HUMAN CAPITAL AND REGIONAL DEVELOPMENT*

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We investigate the determinants of regional development using a newly constructed database of 1,569 subnational regions from 110 countries covering 74% of the world's surface and 97% of its GDP. We combine the cross-regional analysis of geographic, institutional, cultural, and human capital determinants of regional development with an examination of productivity in several thousand establishments located in these regions. To organize the discussion, we present a new model of regional development that introduces into a standard migration framework elements of both the Lucas (1978) model of the allocation of talent between entrepreneurship and work, and the Lucas (1988) model of human capital externalities. The evidence points to the paramount importance of human capital in accounting for regional differences in development, but also suggests from model estimation and calibration that entrepreneurial inputs and possibly human capital externalities help understand the data. *JEL* Codes: O110, R110, I250.

I. Introduction

We investigate the determinants of regional development using a newly constructed database of 1,569 subnational regions from 110 countries covering 74% of the world's surface and 97% of its gross domestic product (GDP). We explore the influences of geography, natural resource endowments, institutions, human capital, and culture by looking within countries. We combine this analysis with an examination of productivity in several thousand establishments covered by the World Bank Enterprise Survey, for which we have both establishment-specific and

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regional data. In this analysis, human capital measured using education emerges as the most consistently important determinant of both regional income and productivity of regional establishments. We then use the combination of regional and establishment-level data to investigate some of the key channels through which human capital operates, including education of workers, education of entrepreneurs/managers, and externalities.

To organize this discussion, we present a new model describing the channels through which human capital influences productivity, which combines three features. First, human capital of workers enters as an input into the neoclassical production function, but human capital of the entrepreneur/manager influences firm-level productivity independently. The distinction between entrepreneurs/managers and workers has been shown empirically to be critical in accounting for productivity and size of firms in developing countries (Bloom and Van Reenen 2007, 2010; La Porta and Shleifer 2008; Syverson 2011). In the models of allocation of talent between work and entrepreneurship such as Lucas (1978), Baumol (1990), and Murphy, Shleifer, and Vishny (1991), returns to entrepreneurial schooling may appear as profits rather than wages. By modeling this allocation, we trace these two separate contributions of human capital to productivity.

Second, our approach allows for human capital externalities, emphasized in the regional context by Jacobs (1969), and in the growth context by Lucas (1988, 2009) and Romer (1990). These externalities result from people in a given location spontaneously interacting with and learning from each other, so knowledge is transmitted across people without being paid for. Because our framework incorporates both the allocation of talent between entrepreneurship and work as in Lucas (1978) and human capital externalities as in Lucas (1988), we call it the Lucas-Lucas model.[1] By decomposing human capital effects into those of worker education, entrepreneurial/managerial education, and externalities using a unified framework, we try to disentangle different mechanisms.

1. We do not consider the role of human capital in shaping technology adoption (Nelson and Phelps 1966). For recent models of these effects, see Benhabib and Spiegel (1994), Klenow and Rodriguez-Clare (2005), and Caselli and Coleman (2006). For evidence, see Coe and Helpman (1995), Ciccone and Papaioannou (2009), and Wolff (2011).

Third, we need to consider the mobility of firms, workers, and entrepreneurs across regions, which is presumably less expensive than that across countries. Our model follows the standard urban economics approach (e.g., Roback 1982; Glaeser and Gottlieb 2009) of labor mobility across regions with land and housing limiting universal migration into the most productive regions. This formulation allows us to analyze the conditions under which the regional equilibrium is stable and to consider jointly the education coefficients in regional and establishment level regressions.

To begin, we examine the determinants of regional income in a specification with country fixed effects. Our approach follows development accounting, as in Hall and Jones (1999), Caselli (2005), and Hsieh and Klenow (2010). Among the determinants of regional productivity, we consider geography, as measured by temperature (Dell, Jones, and Olken 2009), distance to the ocean (Bloom and Sachs 1998), and natural resources endowments. We also consider institutions, which have been found by King and Levine (1993), De Long and Shleifer (1993), Hall and Jones (1999), and Acemoglu, Johnson, and Robinson (2001) to be significant determinants of development. We also look at culture, measured by trust (Knack and Keefer 1997), and ethnic heterogeneity (Easterly and Levine 1997; Alesina et al. 2003). Last, we look at average education in the region. A substantial cross-country literature points to a large role of education. Barro (1991) and Mankiw, Romer, and Weil (1992) are two early empirical studies; de La Fuente and Domenech (2006), Breton (2012), and Cohen and Soto (2007) are recent confirmations. Across countries, the effects of education and institutions are difficult to disentangle: both variables are endogenous and the potential instruments for them are correlated (Glaeser et al. 2004). By using country fixed effects, we avoid identification problems caused by unobserved country-specific factors.

We find that favorable geography, such as lower average temperature and proximity to the ocean, as well as higher natural resource endowments, are associated with higher per capita income in regions within countries. We do not find that culture, as measured by ethnic heterogeneity or trust, explains regional differences. Nor do we find that institutions as measured by survey assessments of the business environment in the Enterprise Surveys help account for cross-regional differences within a country. Some institutions or culture may matter only at the national level, but then large income differences within countries call for explanations other than culture and institutions. In contrast, differences in educational attainment account for a large share of the regional income differences within a country. The within-country R^2 in the univariate regression of the log of per capita income on the log of education is about 25%; this R^2 is not higher than 8% for any other variable.

Acemoglu and Dell (2010) examine subnational data from North and South America to disentangle the roles of education and institutions in accounting for development. The authors find that about half of the within-country variation in levels of income is accounted for by education. This is similar to the Mankiw, Romer, and Weil (1992) estimate for a cross-section of countries. We confirm a large role of education and try to go further in identifying the channels. Acemoglu and Dell also conjecture that institutions shape the remainder of the local income differences. We have regional data on several aspects of institutional quality and find that their ability to explain cross-regional differences is minimal.[2]

In regional regressions, human capital in a region may be endogenous because of migration. To make progress, we examine the determinants of firm-level productivity. We merge our data with World Bank Enterprise Surveys, which provide establishment-level information on sales, labor force, educational level of management and employees, as well as energy and capital use for several thousand establishments in the regions for which we have data. We estimate the production function predicted by our model using several methods, including Levinsohn and Petrin's (2003) panel approach. The micro data point to a large role of managerial/entrepreneurial human capital in raising firm productivity. We also find that regional education has a large positive coefficient, consistent with sizable human capital externalities. However, because regional education may be correlated with unobserved region-specific productivity parameters, we do not have perfect identification of externalities.

To assess the extent to which firm-level results can account for the role of human capital across regions, we combine estimation with calibration following Caselli (2005). We rely on previous research regarding factor shares (e.g., Gollin 2002; Caselli and

2. Recent work argues that regions within countries that were treated particularly badly by colonizers have poor institutions and lower income today (Banerjee and Iyer 2005; Dell 2010; Michalopoulos and Papaioannou 2011).

Feyrer 2007; Valentinyi and Herrendorf 2008), but then combine it with coefficient estimates from regional and firm-level regressions. Our calibrations show that worker education, entrepreneurial education, and externalities all substantially contribute to productivity. We find the role of workers' human capital to be in line with standard wage regressions, which are the benchmark adopted by conventional calibration studies (e.g., Caselli 2005). Crucially, however, our results indicate that focusing on worker education alone substantially underestimates both private and social returns to education. Private returns are very high but to a substantial extent earned by entrepreneurs, and hence might appear as profits rather than wages, consistent with Lucas (1978). Although we have less confidence in the findings for externalities, our best estimates suggest that those are also sizable. In sum, the evidence points to a large influence of entrepreneurial human capital, and perhaps of human capital externalities, on productivity.

In Section II, we present a model of regional development that organizes the evidence. In Section III, we describe our data. Section IV examines the determinants of both national and regional development. Section V presents firm-level evidence, and Section VI calibrates the model to assess its ability to explain income differences. Section VII concludes.

II. A Lucas-Lucas Spatial Model of Regional and National Income

A country consists of a measure 1 of regions, a share p of which has productivity $\tilde{A}_P$ and a share $1-p$ of which has productivity $\tilde{A}_U < \tilde{A}_P$. We refer to the former regions as "productive," to the latter regions as "unproductive," and denote them by $i = P, U$. A measure 2 of agents is uniformly distributed across regions. An agent j enjoys consumption and housing according to the utility function:

$$u(c, a) = c^{1-\theta_j} a^{\theta_j}, \tag{1}$$

where c and a denote consumption and housing, respectively. Half the agents are "rentiers," the remaining half are "laborers." Each rentier owns 1 unit of housing, T units of land, K units of physical capital (and no human capital). Each laborer is endowed with $h \in \mathrm{R}_{++}$ units of human capital. In region $i = P, U$ the distribution of initial, exogenous human capital endowment is Pareto in $[\underline{h},+\infty)$, where $\underline{h} > 1$. We denote its mean value by $\underline{H}_i$ in region $i = P, U$.

A laborer can become either an entrepreneur or a worker. By operating in region i, an entrepreneur with human capital h hires physical capital $K_{i,h}$, land $T_{i,h}$, workers with total human capital $H_{i,h}$, and produces an amount of the consumption good equal to:

$$(2) \qquad y_{i,h} = A_i h^{1-\alpha-\beta-\delta} H^{\alpha}_{i,h} K^{\delta}_{i,h} T^{\beta}_{i,h}, \quad \alpha+\beta+\delta<1.$$

As in Lucas (1978), a firm's output increases, at a diminishing rate, in the entrepreneur's human capital h as well as in $H_{i,h}$, $K_{i,h}$, and $T_{i,h}$. We model human capital externalities (Lucas 1988) by assuming that regional total factor productivity is given by:

$$(3) \qquad A_i = \tilde{A}_i \left(E_i(h)^{\psi} L_i\right)^{\gamma}, \ \gamma > 0, \ \psi \geq 1.$$

According to equation (3), productivity depends on (a) region-specific factors $\tilde{A}_i$, which capture geography, institutions, and other influences; (b) average human capital in the region $E_i(h)$, computed across all laborers who choose to work in the region, including migrants; and (c) the measure L_i of labor in that region. Parameter ψ captures the importance of the quality of human capital: when $\psi = 1$ only the quantity of human capital $H_i = E_i(h)L_i$ matters for externalities; as ψ rises the quality of human capital becomes relatively more important than quantity. Parameter γ captures the importance of externalities. Because $\gamma > 0$, there are regional scale effects, which can be arbitrarily small (if $\gamma \approx 0$) and which we try to estimate. We take regional productivity A_i as given until we describe the spatial equilibrium in which A_i is endogenously determined by regional sorting of laborers.

