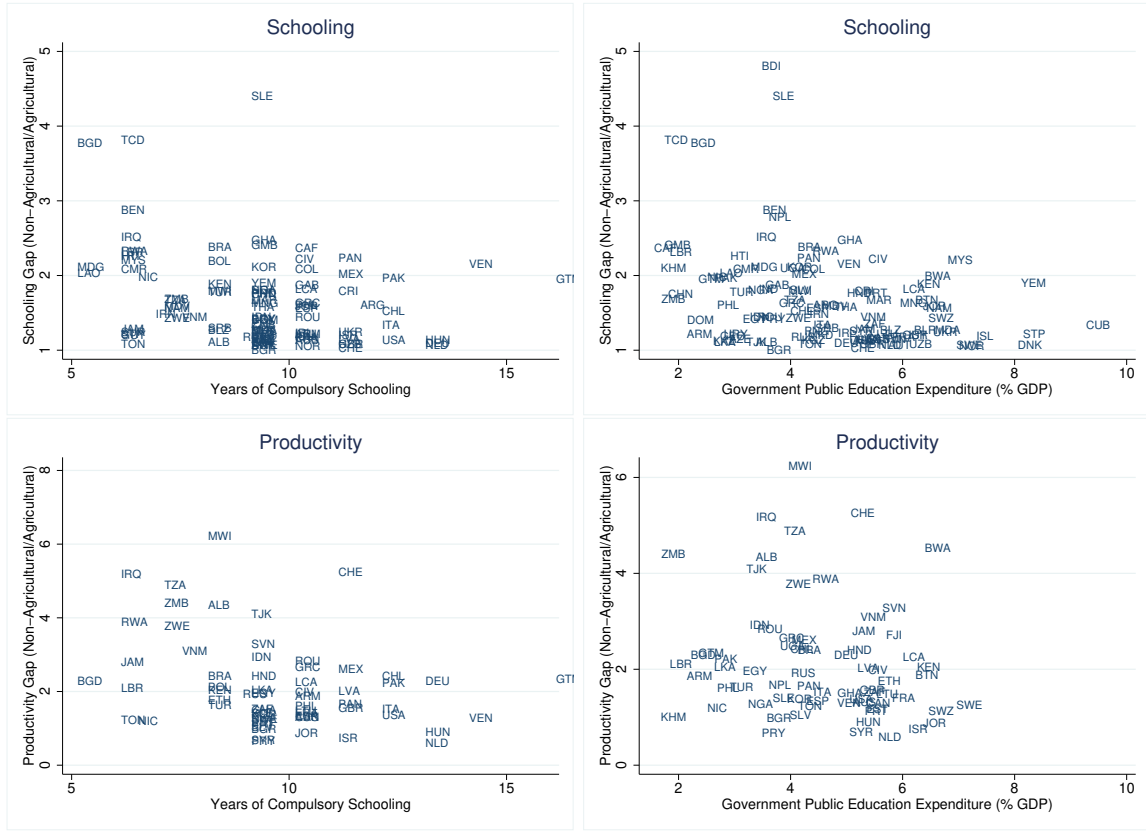
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Figure 4: Schooling and Productivity Gap

decline in agricultural sector.

Second, countries with better education policies also have higher sectoral productivity even if we control for the years of schooling. Based on Fact 1, it is intuitive since the education quality increase with education policies and more human capital is imparted per year of schooling in places with better education policies.

Moreover, the education policies can also partly explain the agricultural productivity gap. It is observed that the difference between the agricultural and non-agricultural productivity is higher in economies with relative worse education policies. One of the reasons behind this observation is that the sectoral difference in years of schooling is more equal in economies with better education policies, as human capital is an productive input in both sectors, less differences in the years of schooling implies less differences in agricultural productivity gap.

3   Model

In this section, we present a life-cycle model that is built on Córdoba and Ripoll (2013), with production side and heterogeneity to aid heterogeneous sectoral allocation choice. The individuals make human capital and sectoral employment decisions based on their endowments. Financial

constraints and education policies play important roles in determining the individuals' human capital investment decisions, and hence financial constraints and education policies also affect their sectoral employment decisions.

3.1   Household and Endowment

Time is continuous and individuals differ in their endowment in initial wealth b, ability ψ and agricultural productivity l. We assume that each individual randomly draw $\{b, \psi, l\}$ from $G(b, \psi, l)$. Although l only affects individuals through its effect on efficiency of agricultural production, ψ affects both (non-agricultural) production efficiency and human capital accumulation process. Different from Córdoba and Ripoll (2013), we abstract from any intergenerational choices to simplify the problem as the focus is on sectoral allocation of talent rather than intergenerational mobility.

We assume that an individual start to derive utility at age 6 when she begin to go to school. An individual chooses a series of consumption and education investment, $\{c(\tau), e_p(\tau)\}_{\tau \in [6,T]}$, during age 6 and terminal age T, and the age s when the individual discontinues schooling (and starts to work). So, the utility maximization problem of an individual with endowment $\{b, \psi, l\}$ and working in sector i is given by:

$$V_i(b; \psi, l) = \max_{c(\tau), e_p(\tau), s, \kappa(s)} \int_6^T e^{-\rho(\tau-6)} u(c(\tau)) d\tau \tag{1}$$

s.t.

$$\int_6^s e^{-r(\tau-6)}[c(\tau) + e_p(\tau)]d\tau + e^{-r(s-6)}\kappa(s) \leq b \tag{2}$$

$$\int_s^T e^{-r(\tau-6)}c(\tau)d\tau \leq \int_s^R e^{-r(\tau-6)}w_i\left(h(s), \tau-s; \psi, l\right)(1-\iota)d\tau + e^{-r(s-6)}\kappa(s) \tag{3}$$

$$h(s) \leq z_h \left[\int_6^s \psi(e_p(\tau) + e_g(\tau))^\alpha d\tau\right]^{\frac{\gamma}{\alpha}} \tag{4}$$

$$e_p(\tau) \geq 0 \text{ for all } \tau$$

$$\kappa(s) \geq 0$$

$$0 \leq s \leq F$$

Equation (2) suggests that the credit market is not perfect for students, when $\tau < s$, so that they cannot borrow against their future earnings. Their borrowing constraints are their initial wealth. Nonetheless, they can save part of their unused initial wealth for future use $\kappa(s) \geq 0$. During $\tau < s$, apart from consumption and saving choices, individuals also choose private education investment $e_p(\tau)$.

When individuals work, $\tau > s$, their lifetime income is the sum of their wage income and saving $\kappa(s)$. In equation (3), sectoral wage $w_i\left(h(s), \tau-s; \psi, l\right)$ is assumed to have the following function

form:

$$w_i\left(h(s), \tau - s; \psi, l\right) = \tilde{w}_i\left(h(s); \psi, l\right) e^{\nu_{1i}(\tau-s)+\nu_{2i}(\tau-s)^2} \tag{5}$$

This captures both schooling effect $\tilde{w}_i\left(h(s); \psi, l\right)$ and experience effect $e^{\nu_{1i}(\tau-s)+\nu_{2i}(\tau-s)^2}$ in the Mincer equation. We assume that ν_{1i} and ν_{2i} are sector-specific and will be pinned down using data. We further assume that the sector-specific experience will be lost once the individual switches sector.[6] An working individual needs to pay ι income tax. The tax is collected by a government, that runs balanced-budget, and the tax is used to fund public education investment e_g for all the current students and initial wealth of the new generation (i.e. $\tau = 6$ cohort).

The human capital $h(s)$ is accumulated through schooling. Define $e(\tau) = e_p(\tau) + e_g(\tau)$ as the total education investment. As in equation (4), human capital accumulation depends on four factors: 1. z_h captures economy-wide efficiency in human capital production; 2. s determines the length of individuals staying in schools and receive education; 3. $e(\tau)$ is the education investment in units of aggregate consumption goods; and 4. ψ is talent that captures idiosyncratic efficiency in human capital accumulation. Similar to Córdoba and Ripoll (2013), parameter α determines the degree of substitution of education investment throughout lifetime while γ governs the return to scale of total effective education expenditure.

There are two sectors, agricultural a and nonagricultural m, in the model economy so that $i \in \{a, m\}$. The instantaneous utility function in equation (1) is given by $u(c(\tau)) = c(\tau)^{1-\sigma}/(1-\sigma)$ and

$$c(\tau) = \frac{\tilde{c}(\tau) - p_a(\tau)\bar{c}}{[\zeta p_a(\tau)^{1-\eta} + (1-\zeta)p_m(\tau)^{1-\eta}]^{\frac{1}{1-\eta}}} \tag{6}$$

where $\tilde{c}(\tau)$ is the total expenditure on consumption.[7]

Finally, the sectoral choice S is such that $S = \arg\max_{S \in \{0,1\}}\{SV_a(b|\psi, l) + (1-S)V_m(b|\psi, l)\}$.

3.2 Financial Constraint and Education

Denote λ_1 and λ_2 be the two Lagrangian multipliers associated with equations (2) and (3), respectively. The FOC's with respect to consumption $c(\tau)$ when $\tau \in [6, s]$ and $\tau \in [s, T]$ gives:

$$J \equiv \frac{\lambda_1}{\lambda_2} = \frac{u_c(c^S(s))}{u_c(c^W(s))} = e^{(\rho-r)(F-6)}\frac{u_c(c(6))}{u_c(c(F))} \geq 1$$

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[6]From Herrendorf and Schoellman (2018), it is found that only 0.45% of workers from 1968-97 switched from agricultural to non-agricultural sector.

[7]This is a indirect utility function that only depends on total expenditure $\tilde{c}(\tau)$ as well as prices. The expression in equation 6 comes directly from maximizing

$$\left[\zeta^{\frac{1}{\eta}}(c_a - \bar{c})^{\frac{\eta-1}{\eta}} + (1-\zeta)^{\frac{1}{\eta}}c_m^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

subject to

$$p_a(\tau)c_a(\tau) + p_m(\tau)c_m(\tau) \leq \tilde{c}(\tau)$$

Notice that $J \geq 1$ represents a potential jump in consumption at age $\tau = s$, i.e. $c^S(s) \leq c^W(s)$. If $J > 1$, then $c^S(s) < c^W(s)$ and the individual is constrained. The individual wants to smooth her consumption by borrowing ($\kappa(s) < 0$), but she is constrained by the non-negativity constraint of $\kappa(s) \geq 0$. So, she will spend all her *inter vivo* transfer and $\kappa(s) = 0$.

If $J = 1$, then $c^S(s) = c^W(s)$. The individual is able to smooth consumption across studying and working periods. Then the saving $\kappa(s)$ is given by:

$$\kappa(s) = \frac{\frac{b-E^*}{D_6^s} - \frac{I_i(s)}{D_s^T}}{e^{-r(s-6)}\left[\frac{1}{D_6^s} + \frac{1}{D_s^T}\right]} > 0$$

where $E^* = \int_6^s e^{-r(\tau-6)} e_p(\tau) d\tau$ is the discounted private education expenditure of the individual, $I_i(s) = \int_s^R e^{-r(\tau-6)} w_i\left(h(s), \tau - s; \psi, l\right) d\tau$ is one's discounted wage income in the work period and $D_x^y = \int_x^y e^{-r(\tau-6)} \left(e^{(\rho-r)(\tau-6)}\right)^{-\frac{1}{\sigma}} d\tau$ is collection of discounted factors. The expression is intuitive that the saving $\kappa(s)$ is decreasing in both private education expenditure E^* and wage income $I_i(s)$, because higher private education expenditure reduces the unused amount of *inter vivo* transfer and higher wage income makes the saving $\kappa(s)$ insignificant.