Rentiers rent land and physical capital to firms and housing to entrepreneurs and workers. In region i, each rentier earns $\lambda_i T$ and η_i by renting land and housing, where λ_i and η_i are rental rates, and $\rho_i K$ by renting physical capital. A region's land and housing endowments T and 1 are immobile; physical capital is fully mobile. Laborers use their human capital in work or in entrepreneurship. By operating in region i, a laborer with human capital h earns either profits $\pi_i(h)$ as an entrepreneur or wage income $w_i \cdot h$ as a worker, where w_i is the wage rate. All laborers, whether they become entrepreneurs or workers, are partially mobile: a laborer moving to region i loses φw_i units of income, where $\varphi < \underline{h}$.[3]

At $t = 0$, a laborer with human capital h selects the location and occupation that maximize his income. The housing market clears, so houses are allocated to each region's labor. At $t = 1$, entrepreneurs hire land and human and physical capital. Production is carried out and distributed in wages, land rental, capital rental, housing rental, and profits. Consumption takes place.

A spatial equilibrium is a regional allocation $\left(H_i^E, H_i^W, K_i\right)$ of entrepreneurial human capital H_i^E, workers' human capital H_i^W, and physical capital K_i such that (a) entrepreneurs hire workers, physical capital, and land to maximize profits; (b) laborers optimally choose location, occupation, and the fraction of income devoted to consumption and housing; and (c) capital, labor, land, and housing markets clear. Because physical capital is fully mobile, there is a unique rental rate ρ. Because land and housing are immobile, their rental rates λ_i and η_i vary across regions depending on productivity and population. To determine the sorting of laborers across regions and their choice between work and entrepreneurship within a region, we must compute regional wages w_i and profits $\pi_i(h_j)$. To do so, we first determine regional output and factor returns at a given allocation $\left(H_i^E, H_i^W, K_i\right)$. Second, we solve for the equilibrium allocation. We consider symmetric spatial equilibria in which all productive regions share the same factor allocation $\left(H_P^E, H_P^W, K_P\right)$, the same wage w_P and rental rates λ_P and η_P, and unproductive regions share the same allocation $\left(H_U^E, H_U^W, K_U\right)$, wage w_U, and rentals λ_U and η_U.

Throughout the analysis, the price of consumption is normalized to one. Endogenous regional differences in the rental rates of housing and land affect the welfare of laborers in different regions, but regional variation in value added does not depend on these prices in our model (precisely because value added just consists of the tradable consumption good). In reality, certain

3. Assuming that migrants lose a fixed amount of human capital φ ensures that skilled laborers have the greatest incentive to migrate. If migrants lose a share of destination earnings, everybody has the same incentive to migrate. For simplicity, we assume that moving costs are a redistribution from migrants to locals (e.g., the latter provide moving services) and are nonrival with the time spent working. This ensures that the human capital employed in a region, as well as the aggregate income of laborers, do not depend on moving costs.

components of regional GDP are nontradable, and their prices will differ across regions (Engel and Rogers 1996). Since we do not have data on local prices, we leave these considerations for future research.

II.A. Production and Occupational Choice

An entrepreneur with human capital h operating in region i maximizes his profit by solving:

$$\max_{H_{i,h},T_{i,h},K_{i,h}} A_i h^{1-\alpha-\beta-\delta} H_{i,h}^{\alpha} K_{i,h}^{\delta} T_{i,h}^{\beta} - w_i H_{i,h} - \rho K_{i,h} - \lambda_i T_{i,h}, \tag{4}$$

implying that in each region firms employ factors in the same proportion. Since at $\left(H_i^E, H_i^W, K_i\right)$ firm j employs a share of entrepreneurial capital $\frac{h_j}{H_i^E}$, it hires the others factors according to:

$$H_{i,j} = \frac{h_j}{H_i^E} \cdot H_i^W, \quad K_{i,j} = \frac{h_j}{H_i^E} \cdot K_i, \quad T_{i,j} = \frac{h_j}{H_i^E} \cdot T. \tag{5}$$

As in Lucas (1978), more skilled entrepreneurs run larger firms.

Equation (5) implies that the aggregate regional output is given by:

$$Y_i = A_i \left(H_i^E\right)^{1-\alpha-\beta-\delta} \left(H_i^W\right)^{\alpha} K_i^{\delta} T^{\beta}. \tag{6}$$

Using equation (6), one can determine wages, profits, and capital rental rates as a function of regional factor supplies via the usual (private) marginal product pricing. That is, the profit $\pi_i(h)$ earned by an individual with human capital h in region i is equal to h times the return of entrepreneurial human capital in the region, $\frac{\partial Y_i}{\partial H_i^E}$. The same individual can earn a wage income equal to h times the return to workers' human capital in the region $\frac{\partial Y_i}{\partial H_i^w}$. A laborer j with human capital h_j chooses to be an entrepreneur if and only if $\left(\frac{\partial Y_i}{\partial H_i^E}\right) \cdot h_j > \left(\frac{\partial Y_i}{\partial H_i^w}\right) \cdot h_j$ and a worker if $\left(\frac{\partial Y_i}{\partial H_i^E}\right) \cdot h_j < \left(\frac{\partial Y_i}{\partial H_i^w}\right) \cdot h_j$. In equilibrium, laborers must be indifferent between the two occupations, which implies:

$$H_i^E = \left(\frac{1-\alpha-\beta-\delta}{1-\beta-\delta}\right) \cdot H_i, \quad H_i^W = \left(\frac{\alpha}{1-\beta-\delta}\right) \cdot H_i\,, \tag{7}$$

where $H_i = H_i^E + H_i^W$ is total human capital in region i. H_i^E increases with the share of the total *private* return to human capital earned by entrepreneurs (that is, with $\frac{(1-\alpha-\beta-\delta)}{(1-\beta-\delta)}$). Equation (7) describes the allocation of labor within in a region from the total quantities of human and physical capital (H_i, K_i).

II.B. The Spatial Equilibrium: Consumption, Housing, and Mobility

To compute the allocation of human capital, we must characterize labor mobility by computing the utility that laborers obtain from operating in different regions. Labourers maximize their utility in equation (1) by devoting a share θ of their income to housing and the remaining share $(1-\theta)$ to consumption. Since the aggregate income of laborers in region i is equal to $w_i H_i$, the demand for housing in the region is $\frac{\theta \cdot w_i H_i}{\eta_i}$. Given the unitary housing supply, the housing rental rate is equal to $\eta_i = \theta \cdot w_i \cdot H_i$. As a consequence, the utility (gross of moving costs) of a laborer in region i is equal to:

$$u_{w,i}(c,a) = \frac{w_i h}{\eta_i^{\theta}} = \frac{w_i^{1-\theta}}{\theta^{\theta}} \cdot \frac{h}{H_i^{\theta}}, \tag{8}$$

which rises with the wage and falls with regional human capital H_i due to higher rents. To find the spatial equilibrium, we need to find the ratio between wages paid in productive and unproductive regions, which determine the incentive to migrate. By taking capital mobility and external effects into account, in Appendix A we show that:

$$\frac{w_P}{w_U} = \left(\frac{\tilde{A}_P}{\tilde{A}_U}\right)^{\frac{\delta}{1-\delta}} \left(\frac{E(h_P)^{\psi} L_P}{E(h_U)^{\psi} L_U}\right)^{\frac{\gamma}{1-\delta}} \cdot \left(\frac{H_U}{H_P}\right)^{\frac{\beta}{1-\delta}}. \tag{9}$$

Ceteris paribus, the wage is higher in productive regions. A higher human capital stock has a negative effect on the wage because of diminishing returns, but once externalities are taken into account the net effect is ambiguous. In the remainder we assume:

$$\left(\frac{\tilde{A}_P}{\tilde{A}_U}\right) \cdot \left(\frac{\underline{H}_P}{\underline{H}_U}\right)^{\gamma\psi-\beta-\delta} > 1, \tag{A.1}$$

which implies that the autarky wage and interest rates are higher in productive regions, so that both capital and labor tend to move there. We then prove the following (in Appendix A).

PROPOSITION 1. Under the parametric restriction:

$$(\beta - \psi\gamma)(1-\theta) + \theta(1-\delta) > 0, \tag{10}$$

there is a stable equilibrium allocation H_P and H_U. In this allocation:

1. There is a cutoff h_m such that agent j migrates from an unproductive to a productive region if and only if $h_j \geq h_m$. The cutoff h_m increases in the mobility cost φ.
2. Denote by $\underline{H} \equiv p\underline{H}_P + (1-p)\underline{H}_U$ the aggregate human capital endowment. Then, when $\varphi = 0$, the equilibrium level of human capital in region i is independent of the region's initial human capital endowment. In particular, for $\psi = 1$ the full mobility allocation satisfies:

$$H_P = \tilde{H}_P^{free} \equiv \frac{A_P^{\frac{1-\theta}{(\beta-\gamma)(1-\theta)+\theta(1-\delta)}}}{E\left[A_i^{\frac{1-\theta}{(\beta-\gamma)(1-\theta)+\theta(1-\delta)}}\right]} \cdot \underline{H}. \tag{11}$$

When $\varphi > 0$ and $\psi \geq 1$, we have that $H_P < \tilde{H}_P^{free}$ and H_P increases in $\underline{H}_P$ holding $\underline{H}$ constant.

Because wages (and profits) are higher in the productive than in the unproductive regions, labor migrates to the former from the latter. The cutoff rule in (1) is intuitive: more skilled people have a greater incentive to pay the migration cost because the wage (or profit) gain they experience from doing so is higher. Even if mobility costs are zero, migration to the more productive regions is not universal. This is due to the limited supply of land T, which causes decreasing returns in production, and to the limited supply of housing, which implies that migration causes housing costs to rise until the incentive to migrate disappears. Regional externalities moderate the adverse effect of fixed supplies of land and housing on mobility. In fact, for migration to be interior, condition (10) must be met, which requires external effects $\psi\gamma$ to be sufficiently small relative to (a) the diminishing returns β due to land and (b) the sensitivity θ of house prices to regional human capital.