The size of J affects the optimal schooling. To see this, consider the following FOC with respect to s, where left-hand side is the marginal benefit of additional schooling while right-hand side represents the marginal cost:

$$\frac{\partial}{\partial s} \int_s^R e^{-r(\tau-6)} w_i\left(h(s), \tau - s; \psi, l\right) d\tau$$
$$= Je^{-r(s-6)} \left[\frac{u(c^W(s)) - u(c^S(s)) + u_c(c^S(s))c^S(s) - u_c(c^W(s))c^W(s)}{u_c(c^S(s))} + e_p(s)\right]$$
$$= RHS_{J>1}$$

and when $J = 1$, $RHS_{J=1} = e^{-r(s-6)} e_p(s)$. It is straightforward to show, with our assumed utilities, $RHS_{J>1} > RHS_{J=1}$. It means that the marginal cost of schooling is higher for individuals who are budget constrained. This is intuitive since the individuals facing $J > 1$ are financially-constrained. So, they attached higher utility for additional unit of consumption. This increases the marginal cost of schooling, in terms of consumption utility.

3.3 Education Policy and Education

In this study, we define public education policies as $\bar{s}$, which is the maximum age of public school provision, and $e_g(\tau)$, which is the public education expenditure. Consider a hypothetical situation in which there is no public education expenditure $e_g(\tau) \equiv 0$. The optimal private education

expenditure in such hypothetical regime $\hat{e}^*(\tau)$ is given by:

$$\hat{e}^*(\tau)$$

$$= \left[\frac{\psi \gamma z_h^{\frac{\alpha}{\gamma}} h(s)^{1-\frac{\alpha}{\gamma}} \int_s^R e^{-r(\tau-6)} \widetilde{w}_i'(h(s), \tau-s; \psi, l) e^{\nu_{1i}(\tau-s)+\nu_{2i}(\tau-s)^2} d\tau}{J} \right]^{\frac{1}{1-\alpha}} e^{\frac{r(\tau-6)}{1-\alpha}}$$

$$= \hat{e}(0) e^{\frac{r(\tau-6)}{1-\alpha}}$$

where $\hat{e}(0) \equiv [\psi \gamma z_h^{\frac{\alpha}{\gamma}} h(s)^{1-\frac{\alpha}{\gamma}} \int_s^R e^{-r(\tau-6)} \widetilde{w}_i'(h(s), \tau-s; \psi, l) e^{\nu_{1i}(\tau-s)+\nu_{2i}(\tau-s)^2} d\tau/J]^{\frac{1}{1-\alpha}}$ and is determined by one's endowment, and can vary across different individuals. This will affect the intercept of $\hat{e}^*(\tau)$ at $\tau = 0$. The function $\hat{e}^*(\tau)$ is strictly increasing in τ, which means that the optimal private education expenditure is increasing in one's age.

Due to the data limitation, we cannot systemically distinguish public education expenditure by age τ, so we assume $e_g(\tau) = e_g$ for $\tau \in [6, \bar{s}]$ and calibrate e_g to fit the public education expenditure as a share of GDP. Define total education investment $e(\tau) = e_p(\tau) + e_g(\tau)$ and is given by:

$$e(\tau) = \begin{cases} \hat{e}^*(\tau) & \text{for } \tau \leq \min\{s, 6\} \\ e_g & \text{for } \min\{s, 6\} \leq \tau \leq s_g \\ \hat{e}^*(\tau) & \text{for } s_g \leq \tau \leq s \end{cases}$$

where $s_g \equiv \min\{s, \bar{s}, \max[6, s_{ug}]\}$ which is the potential upper bound age that an individual depends on public education expenditure. If there exist τ such that for $\tau \lessgtr s_{ug}$ iff $\hat{e}^*(s_{ug}) \lessgtr e_g$, then s_{ug} is defined as $\hat{e}^*(s_{ug}) = e_g$ or $s_{ug} = (1-\alpha)/rln(e_g/\hat{e}(0)) + 6$, depends negatively on $\hat{e}(0)$ which is related to one's general endowment. If $\hat{e}^*(\tau) > e_g$ for all $\tau > 6$, then set $s_{ug} = 6$.

Figure 5 illustrates three cases of $\hat{e}^*(\tau)$ with and without public education expenditure. Three individuals A, B and C have their original schedule of education investment AO^A, BO^B and CO^C in the absence of public education system $\{\bar{s}, e_g\}$. The schematic figure shows that the solution of $e(\tau)$ with public education system is different from that with pure private education investment, except for individual A.

Individual A has $\hat{e}^*(\tau) > e_g$ for all $\tau > 6$, so s_{ug} is set to be 6, and hence $s_g = 6$. As a result, after the age of 6, the individual does not depend on pure public education expenditure. That is the reason that individual A is not affected by the introduction of the public education system.