In equilibrium, wages are higher in the more productive regions, $w_P > w_U$, but the housing rental rate is also higher there,

$\eta_P > \eta_U$. As a result, our model predicts that more productive regions should remain more productive even after mobility is taken into account. When migration is costless (equation (11)), the human capital employed in a region only depends on its productivity. In this respect, Proposition 1 shows that for our regressions to estimate the effect of human capital, mobility must be imperfect (i.e., $\varphi > 0$). When $\psi = 1$ and $\varphi = 0$, national output is equal to:

$$Y = \widehat{A} H^{\gamma} \left(H^{E}\right)^{1-\alpha-\beta-\delta} \left(H^{W}\right)^{\alpha} K^{\delta} T^{\beta}, \tag{12}$$

where $\widehat{A}$ is a function $\widehat{A}(\beta, \delta, \theta, \tilde{A}_P, \tilde{A}_U, p, \psi, \gamma)$ of exogenous parameters. More generally, under condition (10) the Lucas-Lucas model yields the following equation for firm-level output:

$$y_{i,j} = \tilde{A}_i E_i(h)^{\psi\gamma} L_i^{\gamma} h_j^{1-\alpha-\beta-\delta} H_{i,j}^{\alpha} K_{i,j}^{\delta} T_{i,j}^{\beta}, \tag{13}$$

and the following equation for regional output:

$$Y_i = \tilde{A}_i E_i(h)^{\psi\gamma} L_i^{\gamma} (H_i^{E})^{1-\alpha-\beta-\delta} (H_i^{W})^{\alpha} K_i^{\delta} T^{\beta}. \tag{14}$$

Value added (at the regional and firm levels) does not depend on local prices after inputs are accounted for because output in our model consists only of the tradable consumption good.

II.C. Empirical Predictions of the Model

To obtain predictions on the role of schooling, we need to specify a link between human capital (which we do not observe) and schooling (which we do observe). We follow the Mincerian approach in which for an individual j the link between human capital and schooling is:

$$h_j = \exp\left(\mu_j S_j\right), \tag{15}$$

where $S_j \geq 0$ and $\mu_j \geq 0$ are two random variables (distributed according to a density $g_i(S, \mu)$ that ensures that the distribution of h_j is Pareto). The return to schooling μ_j varies across individuals, potentially due to talent. This allows us to estimate different returns to schooling for workers and entrepreneurs. Card (1999) offers some evidence of heterogeneity in the returns to schooling. In line with macro studies, in our regressions we express average human capital in the region as a first-order expansion around the mean Mincerian return and years of schooling $E(h_i) \cong e^{\overline{\mu}_i \cdot \overline{S}_i}$, where $\overline{S}_i$ is average schooling and $\bar{\mu}_i$ is the average Mincerian return, both computed in region i.

II.D. Regional Income Differences

To test equation (14), we must express physical capital, for which we have no data, as a function of human capital. The equalization of the return to capital implies $K_i = B\, A_i^{\frac{1}{1-\delta}} H_i^{\frac{1-\beta-\delta}{1-\beta}}$ where $B > 0$ is a constant. Substituting this condition and the linearized expression for human capital into equation (14) we find:

$$\ln\left(\frac{Y_i}{L_i}\right) = \mathrm{C} + \left[\frac{1}{(1-\delta)}\right]\ln\tilde{A}_i + \left[1 + \gamma\psi - \frac{\beta}{(1-\delta)}\right]\overline{\mu}_i\overline{S}_i + \left[\gamma - \frac{\beta}{(1-\delta)}\right]\ln L_i, \tag{16}$$

where C is a constant absorbed by the country fixed effect. The coefficient on regional schooling captures the product of the "technological" parameter $[1 + \gamma\psi - \frac{\beta}{(1-\delta)}]$ and the nationwide average $\overline{\mu}$ of the regional Mincerian returns $\overline{\mu}_i$. The coefficient $[\gamma - \frac{\beta}{(1-\delta)}]$ on population L_i captures the benefit γ of increasing regional workforce in terms of externalities minus the cost β of crowding the fixed land supply. A similar interpretation holds with respect to the schooling coefficient $[1 + \gamma\psi - \frac{\beta}{(1-\delta)}]$.

If the variation in regional schooling and population is mostly due to imperfect mobility ($\varphi > 0$), the estimated coefficients on schooling and population should reflect their theoretical counterparts in equation (16). In our model, productivity also varies because of limited migration, owing to the fixed housing supply. This creates a serious concern: because in our model some human capital migrates to more productive regions, any mismeasurement of regional productivity A_i may contaminate the coefficient of regional human capital. We deal with this issue in two steps. First, we control in regression (16) for proxies of A_i. Although this is not a panacea for the omitted variable bias, it allows us to rule out some of the most obvious determinants of productivity. Second, we compare these results to the coefficients obtained from firm-level regressions. In these regressions, we control for regional fixed effects and also use panel techniques devised to control for firm-level productivity differences. We then further discipline our interpretation of the data by comparing the coefficients obtained from estimation to the calibration exercises performed in the development accounting literature.

II.E. Firm-Level Productivity

In equation (13), the output of a firm j operating in region i depends on the human capital $h_{E,j}$ of his entrepreneur (we assume there is only one entrepreneur and identify him with the top manager of the firm, as determined by his schooling $S_{E,j}$ and return to schooling $\mu_{E,j}$). It also depends on the average human capital $\mathrm{E}(h_{W,j})$ of workers. Again, we approximate the average human capital of workers in a firm by $e^{\overline{\mu}_{W,j} \cdot \overline{S}_{W,j}}$ (where $\overline{\mu}_{W,j}$ and $\overline{S}_{W,j}$ are average values in the firm's workforce). This implies that the human capital in the firm is equal to $H_{i,j} = l_{i,j} \cdot e^{\overline{\mu}_{W,j} \cdot \overline{S}_{W,j}}$, where $l_{i,j}$ is the size of the firm's workforce.

Ceteris paribus, in our model entrepreneurs have a higher return to schooling than workers because in region i an entrepreneur with schooling S is someone whose return satisfies $e^{\mu S} \geq h_{E,i}$, where $h_{E,i}$ is the human capital threshold for becoming an entrepreneur in region i. At a schooling level S, the entrepreneurial class includes talented laborers whose return satisfies $\mu \geq \mu_{E,i}(S) \equiv \ln \frac{h_{E,i}}{S}$, whereas laborers with $\mu < \mu_{E,i}(S)$ become workers.

We estimate equation (16) in logs. Exploiting the expressions for entrepreneurs' and workers human capital gives the following equation for a firm's output:

$$\text{(17)} \qquad \begin{aligned} \ln(y_{i,j}) = {} & \ln \tilde{A}_t + (1 - \alpha - \beta - \delta)\mu_{E,i} S_{E,j} + \alpha \overline{\mu}_{W,i} \overline{S}_{W,j} \\ & + \alpha \ln l_{i,j} + \delta \ln K_{i,j} + \beta \ln T_{i,j} + \gamma \ln L_i + \gamma \psi \overline{\mu}_i \overline{S}_i . \end{aligned}$$

The coefficient on entrepreneurial schooling is the product of entrepreneurial rents $(1 - \alpha - \beta - \delta)$ and the Mincerian return to entrepreneurial education $\overline{\mu}_E$. The coefficient on workers' schooling is the labour share α times $\overline{\mu}_W$, the Mincerian return of workers. The coefficient on the firm's workforce is equal to the labor share α. The coefficient on regional schooling is the product of the externality parameter $\gamma\psi$ and the population-wide average Mincerian return $\overline{\mu}$.[4]

4. In the regional and firm-level equations (16) and (17), the average return to schooling should vary across regions. To account for this, one could run random coefficient regressions. We have performed this analysis and the results change

The estimation of equation (17) allows us to separate the role of the "low human capital" of workers from the "high human capital" of entrepreneurs in shaping firm productivity, as well as to get at the effect of human capital externalities by including regional human capital (and other controls). There are, however, two potential concerns. First, our model literally implies that output per worker should be equalized across firms within a region. Realistically, though, output per worker is equalized across firms ex ante, but its ex post value varies as a result of stochastic ex post changes in the values of firm level total factor productivity (TFP) and inputs. This is the variation we appeal to when estimating equation (17).[5] Second, because the selection of talented entrepreneurs and workers into more productive firms may contaminate our results, we employ the Levinsohn-Petrin (2003) instrumental variables approach. This approach has been devised precisely to control for productivity differences among firms.

III. Data

Our analysis is based on measures of income, geography, institutions, infrastructure, and culture in up to 110 (out of 193 recognized sovereign) countries for which we found regional data on either income or education. Almost all countries in the world have administrative divisions.[6] In turn, administrative divisions may have different levels. For instance a country may be

very little (the results on human capital become slightly stronger). We do not report them to save space.

5. Formally, if ex ante a firm hires $X_{i,j}$ units of a factor, this results in $X_{i,j} = \varepsilon_X \cdot X_{i,j}$ units of the same factor being employed in production ex post, where ε_X is a random shock to the value of inputs (e.g., an unpredictable change in the value of equipment, size of the workforce). Given the Cobb-Douglas production function, the firm's ex ante optimization problem (occurring with respect to the ex ante inputs $X_{i,j}$) does not change with respect to equations (4) and (5). The only change is that a firm's productivity also includes expectations of the random factors ε_X. Crucially, this formulation implies that ex ante returns are equalized, ex post returns are not, which allows us to estimate equation (17) insofar as our input measures capture the ex post values $X_{i,j}$. In estimation, we deal with the endogenous adjustment of inputs by using the Levinsohn-Petrin instrumental variables approach and view the remaining productivity differences across firms as being the result of classical measurement error.

6. The exceptions are Cook Islands, Hong Kong, Isle of Man, Macau, Malta, Monaco, Niue, Puerto Rico, Singapore, Tuvalu, and Vatican City.

divided into states or provinces, which are further subdivided into counties or municipalities. For each variable, we collect data at the highest administrative division available (i.e., states and provinces rather than counties or municipalities) or, when such data do not exist, at the statistical division (e.g., the Eurostat NUTS in Europe) that is closest to it. Because we focus on regions, and typically run regressions with country fixed effects, we do not include countries with no administrative divisions in the sample.

The reporting level for data on income, geography, institutions, infrastructure, and culture differs across variables. GDP and education are typically available at the first-level administrative division (i.e., states and provinces). In contrast, geographic information systems (GIS) geospatial data on geography, climate, and infrastructure is typically available for areas as small as 10 km^2. Finally, survey data on institutions and culture are typically available at the municipal level. In our empirical analysis, we aggregate all variables for each country to a *region* from the most disaggregated level of reporting available.[7] To illustrate, we have GDP data for 27 first-level administrative regions in Brazil, corresponding to its 26 states plus the Federal District, and survey data on institutions for 248 municipalities. For our empirical analysis, we aggregate the data on institutions by taking the simple average of all observations for establishments located in the same first-level administrative division. Similarly, we aggregate the GIS geospatial data on geography, and climate at the first administrative level using the Collins-Bartholomew World Digital Map.

The final data set has 1,569 regions in 110 countries: (a) 79 countries have regions at the first-level administrative division; and (b) 31 countries have regions at a more aggregated level than the first administrative level because one or several variables (often education) are unavailable at the first administrative

7. We used a variety of aggregation procedures. Specifically, we computed population-weighted averages for GDP per capita and years of schooling. We computed regional averages for temperature and distance to coast by first summing the (average) values of the relevant variable for all grid cells lying within a region and then dividing by the number of cells lying within a region. We computed regional averages natural resources variables (oil and gas) by first summing the relevant variable for all grid cells within a region and then dividing by the region's population. We averaged the responses within a region for all the variables from the Enterprise and World Value Surveys. We sum up the number of unique ethnic groups within a region.

level. For example, Ireland has 34 first-level divisions (i.e., 29 counties and 5 cities), but publishes GDP per capita data for 8 regions and education for 2 regions. Thus, we aggregate all the Irish data to match the two regions for which education statistics are available. The Online Appendix identifies the reporting level for the regions in our data set. As noted earlier, all countries have administrative divisions (although 31 countries in our sample report statistics for statistical regions). The principal constraint on the sample is the availability of human capital data. All countries have periodic censuses and thus have subnational data on human capital, but these data are hard to find.

Figure I portrays the 1,569 regions in our sample. It shows that coverage is extensive outside of North and sub-Saharan Africa. Sample coverage rises with a country's surface area, total GDP, but not GDP per capita. For example, we only have data for 7 of the smallest (by surface area) 50 countries, 9 of the 50 lowest GDP in 2005 countries, but for 26 of the lowest 50 GDP per capita countries.

Our final data set has regional income data for 107 countries in 2005, drawn from sources including national statistics offices and other government agencies (42 countries), Human Development Reports (36 countries), OECDStats (26 countries), the World Bank Living Standards Measurement Survey (Ghana and Kazakhstan), and IPUMS (Israel).[8] Our measure of regional income per capita is typically based on value added but we use data on income (six countries), expenditure (eight countries), wages (three countries), gross value added (two countries), and consumption, investment, and government expenditure (one country) to fill in missing values. We measure regional income in current purchasing-power-parity (PPP) dollars because we lack data on regional price indexes. To ensure consistency with the national GDP figures reported by World Development Indicators, we adjust regional income values so that—when weighted by population—they total the GDP at the country level.

We compute regional income per capita using population data from City Population (http://www.citypopulation.de), which

8. We are missing regional income per capita for Bangladesh and Costa Rica and national income per capita in purchasing power parity terms for Cuba. When regional income data for 2005 is missing, we interpolate regional income shares using as much data as is available for the period 1990–2008 or, when interpolation is not possible, the closest available year.

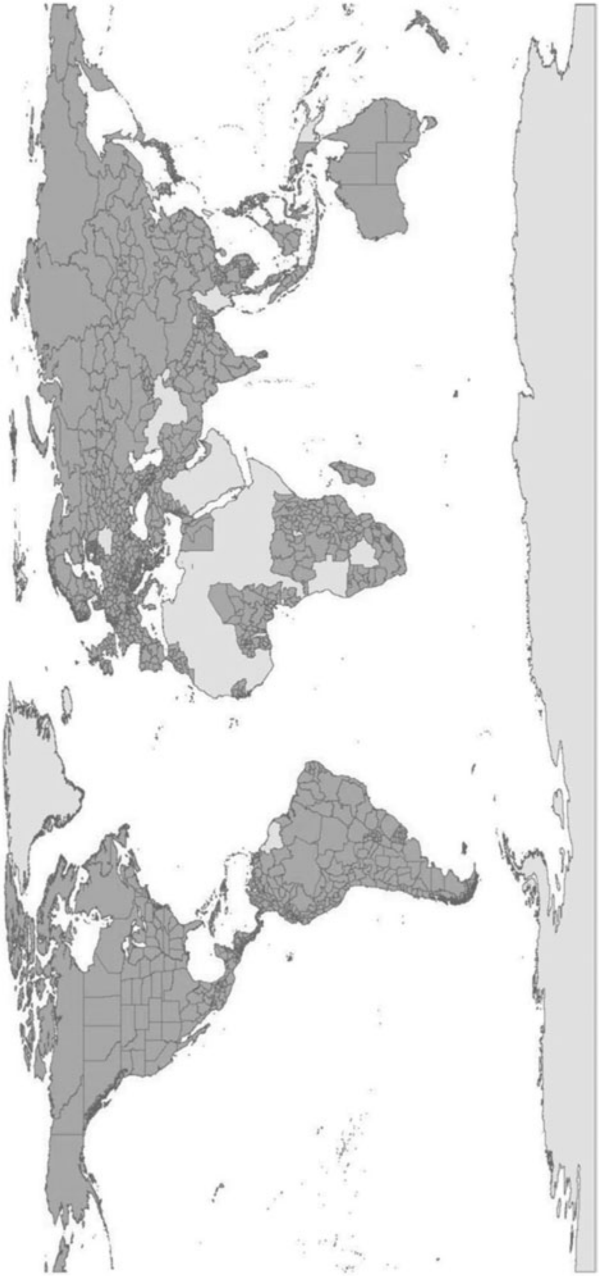

FIGURE I

Shaded Countries Are Included in Our Sample collects official census data as well as population estimates for regions where official census data are unavailable.[9] We adjust these regional population values so that their sum matches the country's population in the World Development Indicators database.

In addition, we examine productivity and its determinants using data from the Enterprise Survey for as many as 6,314 establishments in 20 countries and 76 of the regions in our sample.[10] Sample size is sharply reduced because we estimate alternative ordinary least squares (OLS) specifications on a fixed sample of firms. The Enterprise Survey covers establishments owned by formal firms with five or more employees. We collect firm-level controls such as age, foreign ownership, and the number of establishments owned by the firm. We also collect establishment-level data on sales, exports, cost of raw materials, cost of labor, cost of electricity, and book value of assets (i.e., property, plant, and equipment). Critically, some of the Enterprise Surveys keep track of the highest educational attainment of the establishment's top manager as well as of that of its average worker. Panel data at the firm level is available for only seven of the countries in our sample. Finally, we collect the two-digit SIC code (e.g., food, textiles, chemicals) of the establishments in our sample. These exclude Organisation for Economic Co-operation and Development (OECD) countries, as well as informal firms. We relate regional economic development to (a) geography, (b) education, (c) institutions, and (d) culture. We restrict attention to regional variables available for at least 40 countries and 200 regions.

We use three measures of geography and natural resources obtained from the WorldClim database, which are available for all regions of the world. They include the average temperature during the period 1950–2000, the (inverse) average distance between the cells in a region and the nearest coastline, and the estimated volume of oil production and reserves in 2000.[11]

9. We also used data from OECDStats (for Denmark, Greece, Ireland, Italy, and the United Kingdom) and the National Statistics Office of Macedonia.

10. The Enterprise Survey data were collected between 2002 and 2009. When data from the Enterprise Survey for one of the countries in our sample are available for multiple years, we use the most recent one in the OLS regressions. In contrast, we use all available years in the panel regressions.

11. The results in the article are robust to controlling for the standard deviation of temperature, the average annual precipitation during the period 1950–2000, the average output for multiple cropping of rain-fed and irrigated cereals during the

We gather data on the educational attainment of the population 15 years and older for 106 countries and 1,519 regions from EPDC Data Center (55 countries), Eurostat (17 countries), National Statistics Offices (27 countries), and IPUMS (8 countries); see the Online Appendix for sources. We also gather data on the educational attainment of the population 66 years and older from IPUMS for 39 countries. We collect data on school attainment during the period 1990–2006 and use data for the most recently available period. We compute years of schooling following Barro and Lee (2010). We use UNESCO data on the duration of primary and secondary school in each country and assume (a) zero years of school for the preprimary level, (b) four additional years of school for tertiary education, and (c) zero additional years of school for postgraduate degrees. We do not use data on incomplete levels because they are only available for about half of the countries in the sample. For example, we assume zero years of additional school for the lower secondary level. For each region, we compute average years of schooling as the weighted sum of the years of school required to achieve each educational level, where the weights are the fraction of the population aged 15 and older that has completed each level of education.

To illustrate these calculations consider the Mexican state of Chihuahua. The EPDC data on the highest educational attainment of the population 15 years and older in Chihuahua in 2005 shows that 4.99% of that population had no schooling, 13.76% had incomplete primary school, 22.12% had complete primary school, 5.10% had incomplete lower secondary school, 23.04% had complete lower secondary school, 17.94% had complete upper secondary school, and 13.05% had complete tertiary school. Next, based on UNESCO's mapping of the national educational system of Mexico, we assign six years of schooling to people who have completed primary school and 12 years of schooling to those that have completed secondary school. Finally, we calculate the average years of schooling in 2005 in Chihuahua as the sum of (a) 6 years times the fraction of people whose highest educational attainment level is complete primary school (22.12%), incomplete lower secondary (5.1%), or complete lower secondary school (23.04%); (b) 12 years times the fraction of people whose highest

period 1960–96, the estimated volume of natural gas production and reserves in 2000, and dummies for the presence of various minerals in 2005.

attainment level is complete upper secondary school (17.94%); and (c) 16 years times the fraction of people whose highest attainment level is complete tertiary school (13.05%). Accordingly, we estimate that the average years of schooling of the population 15 and older in Chihuahua in 2005 is 7.26 years (= 6 * 0.5026 + 12 * 0.1794 + 16 * 0.1305).

We compute years of schooling at the country level by weighting the average years of schooling for each region by the fraction of the country's population 15 and older in that region. The correlation between this measure and the number of years of schooling for the population 15 years and older in Barro and Lee (2010) is .9. For the average (median) country in our sample, the number of years of schooling in Barro and Lee (2010) is 8.18 versus 6.88 in ours (8.56 versus 6.92 years). Two factors largely explain why the Barro-Lee data set yields a higher level of educational attainment than ours: (a) Barro-Lee captures incomplete degrees, whereas we do not; and (b) education levels have increased rapidly over time, but some of our educational attainment data is stale (e.g., for 14 countries our educational attainment data is for 2000 or earlier).[12] Because most of our results are run with country fixed effects, country-level biases in our measure of human capital do not affect our results.