Individuals B and C are affected by the introduction of the public education system. Individual B, with the original schedule of education investment BO^B, will benefit from switching her private education expenditure to public during $\tau \in [6, s_{ug}^B]$ since it will increase her human capital with no cost. After the age of s_{ug}^B, she switch back to private education expenditure. So, for individual B, $s_g^B = s_{ug}^B$. Similar argument applies to individual C with only one exception: individual C still wants to depend on public education system during $\tau \in [\bar{s}, s_{ug}^C]$ but the public education system
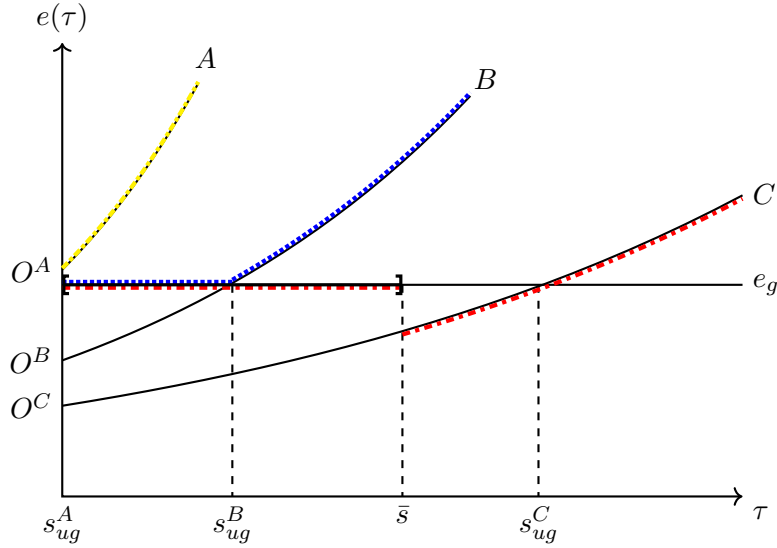
Figure 5: Schematic Figure of Education Expenditure

stops after the age $\tau = \bar{s}$.

Finally, one's human capital is

$$h(s) = z_h \psi^{\frac{\gamma}{\alpha}} \hat{e}(0)^{\gamma} \left[\int_6^{\min\{s,6\}} e^{\frac{r\alpha(\tau-6)}{1-\alpha}} d\tau + \int_{\min\{s,6\}}^{s_g} \left(\frac{e_g}{\hat{e}(0)} \right)^{\alpha} d\tau + \int_{s_g}^{s} e^{\frac{r\alpha(\tau-6)}{1-\alpha}} d\tau \right]^{\frac{\gamma}{\alpha}}$$

3.4 Education Quality

Notice that the introduction of the public education system weekly increase the expenditure during the schooling years. According to Figure 5, the total education expenditure by individuals B and C increases after the introduction of the public education system. The human capital accumulation equation (4) shows that the increase in total education expenditure leads to the increase in human capital stock of an individual, other things being constant.

However, some individuals who do not depend on the public education system (e.g. individual A) do not experience increase in human capital stock when the public education system is introduced or marginally improved. So, the introduction of the education system increases total education expenditure for some without lowering the total education expenditure of the others.

3.5 Government

The government collects labor income tax at a proportional rate ι. The tax revenue is used to meet two needs. They are public education expenditure and *inter vivo* transfer to $\tau = 6$ agents for their initial wealth endowment. We assume that the government's budget is balanced at each point in

time. Denote $x = \{b, \psi, l\}$. For each point in time, the following balanced-budget equation holds:

$$\iint \int_s^R w\left(h(s), \tau - s; \psi, l\right) \iota N(\tau; x) d\Pi(\tau) dG(x) = e_g \iint \int_6^{s_g} N(\tau; x) d\Pi(\tau) dG(x) + e^{\mu_b + \sigma_b^2/2} \int N(6; x) dG(x) \tag{7}$$

$N(\tau; x)$ is the measure of individuals at age τ with the initial endowment x, and Π is the age distribution. The total labor income tax revenue on the left-hand side is spent on funding public education, i.e., e_g for everyone with $s \in [6, \bar{s}])$, and allocated to all new generations at age $\tau = 6$ as initial endowment.

The introduction of the government sector makes the initial wealth endowment of the household depends on the level of a country's development. Although they are pre-determined using data in the calibration exercise, the government sector becomes important in the counterfactual experiment because it allows the aggregate initial wealth of the individuals to change when different exogenous parameters change. This different wealth will then change the tightness of budget constraint and will have implication on years of schooling.

3.6 Production

To close the model, we introduce the production side. The two sectors in the economy both use efficiency units of labor $\xi_i(h(s); \psi, l)$ as the only input:

$$\xi_a(h(s); l) = \left[\theta_a h(s)^{\frac{1}{\phi_a}} + (1 - \theta_a) l^{\frac{1}{\phi_a}}\right]^{\phi_a} \tag{8}$$

$$\xi_m(h(s); \psi) = \left[\theta_m h(s)^{\frac{1}{\phi_m}} + (1 - \theta_m) \psi^{\frac{1}{\phi_m}}\right]^{\phi_m} \tag{9}$$

where we assume that $\theta_m > \theta_a$ so that the non-agricultural sector is more human capital intensive. The sectoral outputs Y_i are produced using the following technologies:

$$Y_i = A_i \iint_{\Omega_i} \xi_i(h(s); \psi, l) e^{\nu_{1i}(\tau - s) + \nu_{2i}(\tau - s)^2} N(\tau; x) dG(x) d\Pi(\tau)$$

where A_i is the sectoral productivity in sector i, Ω_i is the endogenous mass of agents self-selected into sector i. The firm maximization problem will then imply that:

$$w_i\left(h(s), \tau - s; \psi, l\right) = \hat{w}_i \xi_i(h(s); \psi, l) e^{\nu_{1i}(\tau - s) + \nu_{2i}(\tau - s)^2}$$

together with equation (5), it is immediate that $\tilde{w}_i = \hat{w}_i \xi_i(h(s); \psi, l)$.

4   Calibration

We first calibrate the model for the US economy, which is used as our benchmark model; and then we recalibrate a set of country-specific parameters for other countries, ranging from high- to low-income in the world income distribution. We calibrate the model in the steady state equilibrium for all the countries.

4.1   Calibration of the U.S. economy

When calibrating the US economy, our main strategy is to first set some parameters with values from the literature or data, and then calibrate the rest parameters within the model by searching parameterization that minimizes the distance of a set of targeted moments between the model and the data. Table 1 summarizes the parameter values. Below we describe the major steps of calibration.