To shed light on the channels through which education affects regional income, we gather census data on occupations for as many as 565 regions in 35 countries. We focus on the incidence of directors and officers as well as employers in the workforce.

We create an index of the quality of institutions based on seven variables from the Enterprise Survey and one from the subnational *Doing Business* reports. The Enterprise Survey covers as many as 80 of the countries and 428 of the regions in our sample.[13] The Enterprise Survey asked business managers to

12. To make the Barro and Lee (2010) measure of educational attainment more comparable to ours, we make two adjustments to their data. First, we apply our methodology to the Barro-Lee data set and compute the level of educational attainment in 2005. After this first adjustment, the level of educational attainment computed with the Barro-Lee data set for the average (median) country in our sample drops to 7.07 (7.23). Second, we apply our methodology to the Barro-Lee data set but—rather than use data for 2005—use figures for the year that best matches the year in our data set. After this second adjustment, the level of educational attainment using the Barro-Lee data set for the average (median) country in our data set drop further to 6.95 (7.22).

13. The main reason why we have more regions with measures of institutions than regions with productivity data is because many Enterprise Surveys lack data

quantify: (a) informal payments in the past year, (b) the number of days spent in meeting with tax authorities in the past year, (c) the number of days without electricity in the previous year, and (d) security costs. The survey also asks managers to rate a variety of obstacles to doing business, including (e) access to land, and (f) access to finance.[14] For each of these obstacles to doing business, we keep track of the percentage of the respondents rating the item as a major or a very severe obstacle to business. The final Enterprise Survey variable we use is government predictability (measured as the percentage of respondents who tend to agree, agree in most cases, or fully agree that government officials' interpretations of regulations are consistent and predictable). We also use the overall ranking of the business environment from subnational *Doing Business* reports, which summarizes government regulations in a range of areas, including starting a new business, enforcing contracts, registering property, and dealing with licenses. The index of the quality of institutions is the latent variable that captures the common variation in these eight variables (the Online Appendix presents the results for individual variables).

To measure culture, we gather data on trust in others from the World Value Survey (WVS) for as many as 69 countries and 745 regions.[15] Specifically, we focus on the percentage of respondents in each region answering that "most people can be trusted" when asked whether "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in

on the education of managers. For the computation of our index of institutional quality, we required a minimum of 10 establishments answering the particular institutions question.

14. From the Enterprise Survey, we also assembled data on the number of days in the past year with telephone outages, the percentage of sales reported to the tax authorities, and the confidence that the judicial system would enforce contracts and property rights in business. We also gathered data on public infrastructure (e.g. power lines, air fields, highways, roads) from the US Geological Survey Global GIS database as well as the average travel time between cells in a region and the nearest city of 50,000 or more from the Global Environment Monitoring Unit. These variables are generally insignificant in regional income regressions (see the Online Appendix).

15. The WVS was collected between 1981 and 2005. When data from WVS for a country are available for multiple years, we use the most recent data. We set to missing 38 WVS observations in five countries (France, Japan, the Philippines, Russia, and the United States) because the subnational units in WVS are very coarse.

dealing with people?"[16] In addition, as a rough proxy for ethnic fractionalization, we gather data on the number of ethnic groups that inhabited each region in 1964 for up to 1,568 regions and 110 of our sample countries.[17]

In addition to running regressions using regional data, we examine GDP per capita at the country level, which comes from World Development Indicators. All other country-level variables in the article are computed based on our regional data rather than drawn from primary sources. The country-level analogs of our regional measures of education, geography, institutions, public goods, and culture are the area- and population-weighted averages of the relevant regional variables.

Table I summarizes our data. For each variable used in the regional regressions, Table I shows the number of regions for which we have data, the number of countries, the median value of the country mean, the median range and standard deviation within a country, and the ratio of the variable in the region with the highest versus lowest GDP per capita. The data show substantial income inequality among regions within a country. On average, the ratio of the income in the richest region to that in the poorest region is 4.41. This ratio is 3.77 for Africa, 5.63 for Asia, 3.74 for Europe, 4.60 for North America, and 5.61 for South America. The country with the highest ratio of incomes in the richest to that in the poorest region is Russia (43.30); the country with the lowest ratio is Pakistan (1.32). Interestingly, this ratio is 5.16 for the United States, 2.59 for Germany, 1.93 for France, and 2.03 for Italy. Italy has attracted enormous attention because of differences in income between its north and its south, usually attributed to culture. As it turns out, Italian regional income inequality is not unusual.

16. From WVS, we also examined proxies for civic values (Knack and Keefer 1997), for confidence in various institutions, for what is important in people's lives, as well as for characteristics valued in children. We also examined proxies for broad cultural attitudes with regard to authority, tolerance for other people, and family. Finally, we examined the percentage of respondents that participate in professional and civic associations. The results for these variables are qualitatively similar to those for trust in others that we discuss in the text.

17. We also gathered data on the probability that a randomly chosen person in a region shares the same mother language with a randomly chosen people from the rest of the country in 2004. The results for linguistic fractionalization are qualitatively similar to the results for ethnic fractionalization that we discuss in the text.

TABLE I
DESCRIPTIVE STATISTICS

			Median						
	Observations	Number of countries	Number of observations	Mean	Minimum	Maximum	Within-country range	Within-country std dev.	Average ratio region highest to lowest income per capita
Income per capita	1,537	107	11	6,636	3,198	13,859	9,924	2,782	4.41
Years of education	1,519	107	12	6.52	5.30	8.69	2.37	0.73	1.80
Share pop with high school degree	1,525	110	12	0.18	0.12	0.25	0.11	0.03	2.45
Share pop with college degree	1,525	110	12	0.11	0.06	0.20	0.13	0.04	4.70
Population	1,569	110	12	1,284,631	330,071	3,052,762	2,458,956	873,594	3.11
Temperature	1,568	110	12	16.84	10.23	21.13	4.47	1.45	1.02
Inverse distance to coast	1,569	81	12	0.90	0.80	0.99	0.13	0.05	1.05
Oil production per capita	1,569	69	12	0.00	0.00	0.00	0.00	0.00	1.70
Institutional quality	507	110	5	−0.01	−0.09	0.10	0.15	0.07	0.12
Trust in others	745	107	9	0.23	0.12	0.38	0.22	0.07	1.25
No. ethnic groups	1,568	107	12	3.00	1.00	6.00	4.00	1.35	0.86
% Directors and officers in workforce	471	28	14	0.63	0.23	1.36	0.82	0.26	6.84
% Employers in workforce	565	35	13	3.60	2.03	5.29	2.62	0.80	2.52

Notes. The table reports descriptive statistics for the variables in the article. Columns 4 through 9 report the value of each statistic in the median country. All variables are described in Appendix B.

There is likewise substantial inequality in education among regions within a country. On average, the ratio of educational attainment in the richest region to that in the poorest region is 1.80. This ratio is 2.74 for Africa, 1.68 for Asia, 1.16 for Europe, 1.33 for North America, and 1.81 for South America. The highest ratio is in Kenya (12.99), where education is 8.00 in Nairobi but only 0.62 in the northeastern region. The lowest ratio is 0.62 in Malawi, where the central region has lower education than the northern region (1.73 versus 2.79) despite having higher income per capita ($739 versus $555). Perhaps not surprisingly, there is more variation between rich and poor regions in the fraction of the population with a college degree than in the level of education. On average, the ratio of the fraction of the population with a college degree in the richest region to that in the poorest region is 4.70. To continue with the example of Kenya, 19.5% of the population older than 15 years in Nairobi has a college degree while only 0.9% of the comparable population in the northeastern region completed college.

The patterns of inequality among regions within countries are interesting for other variables as well. Table I shows large differences in the incidence of employers and of directors and officers in the workforce. There is also substantial variation across regions in culture and institutions. On average, the quality of institutions is *lower* in the richest region than in the poorest one, which suggests that regional differences in institutions may have trouble explaining differences in development.[18] Differences in endowments between rich and poor regions, such as temperature and distance to coast, are small.

IV. Accounting for National and Regional Productivity

In this section, we present cross-country and cross-region evidence on the determinants of productivity. We present national regressions only for comparison. These regressions are difficult to interpret because in our model we cannot express national output in closed form. More important, the estimated

18. This does not seem to be merely a matter of measurement error. The relationship holds even for the regional *Doing Business* indicators, which are fairly objective and less vulnerable to measurement error.

coefficients of education in the cross-country regressions may pick up the effect of omitted variables. The inclusion of country dummies in the regional regressions alleviates this concern. With respect to regional income, our benchmark is equation (16). We have measures of average education at the regional level, but we do not have national or regional data on physical capital or other inputs, so these variables only appear in the firm-level regressions in Section V.

Table II presents our basic regional results in perhaps the most transparent way. It reports the results of univariate regressions of regional income on its possible determinants, all with country dummies. Such specifications are loaded in favor of each variable seeming important because it does not compete with any other variable. We report both the within country and between countries R^2 of these regressions. The first column shows that education explains 58% of between-country variation of per capita income, and 38% of within country variation of per capita income. Figure II shows for Brazil, Colombia, India, and Russia the striking raw correlation between regional schooling and per capita income. The results are qualitatively similar if we use the fraction of the population with a high school degree or that with a college degree. Regional population explains only 3% of between-country variation of per capita income and 1% of within-country variation of per capita income.