Parameters	Value	Target
Panel A: Predetermined		
Talent	$\mu_\psi = \mu_l = 1$	Normalize
Preference	$\rho = 0.03$, $\zeta = 0.005$, $\sigma = 1.5$, $\eta = 0.85$	Preset or Literature
Human capital	$z_h = 1$, $\underline{s} = 6$, $\bar{s} = 18$	Normalize or Data
Experience	$\nu_{1,a} = 0.0254$, $\nu_{2,a} = -0.0004$, $\nu_{1,m} = 0.0382$, $\nu_{2,m} = -0.0006$	IPUMS USA
Production	$A_a = 1$	Normalize
Life exp. & retirement	$T = 76.6$, $R = 65$	Data
Panel B: Calibrated		
Production	$A_m = 0.37$, $\theta_m = 0.80$, $\phi_m = 4.78$, $\theta_a = 0.75$, $\phi_a = -2.65$	1. Agri. Wage Gap, 2. Var. Agr. Wage, 3. Var Non-agr. Wage, 4. Agr. Emp. Share, 5. Agr. V.A. Share, 6. Agr. School Years, 7. Non-Agr. School Year, 8. Private Exp. on School, 9. Public Exp. on School, 10. Agr. Return to School, 11. Non-agr. Return to School, 12. Wealth-Wage Ratio, 13. S.D. log Wealth, 14. Non-agr. Price Gap, 15. Balanced Budget
Talent/ Wealth	$\sigma_\psi = 0.44$, $\sigma_l = 0.45$, $\rho_{\psi l} = 9.64$, $\mu_b = 5.31$, $\sigma_b = 0.66$	
Human capital	$\alpha = 0.26$, $\gamma = 0.27$, $e_g = 5.34$	
Preference	$\bar{c} = 0.15$	
Tax	$\iota = 0.24$	

Table 1: Summary of Parameter Values

Distribution of (ψ, l, b). We assume that ψ, l, and b all follow lognormal distributions; that is, $\ln(y) \sim \mathcal{N}(\mu_y, \sigma_y)$, with *cdf* $G_y(y)$, where $y \in \{\psi, l, b\}$. The distributions of ψ and l are interdependent, while that of b is independent from others. The assumption that ψ and l are interdependent is consistent with Lagakos and Waugh (2013). Thus, the joint distribution of (ψ, l, b) satisfies $G(\psi, l, b) = G_{\psi l}(\psi, l) G_b(b)$, where $G_{\psi l}(\psi, l)$ is the joint distribution of (ψ, l), with parameter $\rho_{\psi l}$ determining the extent of dependence (using Frank copula). We set $\mu_\psi = \mu_l = 1$, leaving σ_ψ, σ_l, $\rho_{\psi l}$, μ_b, and σ_b to be calibrated within the model to match sectoral wage and wealth related moments.

Preference. We set the subjective discounter rate $\rho = 0.03$, consistent with the macro literature. We set $\zeta = 0.005$ to match the long-run agricultural employment share at around 0.5%. Based on Cooley and Prescott (1995), we set the reciprocal of intertemporal elasticity of substitution, $\sigma = 1.5$, and following Herrendorf, Rogerson and Valentinyi (2013), we set elasticity of substitution between agricultural and nonagricultural goods consumption, $\eta = 0.85$. We then calibrate $\bar{c}$ in the

model.

Human capital and experience. In the human capital production function, we set $z_h = 1$ and leave α and γ to be calibrated in the model. To pin down the values of $\bar{s}$ and e_g, we use data from UNESCO and World Bank. We set $\bar{s} = 18$, which is the end of grade 12, when the compulsory education ends in the U.S. We calibrate e_g, public education expenditure in the model to match public education expenditure to GDP ratio. Moreover, we estimate the return to experience in each sector from 2000 US Census (Ruggles et al., 2018) and obtain $\nu_{1,a} = 0.0254$, $\nu_{2,a} = -0.0004$, $\nu_{1,m} = 0.0382$, and $\nu_{2,m} = -0.0006$. Thus, return to experience is higher in nonagriculture but also depreciates more rapidly.

Production. We set $A_a = 1$ and calibrate A_m, θ_m, θ_a, ϕ_m, and ϕ_a within the model.

Life span and retirement age. We set life span T to be 76.6, matching the life expectancy in the U.S. in the 2000s and set the retirement age $R = 65$.

Now 15 parameters remain to be calibrated within the model and these are A_m, θ_m, θ_a, ϕ_m, ϕ_a, σ_ψ, σ_l, μ_b, σ_b, $\rho_{\psi l}$, $\bar{c}$, α, γ, e_g, and ι. We calibrate them jointly to match the following 15 targeted moments from the data: sectoral wage gap (w_m/w_a), sectoral (log) wage variance ($Var(w_a)$, $Var(w_m)$), agricultural employment share (L_a/L), agricultural value added share (Y_a/Y), sectoral years of schooling (s_a, s_m), private and public education expenditures to GDP ratios (E_p/Y, E_g/Y), sectoral return to schooling ($\partial w_a/\partial s$, $\partial w_m/\partial s$), wealth-income ratio and standard deviation of (log) wealth at the beginning of work year (W_i/w_i, $SD(\ln(W_i))$), sectoral goods price ratio (p_m/p_a), and government budget balance equal to zero.

The targeted moments above deserve some explanations. First, sectoral wage gap and wage variance are taken from Lagakos and Waugh (2013), who estimate these moments with non-transitory component of log wages using CPS (1996–2010). Second, Agricultural employment share and value added share are taken from Gollin, Lagakos and Waugh (2014), sectoral years of schooling are also from Gollin, Lagakos and Waugh (2014), and private and public education expenditure share from World Bank. Third, returns to schooling was estimated to be about 7.5% in Angrist and Keueger (1991) after correcting selection bias; we take this value for the return in the nonagricultural sector, and set that for agriculture to be 5%.[8] Fourth, the wealth-income ratio and standard deviation of (log) wealth at the beginning of working age are computed from PSID (1999–2019), using net worth and labor income data of individuals aged between 24–29;[9] and sectoral price ratio is taken from Alvarez-Cuadrado and Poschke (2011).