Although several other variables in Table II explain a significant share of between-country variation, none come close to education in explaining within country variation in income per capita. Starting with geographical variables, temperature and inverse distance to coast—taken individually—explain 27% and 13% of between-country income variation, but 1% and 4%, respectively, of within-country variation. Oil reserves explain a trivial amount of variation at either level. The index of institutional quality explains 25% of cross-country variation, consistent with the empirical findings at the cross-country level such as King and Levine (1993) or Acemoglu, Johnson, and Robinson (2001), but the index explains 0% of within-country variation of per capita incomes. Although some of the individual components of the index, such as access to finance or the number of days it takes to file a tax return, explain as much as 25% of cross-country variation, none explains more than 2% of within-country variation of per capita incomes (see Online

TABLE II

UNIVARIATE REGRESSIONS FOR REGIONAL GDP PER CAPITA

	Slope	Constant	Observations	No. countries	Within R^2	Between R^2
Years of Education	0.2866[a] (0.0173)	6.7245[a] (0.1234)	1,500	105	38%	58%
Share pop with high school degree × 12	0.3180[a] (0.0502)	7.7729[a] (0.1564)	1,506	105	15%	33%
Share pop with college degree × 16	0.2926[a] (0.0254)	8.1305[a] (0.0549)	1,506	105	27%	34%
Ln(population)	0.0536[b] (0.0211)	8.0211[a] (0.2905)	1,537	107	1%	3%
Temperature	−0.0093 (0.0095)	8.8996[a] (0.1418)	1,536	107	1%	27%
Inverse distance to coast	0.8937[a] (0.2437)	8.0034[a] (0.2063)	1,537	107	4%	13%
Ln(oil production per capita)	0.1518[a] (0.0503)	8.7447[a] (0.0051)	1,537	107	2%	4%
Institutional quality	0.0801 (0.3542)	8.5217[a] (0.0000)	496	79	0%	25%
Trust in others	0.0126 (0.1555)	8.9889[a] (0.0416)	739	68	0%	18%
Ln(No. ethnic groups)	−0.1473[a] (0.0324)	8.9055[a] (0.0322)	1,536	107	5%	17%
% Directors and officers in workforce	0.2106[a] (0.0298)	8.8325[a] (0.0350)	447	27	15%	7%
% Employers in workforce	0.0474 (0.0353)	8.8119[a] (0.1257)	553	35	3%	14%

Notes. OLS regressions of (log) regional income per capita. The independent variables are proxies for (a) education, (b) geography, (c) institutions, and (d) culture. All regressions include country dummies. The table reports the number of observations, the number of countries, the R^2 within, and the R^2 between. Robust standard errors are shown in parentheses. All variables are described in Appendix B.

[a]Significant at the 1% level. [b]Significant at the 5% level. [c]Significant at the 10% level.

Appendix).[19] Cultural variables account for a substantial share of between-country variation but none accounts for much of within country variation. Of course, culture might operate at the national rather than the subnational level, although we note that much of the research on trust focuses on regional rather than national differences (e.g., Putnam 1993).

19. Consistent with the results on institutions, two indicators of infrastructure—density of power lines and travel time between cities—explain a good deal more of the cross-country than of within-country variation (see Online Appendix). Density of power lines account for 36% of cross-country variation but only 5% of within-country variation. Travel time accounts for 15% of cross-country variation but only 7% of within-country variation.

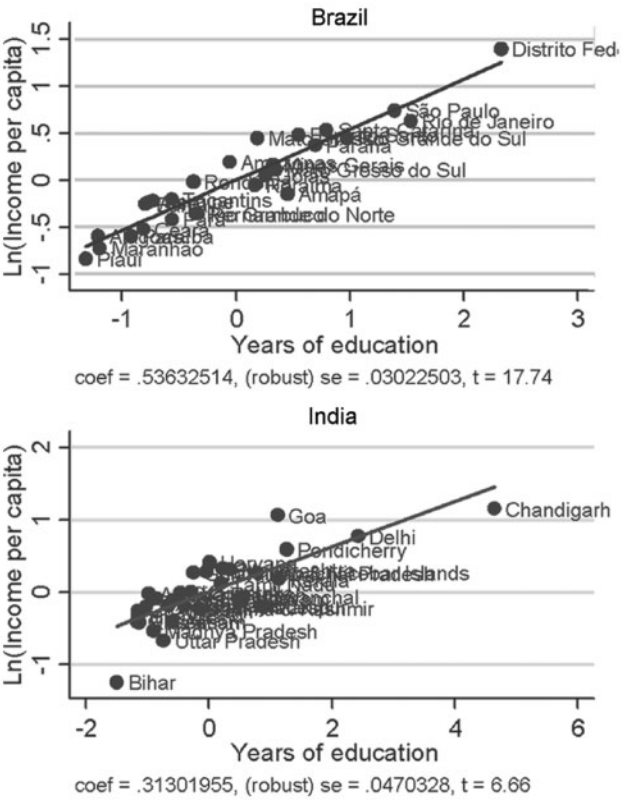

FIGURE II

Partial Correlation Plot of (log) Regional Income per Capita and Years of Education in Brazil and India

Tables III and IV show the multivariate regression results at the national and regional level. Table III presents regressions of national per capita income on geography and education, in some instances controlling for population or employment, as suggested by our model. At the country level, temperature, inverse distance to coast, and oil endowment are all highly statistically significant in explaining cross-country variation in incomes, and together explain an impressive 50% of the variance. Education is also statistically significant, with a coefficient of .26, raising the R^2 to 63%. Next we add, one at a time, two measures of institutions (our index and expropriation risk) and two measures of culture (trust in others and the number of ethnic groups). Education

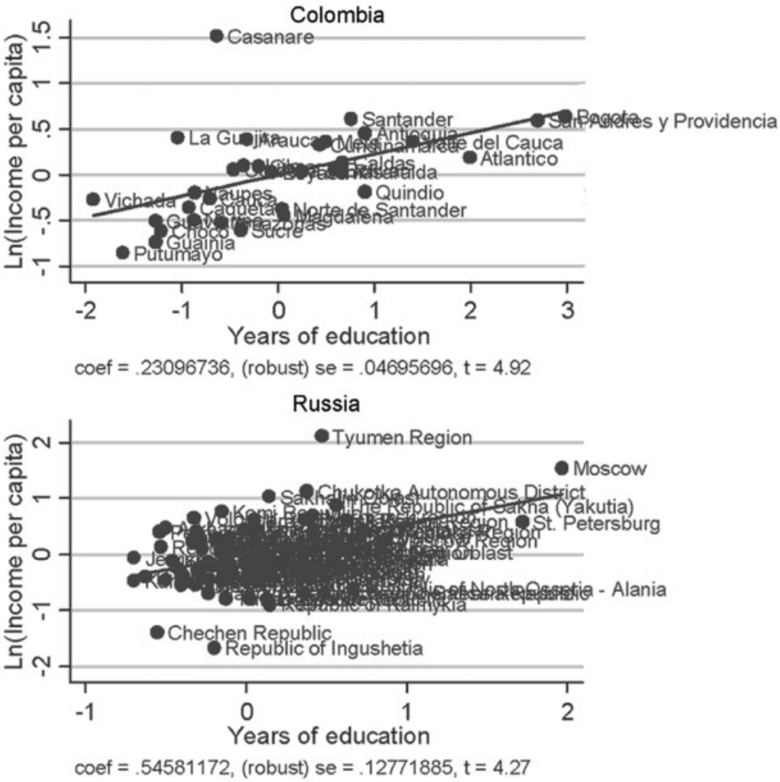

FIGURE II (Continued)

Partial Correlation Plot of (log) Regional Income per Capita and Years of Education in Colombia and Russian Federation

remains highly statistically significant in each specification, and its coefficient does not fall much. At the country level, both institutional quality and expropriation risk are statistically significant with coefficients of .32 and .36, respectively. In contrast, proxies for culture are statistically insignificant. The final specification combines geography, education, institutions, and culture in one regression. Although we lose roughly two thirds of the observations, there are no surprising results: the coefficient on years of education drops to .15 but remains the most powerful predictor of GDP per capita, whereas distance to the coast, oil reserves, and risk of expropriation are also statistically significant, although their combined explanatory power is low.

TABLE III

NATIONAL INCOME PER CAPITA, GEOGRAPHY, INSTITUTIONS, AND CULTURE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Temperature	−0.0914[a]	−0.0189[c]	−0.0079	−0.0023	−0.0283[b]	−0.0188[c]	−0.0171
	(0.0100)	(0.0106)	(0.0110)	(0.0108)	(0.0134)	(0.0107)	(0.0171)
Inverse distance to coast	4.4768[a]	2.9646[a]	2.0100[a]	2.4041[a]	3.6523[a]	2.7760[a]	1.6460[b]
	(0.5266)	(0.5735)	(0.5972)	(0.5933)	(0.7897)	(0.6469)	(0.7154)
Ln(oil production per capita)	1.2192[a]	0.9489[a]	1.0356[a]	1.0187[a]	0.9825[a]	0.9554[a]	0.6642[a]
	(0.1985)	(0.1238)	(0.3195)	(0.1795)	(0.2446)	(0.1303)	(0.2352)
Years of education		0.2567[a]	0.2215[a]	0.1661[a]	0.1936[a]	0.2533[a]	0.1522[a]
		(0.0305)	(0.0331)	(0.0484)	(0.0496)	(0.0345)	(0.0364)
Ln(population)		0.0683[c]	0.0307	−0.0280	0.1238	0.0999	0.0909
		(0.0407)	(0.0463)	(0.0482)	(0.0787)	(0.0640)	(0.1051)
Institutional quality			0.3241[b]				0.1227
			(0.1576)				(0.2804)
Expropriation risk				0.3600[a]			0.2399[b]
				(0.0943)			(0.1064)
Trust in others					1.2472		−1.0995
					(0.8789)		(0.7480)
Ln(no. ethnic groups)						−0.0996	−0.1180
						(0.1549)	(0.1378)
Constant	6.3251[a]	3.5765[a]	4.9356[a]	3.3713[b]	2.3953	3.4622[a]	3.8201[c]
	(0.4598)	(0.9368)	(0.9703)	(1.3235)	(2.0129)	(0.9282)	(2.1565)
Observations	107	105	78	83	68	105	35
Adjusted R^2	50%	63%	70%	69%	49%	63%	79%
Adj. R^2 excluding institutions and culture	50%	63%	69%	63%	49%	63%	74%
Adj. R^2 without education	50%	50%	52%	66%	44%	51%	73%

Notes. Ordinary least square regressions of (log) income per capita. All regressions include temperature, inverse distance to coast, and (log) per capita oil production and reserves. In addition, regressions include measures of (a) human capital, (b) institutions, and (c) culture. Robust standard errors are shown in parentheses. For comparison, the bottom panel shows the adjusted R^2 of two alternative specifications: (a) a regression that excludes the relevant measure of institutions or culture; and (b) a regression that excludes years of education. All variables are described in Appendix B.

[a]Significant at the 1% level. [b]Significant at the 5% level. [c]Significant at the 10% level.

TABLE IV

REGIONAL INCOME PER CAPITA, GEOGRAPHY, INSTITUTIONS, AND CULTURE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Temperature	−0.0156[c]	−0.0128	−0.0069	0.0003	−0.0142	0.0020	−0.0095[c]
	(0.0082)	(0.0083)	(0.0053)	(0.0063)	(0.0089)	(0.0081)	(0.0047)
Inverse distance to coast	1.0283[a]	0.5236[a]	0.5066	0.5806[b]	0.4568[a]	0.5713[c]	0.8842[a]
	(0.2080)	(0.1380)	(0.3257)	(0.2377)	(0.1292)	(0.3397)	(0.2547)
Ln(oil production per capita)	0.1650[a]	0.1848[a]	0.1604	0.1459[b]	0.1983[a]	0.1041	0.1403[b]
	(0.0477)	(0.0470)	(0.0970)	(0.0593)	(0.0491)	(0.2006)	(0.0643)
Years of education		0.2763[a]	0.3476[a]	0.3032[a]	0.2653[a]	0.3678[a]	
		(0.0170)	(0.0215)	(0.0278)	(0.0178)	(0.0443)	
Ln(population)		0.0122	0.0008	0.0091	0.0165	0.0050	−0.0259
		(0.0164)	(0.0215)	(0.0177)	(0.0169)	(0.0393)	(0.0177)
Institutional quality			0.3667			0.4667	
			(0.2297)			(0.2850)	
Trust in others				−0.0413		0.0439	
				(0.0879)		(0.1632)	
Ln(no. ethnic groups)					−0.0499[b]	0.0005	
					(0.0243)	(0.0490)	
Years of education 65+							0.2515[a]
							(0.0283)
Constant	8.1061[a]	6.3594[a]	5.9375[a]	5.9902[a]	6.5044[a]	5.4934[a]	7.7483[a]
	(0.2277)	(0.1857)	(0.4235)	(0.2809)	(0.1637)	(0.6989)	(0.2680)
Observations	1,536	1,499	483	728	1,498	281	608
Number of countries	107	105	78	66	105	45	39
Within R^2	8%	42%	62%	48%	42%	62%	39%
Between R^2	47%	60%	61%	51%	60%	51%	62%
Within R^2 excluding institutions and culture	8%	42%	61%	48%	42%	61%	39%
Within R^2 excluding education	8%	10%	6%	12%	15%	16%	9%
Between R^2 excluding institutions and culture	47%	60%	60%	51%	60%	50%	62%
Between R^2 excluding education	48%	42%	46%	6%	47%	63%	68%

Notes. Country fixed-effects regressions of (log) regional income per capita. All regressions include temperature, inverse distance to coast, and (log) per capita oil production and reserves. In addition, regressions include measures of (a) human capital, (b) geography, (c) institutions, and (d) culture. Robust standard errors are shown in parentheses. For comparison, the bottom panel shows the adjusted R^2 of two alternative specifications: (a) a regression that excludes the relevant measure of institutions or culture; and (b) a regression that excludes education. All variables are described in Appendix B.

[a]Significant at the 1% level. [b]Significant at the 5% level. [c]Significant at the 10% level.

The last two rows of Table III show the adjusted R^2 of each regression if we omit the institutional (or cultural) variable, as well as the adjusted R^2 if we omit education. The effect on R^2 of dropping education ranges from a sharp reduction in the specifications that controls for the quality of institutions and the number of ethnic groups (columns (3) and (6)) to a modest increase in the specification that includes risk of expropriation (column (4)). The risk of expropriation has a 76% sample correlation with years of schooling. These results illustrate the difficulty of disentangling the effect of institutions and human capital in cross-country regressions (see Glaeser et al. 2004).[20]

Table IV presents the corresponding results at the regional level, including country fixed effects. Among the geography variables, inverse distance to coast is the most robust predictor of regional income per capita. The education coefficient is slightly higher than in Table III, and is highly significant, as illustrated in Figure III. When we include our proxies for institutions and culture one at a time, we find a small adverse effect of ethnic heterogeneity on income and no effect of the quality of institutions or of trust in others.[21] Institutional quality is insignificant, and its incremental explanatory power is tiny. Combining our proxies for human capital, institutions, and culture in one specification, we find that the coefficient on years of education rises from .27 to .37 and is highly significant while inverse distance to the coast is the only other variable that is statistically significant (at the 10% level). The last four rows of Table IV show the within- and between-country adjusted R^2 of each regression if we omit the institutional or cultural variable, as well as the analog statistics if we omit education. Although geography, institutions, and culture jointly explain a respectable fraction of the cross-country variation, they explain at most 16% of the within-country variation. In contrast, education explains a large fraction of the variance both across and within countries.

20. Risk of expropriation has the highest explanatory power among standard measures of institutions, such as constraints on the executive, proportional representation, and corruption (see the Online Appendix).

21. The region's ranking in the *Doing Business* report is the only component of the quality of institutions variable that is statistically significant but its incremental explanatory power is tiny (see Online Appendix). In results reported in the Online Appendix, we also find a small adverse effect of travel time but no role for other infrastructure variables, such as the density of power lines. Finally, we find no role for cultural variables, such as linguistic fractionalization and civic values.

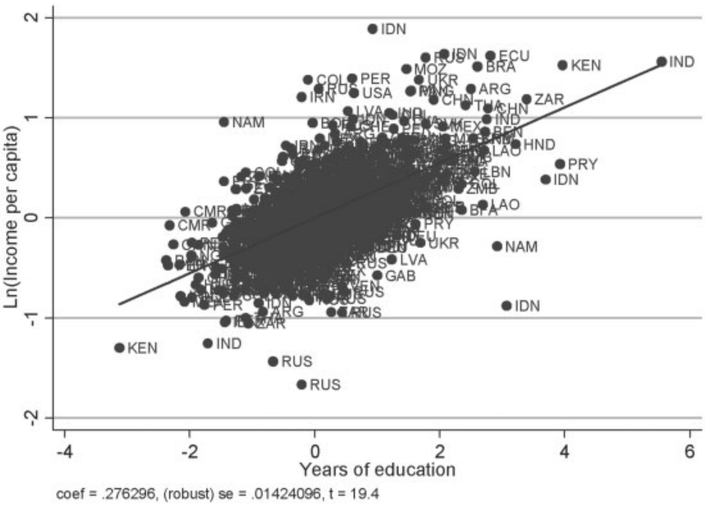

FIGURE III

Partial Correlation Plot of (log) Regional Income per Capita and Years of Education Controlling for Temperature, Inverse Distance to Coast, Ln(oil production per capita), Ln(population), and Country Dummies

The final regression in Table IV addresses the concern that the coefficient on education is biased because richer regions invest more in education. To address this simultaneity bias, we include in the regression years of education for the population over 65 years old rather than for the population over 14 years as we do in all other regressions. The results show that the estimated coefficient on years of education for the population over 65 is highly statistically significant and only marginally lower than the coefficient of the standard measure of education in column (2) (.25 versus .28). Although this strategy does not fully address endogeneity concerns—some long-run factors may determine both past regional schooling and current income—it nonetheless provides a useful robustness check with respect to the effects of recent economic growth. We discuss the omitted variable bias when we present firm-level regressions in the next section.

We have conducted several robustness checks of our basic findings, and summarize them here but do not present the results. First, we estimated separate regressions for countries above and below the median GDP per capita to examine whether the relationship between regional income and human capital is different for developed and developing countries. Consistent with the cross-country findings of Barro (1991) and Krueger and Lindahl (2001), the estimated coefficient on years of education is typically higher for richer countries. Second, we eliminated regions that include national capitals from the regressions; the results are not materially affected. Third, we included measures of regional population density in the specifications; density is typically insignificant and other results are not importantly affected. Fourth, we have tested the robustness of these results using data on regional luminosity instead of per capita income (see Henderson, Storeygard, and Weil 2011, 2012). The results are consistent with the evidence we have described, with respect to the importance of human capital, and the relative unimportance of other factors, in accounting for cross-regional differences.

The low explanatory power of institutions is puzzling. The measures we use (and also the components of the aggregate index) are standard and theoretically appropriate. In general, subjective assessments correlate much better with measures of development than objective measures of institutions (Glaeser et al. 2004). Even subjective assessments of institutions have low explanatory power in the sample of developing countries covered by the Enterprise Survey (see Online Appendix). The weakness of institutional variables may result in part from different data and in part from the fact that institutions may be important at the national, but not at the regional level (see Table III).

Due to potential migration of better educated workers to more productive regions, we cannot interpret the large education coefficients—which appear to come through with a similar magnitude across a range of specifications—as the causal impact of human capital on regional income. Next we estimate the role of human capital in the production function by looking at firm-level evidence based on Enterprise Surveys, which allows us to partially address this problem by including region fixed effects as well as taking advantage of panel data. By combining estimation and calibration, we then assess the extent to which the role of human capital at the firm level can account for its role across regions.

V. Establishment-Level Evidence

In Table V, we turn to the micro evidence and estimate essentially equation (17). We use the Enterprise Survey data

TABLE V

Gross Value Added

	OLS			Levinsohn-Petrin
	(1)	(2)	(3)	(4)
Temperature	0.0505[b]	0.0251	0.0303[c]	0.0698[a]
	(0.0226)	(0.0183)	(0.0180)	(0.0197)
Inverse distance to coast	−0.1979	−0.2579	−0.3264	−0.2429
	(0.4519)	(0.4748)	(0.5051)	(0.5333)
Ln(oil production per capita)	−1.4113[c]	−1.1546	−1.1133	15.4289
	(0.7138)	(0.7858)	(0.8374)	(45.4751)
Years of education	0.0730[a]	0.0765[a]	0.0866[a]	−0.0087
	(0.0228)	(0.0200)	(0.0207)	(0.0317)
Ln(population)	0.1263[b]	0.0967[b]	0.1010[b]	0.0135
	(0.0481)	(0.0445)	(0.0464)	(0.0938)
Years of education of manager	0.0263[a]	0.0164[a]	0.0147[a]	0.0256[a]
	(0.0052)	(0.0049)	(0.0049)	(0.0090)
Years of education of workers	0.0169[b]	0.0149[c]	0.0146[c]	0.0265[a]
	(0.0078)	(0.0076)	(0.0075)	(0.0100)
Ln(no. employees)	0.8602[a]	0.6757[a]	0.6399[a]	0.6151[a]
	(0.0340)	(0.0279)	(0.0265)	(0.0301)
Ln(property, plant, and equipment)	0.2434[a]	0.1668[a]	0.1614[a]	0.3450[a]
	(0.0169)	(0.0164)	(0.0161)	(0.0493)
Ln(expenditure on energy)		0.2548[a]	0.2457[a]	
		(0.0227)	(0.0227)	
Ln(1 + firm age)			0.0348[c]	−0.0325
			(0.0182)	(0.0286)
Multiple establishments			0.1522[a]	
			(0.0377)	
% Export			0.0017[a]	
			(0.0006)	
% Equity owned by foreigners			0.0032[a]	
			(0.0006)	
Constant	2.1234[b]	2.6136[a]	2.5454[a]	
	(0.9712)	(0.9128)	(0.9378)	
Observations	6,314	6,314	6,312	2,922
Number of countries	20	20	20	7
Within R^2	73%	75%	76%	
Between R^2	35%	78%	76%	

Notes. The table reports regressions for (log) sales minus expenditure on raw materials and energy. The first three columns show fixed-effect regressions for the cross-section, while the last column shows Levinsohn and Petrin (2003) panel regressions. All regressions include country and industry fixed effects. The errors of the fixed-effect regression are clustered at the country-regional level. Robust standard errors are shown in parentheses. All variables are described in Appendix B.