4.2 Model Fit

We take 20 points from each of the distributions of ψ and l; the cdf of these points are from 0.025 to 0.975 with an interval of 0.05; and we take 5 points of b, of which the cdf are from 0.1 to 0.9 with an interval of 0.2. Thus, there are in total 2000 ($20 \times 20 \times 5$) number of different types of individuals in (ψ, l, b). Then we solve the model for each type of individuals and compute the aggregate for

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[8]Estimates using US census in different years show that return to schooling in agriculture is about 40–50% higher than that in agriculture.

[9]When computing standard deviation of log wealth, we set an individual's wealth to be $1e-6$ if it is negative.

Target	Numerically	Data	Model
Agri. Wage Gap	$\frac{w_m}{w_a}$	1.427	1.469
Var. Agr. Wage	$Var(w_a)$	0.144	0.153
Var. Non-agr. Wage	$Var(w_m)$	0.224	0.220
Agr. Emp. Share (%)	$\frac{L_a}{L}$	1.50	1.51
Agr. V.A. Share (%)	$\frac{Y_a}{Y}$	1.10	1.03
Agr. School Years	s_a	11.55	11.01
Non-Agr. School Years	s_m	13.18	13.92
Private Exp. on School (%)	$\frac{E_p}{Y}$	2.10	2.74
Public Exp. on School (%)	$\frac{E_g}{Y}$	4.95	5.56
Agr. Return to School	$\frac{\partial w_a}{\partial s}$	0.050	0.056
Non-Agr. Return to School	$\frac{\partial w_m}{\partial s}$	0.075	0.074
Wealth-Income Ratio	$\frac{W_i}{w_i}$	2.45	1.92
S.D. log Wealth	$SD(ln(W_i))$	11.41	10.52
Non-agr. Price Gap	$\frac{p_m}{p_a}$	1.60	1.60

Table 2: Model Fit

targeted moments. Table 2 shows the model fit. The model fits all the targeted moments very well.

Figure 6 compares the model predicted value of years of schooling distribution across different sectors, which is not targeted in the model. The calibrated model matches quite well the pertinent features of the sectoral years of schooling distribution. The model closely matched the years of schooling distribution of the non-agricultural sector. The model is also consistent with the years of schooling distribution in the agricultural sector. The goodness of fit, however, is not as good as the one in the non-agricultural sector. In particular, the model predicts lower variance in the years of schooling distribution when compared to the data. In reality, however, the heterogeneity of agricultural workers years of schooling distribution is larger.
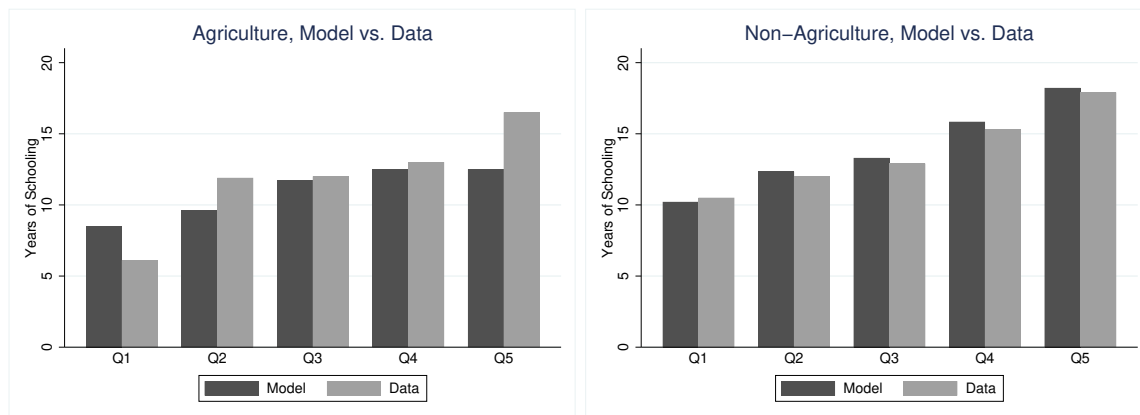

Figure 6: Sectoral Years of Schooling by Quintile, Model vs. Data

5 Quantitative Exercise and Discussion

We use the calibrated model as a framework for understanding cross-country differences in the years of schooling, the share of employment in agriculture, and agricultural and aggregate labor productivity.

5.1 Comparative Statics

In the following counterfactual analysis, we assume each of the exogenous productivity level $\{A_a, A_m\}$, length of the public funding $\bar{s}$ and level of the public funding e_g increase by 10% and recalculate the endogenous responses of the model. Four observations stand out.

First, increase in $\{A_a, A_m, \bar{s}\}$ leads to increase in sectoral years of schooling but the increase in level of the public funding e_g reduce the sectoral years of schooling as seen in rows (I) and (II) of Table 3. This seemingly counter-intuitive observation can be rationalized by the fact that increase in e_g leads to faster accumulation of human capital since more human capital can be imparted in each schooling years. This is due to the fact that there is a non-decreasing total education expenditure $e(\tau)$ after e_g is introduced as depicted in Figure 5. As there is opportunity cost of schooling (forgone wage), individuals decide to leave schools earlier for work, leading to a reduction in years of schooling.

Second, all the experiments predict increase in the sectoral productivity as shown in rows (IV) and (V) of Table 3, their mechanism, however, differs. The increase in $\{A_a, A_m\}$ increase the productivity because they are the sectoral TFP. The increase in $\{\bar{s}, e_g\}$ leads to higher productivity by the combination of two factors: years of schooling and education quality. Better education policies result in more human capital accumulated for each individuals on average, and as human capital is productive input in both sectors, the better education policies lead to higher sectoral productivity.

Third, the increase in schooling policies $\{\bar{s}, e_g\}$ works as good as the increase in exogenous sectoral productivity level $\{A_a, A_m\}$ in reducing the share of agricultural employment as shown in rows (III) of Table 3. The increase in $\{\bar{s}, e_g\}$ leads more years of schooling and/or better education quality. As the non-agricultural sector is more human capital intensive, increase in human capital leads to relative decline in agricultural sector. Moreover, the fact that increase in $\{\bar{s}, e_g\}$ leads to higher sectoral productivity discussed above also promotes the income effect (see row (VII) of Table 3) of structural transformation.

Forth, the increase in schooling policies $\{\bar{s}, e_g\}$ leads to reduction in the agricultural productivity gap as shown in rows (VI) of Table 3. The increase in the schooling policies leads to the increase in human capital in the economy. This will then lead to a more equal sectoral human capital distribution, which leads to the reduction in the agricultural productivity gap.

5.2 Cross-Country Analysis

Based on the benchmark model, we recalibrate a set of country-specific parameters for other countries. These parameters are: productivity parameters $\{A_a, A_m\}$, public education system parame-

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		Baseline	$A_a \uparrow$	$A_m \uparrow$	$\{A_a, A_m\} \uparrow$	$\bar{s} \uparrow$	$e_g \uparrow$ and μ_b fixed
(I)	Agr. YOS	11.01	11.03	11.09	11.02	11.51	10.97
(II)	Non-Agr. YOS	13.99	13.98	14.04	14.04	14.30	13.98
(III)	Agr. Emp. Share	1.54%	1.45%	1.54%	1.46%	1.50%	1.52%
(IV)	Agr. Labor Prod	1.000	1.086	1.007	1.092	1.028	1.014
(V)	Non-Agr. Labor Prod	1.000	1.000	1.116	1.124	1.016	1.011
(VI)	Agr. Prod. Gap	1.000	0.921	1.116	1.029	0.988	0.997
(VII)	Output per worker	1.000	1.001	1.122	1.124	1.016	1.011

Table 3: Comparative Statics Analysis in USA, Respective Parameters Increase 10%

ters $\{e_g, z_h, \bar{s}\}$, production parameters $\{\theta_a, \theta_m\}$, initial wealth distribution parameter $\{\mu_b, \sigma_b\}$, and life expectancy T. The four parameters on wealth distribution, life expectancy and years of compulsory schooling are pinned down by the data, while the former seven are to be calibrated within the model to match seven targeted moments of the country: GDP per worker relative to US, agricultural employment share, sectoral years of schooling, public education expenditure to GDP ratio, return to schooling relative to US, and government budget balance.

We start from Bangladesh (BGD), which is at 10 percentile at the world income distribution in around 2005. We set $T = 65.4$ based on World Bank data, and set $\bar{s} = 11$, according to UNESCO.[10] We back out μ_b using BGD to US ratio of GDP per capita and wealth-to-income ratio, and $\mu_{b,US}$, adjusted with the ratio of fertility rate of the two countries;[11] we back out σ_b using ratio of top 10% wealth concentration of both countries and $\sigma_{b,US}$. Wealth distribution data is taken from World Inequality Database.

The calibration of human capital accumulation efficiency $z_{h,BGD}$ warrants some discussion. Notice that the the return to schooling can be expressed as the following:

$$\frac{\partial \ln(w)}{\partial s} = \frac{\partial \ln(w)}{\partial h(s)} \times \frac{\partial h(s)}{\partial s}$$

So, the return to schooling (Mincer return) can be decomposed into two parts. The first part is how the human capital affects log income $\partial \ln(w)/\partial h(s)$ and the second part is the effect of additional year of schooling on human capital $\partial h(s)/\partial s$. Using the data of Schoellman (2012) allows us to focus on only the second term, since the return to human capital in the U.S. is fixed. With this information, we vary $z_{h,BGD}$ so that the ratio of Mincer returns between the U.S. and Bangladesh match that in Schoellman (2012) data.

The calibrated model can generate some observations in the cross-country income difference. As shown in Table 4, the model can generate the agricultural output per worker, GDP per worker and agricultural productivity gap between USA and BGD well. However, it cannot generate a satisfactory result for the non-agricultural output per worker. Such problem also presents in most frictionless model. We borrow result between the 90th and 10th percentile countries from Lagakos and Waugh (2013, Table 2) as comparison.

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[10]The retirement age is set to be the same as US, 65, as it is common for people in developing countries to work for prolonged years until advanced ages.

[11]Specifically, mean b is BGD is computed as $E(b)_{BGD} = e^{\mu_{b,US} + \sigma_{b,US}^2/2} \cdot \frac{ki_{ratio,BGD}}{ki_{ratio,US}} \cdot \frac{gdppc_{BGD}}{gdppc_{US}} / \frac{fert_{GBD}}{fert_{US}}$.

| | This Model: USA-BGD | | Lagakos & Waugh (2013): 90-10 | |
	Model	Data	Model	Data
Agricultural output per worker	75.6	79.2	5.5	45
Non-Agricultural output per worker	28.4	3.4	4	4
GDP per worker	43.3	32.4	4.3	22
Agricultural Productivity Gap	3.0	3.7	1.4	5.2

Table 4: Model Performance, Cross-Country Comparison

5.3 Comparison between USA and Bangladesh

If we compare the comparative statics analysis in both the U.S. and Bangladesh as shown in Table 5, we will discuss the similarity and differences between the two countries.

	Baseline (I)	$A_a \uparrow$ (II)	$A_m \uparrow$ (III)	$\bar{s} \uparrow$ (IV)	$e_g \uparrow$ and μ_b fixed (V)
Panel A: USA, $\theta_a = 0.75, \theta_m = 0.80$					
Agricultural YOS	11.01	11.03	11.09	11.51	10.97
Non-Agricultural YOS	13.99	13.98	14.04	14.30	13.98
Agricultural Employment Share	1.54%	1.45%	1.54%	1.50%	1.52%
Agricultural Productivity Gap	1.00	0.92	1.12	1.00	0.99
Output per Worker	1.00	1.00	1.12	1.02	1.01
Panel B: BGD, $\theta_a = 0.06, \theta_m = 0.40$					
Agricultural YOS	2.39	2.38	2.40	2.23	2.27
Non-Agricultural YOS	5.89	5.79	5.95	6.26	5.93
Agricultural Employment Share	46.4%	39.1%	44.2%	42.6%	42.7%
Agricultural Productivity Gap	1.00	0.87	1.03	0.90	0.91
Output per Worker	1.00	1.04	1.07	1.02	1.01

Table 5: Comparative Statics Analysis Comparison, Respective Parameters Increase 10%

There are two notable similarities in the analysis. When the agricultural productivity increase, in column (II), the increase in education is not significant. This is because the agricultural sector is relatively less human capital intensive. So, when the wage of the agricultural sector increase, due to the agricultural productivity progress, it reduce the incentive for the individuals to study. This counteract the income effect on education. So, the reduction in the agricultural employment share in this case is mainly due to the income and productivity effect driven by the productivity progress.

Second, better education policies in columns (IV) and (V) also lead to structural transformation. Similar to the case in the U.S., better education policies is as important as the technological progress in understanding the sectoral allocation of labor. For example, in the case of increase in government expenditure in public education e_g in Panel B, there is an increase in total human capital in the economy by 4 percentage point (even though the years of schooling drops). This leads to more households self-select into the non-agricultural sector.

There are also differences between these two countries. First, the reduction in the agricultural employment share is more responsive to the changes in sectoral productivity and education policies, both in absolute and relative terms. This is the consequence of closed-economy assumption. As each economy needs to supply its own agricultural consumption, which is subject to subsistence

constraint, the agricultural employment cannot be too low. So, in the case of the U.S., the lowering of the agricultural employment share will increase the marginal utility of agricultural consumption substantially and leads to increase in agricultural price and wage of agricultural workers, which eventually leads to increase in agricultural employment.

Second, due to the fact that human capital intensity in Bangladesh is very low ($\theta_a = 0.06$), the better education policies in columns (IV) and (V) always lead to reduction in the years of schooling in the agricultural sector. Moreover, in the case of increase in duration of subsidy e_g, the human capital in the agricultural sector even drops. This is due to selection. Using the example in Figure 5, originally individual A who have higher endowment when compared to individuals B and C are more likely to work in the non-agricultural sector. However, if there is an slight increase in e_g, the human capital of individual B and C will increase while that of individuals A is not affected. Then, it is more likely that individual B and C will join the non-agricultural sector, leading to lower years of schooling and hence average human capital in the agricultural sector.

5.4   Importance of Public Education System

In this section, we do two different experiments and both of them show the importance of the public education system in determining the structural transformation. The first experiment assumes that the public education policies are removed so that there is no subsidy for public education $e_g = 0$ and the duration of subsidy also goes to zero $\bar{s} = 6$. The sectoral years of schooling reduced and the agricultural employment share increased by more than 46%.

	Baseline	Experiment 1 No Education Policies	Experiment 2 Education Policies Quality Equal
Agr. Schooling	2.39	1.92	2.32
Non-Agr. Schooling	5.89	5.54	5.60
Agr. Emp. Share	46.4%	69.4%	40.4%

Table 6: Importance of Public Education System

We also perform the second experiment which eliminates the differences in public education policies (e_g and $\bar{s}$) and human capital accumulation efficiency (z_h). In particular, we assume that $\{e_g, \bar{s}, z_h\}_{BGD} = \{e_g, \bar{s}, z_h\}_{USA}$, and that the years of schooling for each of the individuals (in each $\{l, \psi, b\}$ cell) do not change. This experiment wants to show that the quality of education is also important to understand structural transformation. Even when the years of schooling remains the same,[12] the better public education policies and human capital accumulation efficiency can impart more human capital in additional year of schooling. The experiment predicts that the agricultural employment share reduced by 13%.

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[12]Notice that both of the sectoral years of schooling drop. This is because the higher educated individuals in the agricultural sector join the non-agricultural sector, leading to a drop in average schooling in the agricultural sector. However, these new comers have lower than average years of schooling when compared to the average non-agricultural individuals.

6　Conclusion

This paper argues that differences in human capital, which is partly induced by cross-country education policies differences, is important to understand the structural transformation and sectoral productivity. Empirically, it is shown that economies with better education policies have smaller agricultural employment share and gap between the agricultural and non-agricultural productivity levels. This is because human capital is relatively more valuable in the non-agricultural sector, people with more human capital choose to work in the non-agricultural sector, leading to structural transformation. Moreover, as human capital is a productive input, the relative composition of sectoral human capital affects sectoral productivity.

This paper considers both quantity and quality of education. The quantity of education refers to the years of schooling while the quality of education considers how much human capital can be imparted per year of schooling. The two dimensions of education policies, namely years of government subsidized schooling and government expenditure on public education, are important to determine the quantity and quality of education.

Using a heterogeneous-agent life-cycle model featuring years of schooling, education investment and sectoral employment choices, we find that the education policies are as important as sectoral productivity progress to understand the sectoral labor allocation and labor productivity. In developing countries, counterfactual experiments show that eliminating public education policies increases agricultural employment share by 46% while endowing the developing countries with U.S. public education policies reduces the agricultural employment share by 13%.

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