[a]Significant at the 1% level. [b]Significant at the 5% level. [c]Significant at the 10% level.

described in section III. We estimate OLS regressions using a single cross-section of 6,314 firms in 20 countries and panel regressions using 2,922 firms in 7 countries.[22] We report results using a rough measure of value added, namely, the logarithm of sales net of raw material and energy inputs, as the dependent variable.[23] We use the log of the number of employees as a proxy for $l_{i,j}$. We measure capital (which includes both land $T_{i,j}$ and physical capital $K_{i,j}$) by the log of property, plant, and equipment and also use the log of expenditure on energy as a proxy for it. We include firm-level controls such as age, number of establishments, exports, and equity ownership by foreigners.

Most important, to trace out the effects of human capital, we include the years of schooling of the manager S_E, the years of schooling of workers S_W, and the average years of schooling in the region S_i. We thus implicitly assume that the establishment's top manager plays the role of the entrepreneur in our Lucas-Lucas model. As we explained in section II, the Mincer model implies that schooling should enter the specification in levels, rather than in logs. We include geographic variables to control for exogenous differences in productivity.[24] To capture scale effects in regional externalities, we control for the log of the region's population L_i.

In Table V, we begin with three OLS specifications. In the most parsimonious specification in the first column, we include proxies for geography and regional education; worker and manager schooling, log number of employees; log of property, plant, and equipment; and industry fixed effects (for 16 industries). Errors are clustered at the regional level. The estimated coefficient on capital is only .24 and the estimated coefficient on labor is .86. To address concerns over measurement error, the second specification adds the log of energy expenditure as a proxy for

22. Panel data for two of the countries in our sample (Brazil and Malawi) are available but we can't use them because data on schooling are missing for one of the years.

23. Results are qualitatively similar if we use the log of sales as the dependent variable (see Online Appendix).

24. Consistent with the findings for regional data, measures of regional institutions and infrastructure are usually insignificant, and hence we do not focus on these results. The coefficient on management schooling may be biased insofar as our regional proxies leave out much of the variation in A_i. To address this issue, we estimate equation (17) by controlling for the full set of region $\times$ industry dummies. The results on years of schooling of managers and workers are robust to including region $\times$ industry fixed effects (see Online Appendix).

physical capital. The estimated coefficient on labor drops to .68 while the sum of the estimated coefficients on capital and energy is .42. The third specification adds to the previous one four firm-level controls, namely, log firm age, a dummy variable if the firm has multiple establishments, the percentage of sales that are exported, and the percentage of the equity owned by foreigners. These firm-level controls have the expected signs and are highly statistically significant. Yet including these controls does not materially change any of the coefficients of interest.

Depending on the specification, the coefficient on management schooling ranges from .026 to .015 while the coefficient on worker schooling takes values between .017 and .015. The similarity in the magnitude of the management and worker schooling coefficients drives our calibration exercise. In the context of equation (17), this implies that $(1 - \alpha - \beta - \delta)\,\overline{\mu}_E$ is roughly equal to $\alpha\,\overline{\mu}_W$. The return on entrepreneurial schooling must thus be substantially higher than that on worker schooling because the labor share α is typically much higher than the entrepreneurial share $(1 - \alpha - \beta - \delta)$.

The coefficient on regional schooling is statistically significant across specifications and varies in a narrow range between .07 and .09. Insofar as there is large measurement error in workers' schooling at the firm level, regional education may provide a more precise proxy for workers' skills, creating a false impression of human capital externalities. However, this is unlikely to be the case because the average education of workers does not vary much across firms within regions. Consistent with agglomeration economies, the coefficient on regional population is positive, ranging from .10 and .12 depending on the specification. Finally, the coefficients on geography variables are generally insignificant. Thus, the most obvious proxies for omitted regional productivity do not appear to be important. These results on geography should partially address the concern that regional schooling picks up the effect of omitted regional productivity. Still, other endogeneity issues may contaminate our estimates of externalities. In section VI, we perform a calibration exercise intended to quantify the importance of the coefficients on regional human capital and population for explaining income variation across space.

In the OLS results in Table V, the coefficients on production inputs (including managerial and worker education) may be biased by unobservable differences in firm-level productivity. In the last column of Table V, we follow Levinsohn and Petrin's

(2003) panel data approach and use expenditure on energy to control for the unobserved correlation between production inputs and productivity.[25] This estimation strategy provides a way to control for the selection of managers and workers into more productive firms. Our sample contains at most three observations per establishment and the average number of observations per establishment is only 1.2, so these panel data results should be interpreted with caution. None of the regional variables come in significant, most likely because we only have panel data for 22 regions in 7 countries. Turning to the firm-level variables, the results are consistent with our earlier findings. The coefficient on labor is .62, whereas that on property, plant, and equipment is .34. The estimated coefficients on managerial and worker schooling are close to their respective OLS levels: the coefficient on management schooling rises to .027 from .015 under OLS and the coefficient on worker schooling rises to .032 from .015 under OLS.

We added additional controls to these regressions, and obtained similar results, including similar parameter estimates as those in Table V. There does not appear to be much evidence of significant omitted regional effects, although because we do not have all of the determinants of regional productivity, our assessment of external effects might be exaggerated. As a robustness check, we reestimated the panel regression in Table V using the methodology of Olley and Pakes (1996). Since establishments with zero investment are excluded from the analysis, the number of observations drops from 2,922 to 1,426. Nevertheless, the estimated coefficients on management and worker education are qualitatively similar to our basic findings (.0367 versus .0256 and .0236 versus .0265, respectively). Ackerberg, Caves, and Frazer (2006) raise concerns about the identification of the coefficients on flexible inputs in the Levinsohn-Petrin, and to a lesser extent Olley-Pakes, procedures. Although it is reassuring that both procedures yield similar results, we cannot fully address these concerns given the small number of establishments with

25. Specifically, we use the "levpet" command in STATA (see Petrin, Poi, and Levinsohn 2004). We assume that labor inputs are flexible and property, plant, and equipment are not.

multiple observations.[26] We return to this in the calibration exercise.

In light of this evidence, it is interesting to go back to the regional data and ask: if entrepreneurs/managers are so important in determining firm-level productivity, can we also find evidence of their influence on regional income? To address this issue, Table VI uses an approach similar to that in Table IV, but estimates the correlation between regional GDP per capita, the composition of human capital, and the structure of the workforce. We run regressions with and without years of education but always include the standard geography controls. We first examine whether the share of the population with a college degree—a measure of skilled labor—plays a special role (Vanderbussche, Aghion, and Meghir 2006). To this end, we divide the population in each region according to their highest educational attainment into three groups: (a) less than high school, (b) high school, and (c) college or higher. We then include in the regressions the share of the population with high school and, separately, that with college degree (the omitted category is the population with less than high school). To make the estimated coefficients comparable to those for years of education in Table IV, we multiply the shares of the population with college and high school degrees by 16 and 12, respectively (their weights in our standard measure of years of education). The estimated coefficient is higher for the (scaled) share of the population with college than with high school (.25 versus .20) but cannot reject the hypothesis that the two coefficients are equal (the F-statistic is 1.28).

Although it cannot be interpreted as causal evidence, Table V documents—consistent with our model—a positive correlation between regional income and the share of educated workers becoming managers. We use data on the fraction of the workforce classified by the census as directors and officers to explore this prediction. The data are noisy because occupational categories are not standardized across countries and data are available for only 28 countries (not all countries have census data online, and not all censuses have detailed occupational data). With these caveats in mind, we find that, controlling for the percentage of the population with college and high school, increasing by

26. We could estimate OLS regressions with firm fixed effects. However, very few establishments have more than one observation and within-establishment variation in the education of the top manager over time is very limited.

TABLE VI

REGIONAL INCOME PER CAPITA AND THE COMPOSITION OF HUMAN CAPITAL

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Temperature	−0.0136[c]	−0.0127	−0.0097	−0.0063	−0.0087	−0.0048	−0.0112[b]	−0.0070
	(0.0078)	(0.0084)	(0.0073)	(0.0061)	(0.0063)	(0.0054)	(0.0055)	(0.0051)
Inverse distance to coast	0.6476[a]	0.5207[a]	0.6659[b]	0.5047[b]	0.6665[b]	0.5138[b]	0.4965[b]	0.3618[c]
	(0.1603)	(0.1395)	(0.2593)	(0.2417)	(0.2566)	(0.2382)	(0.1990)	(0.1818)
Ln(oil production per capita)	0.1808[a]	0.1881[a]	0.1081[c]	0.1132[b]	0.1120[b]	0.1186[b]	0.1405[b]	0.1426[b]
	(0.0463)	(0.0463)	(0.0560)	(0.0533)	(0.0528)	(0.0502)	(0.0546)	(0.0532)
Share Pop with high school degree × 12	0.2024[a]		0.2408[a]	−0.1089	0.2427[a]	−0.1020[c]	0.1829[a]	−0.1121[c]
	(0.0309)		(0.0570)	(0.0652)	(0.0552)	(0.0579)	(0.0550)	(0.0619)
Share Pop with college degree × 16	0.2488[a]	0.0835[a]	0.2350[a]	−0.0175	0.2323[a]	−0.0175	0.2343[a]	0.0171
	(0.0210)	(0.0256)	(0.0398)	(0.0439)	(0.0401)	(0.0412)	(0.0344)	(0.0348)
Years of education		0.2246[a]		0.3806[a]		0.3708[a]		0.3249[a]
		(0.0245)		(0.0677)		(0.0624)		(0.0471)
Ln(population)		0.0045		−0.0255[b]		−0.0237[b]		−0.0233[c]
		(0.0160)		(0.0115)		(0.0098)		(0.0117)
% Directors and officers in workforce			0.0839[a]	0.0725[a]				
			(0.0208)	(0.0199)				
% Directors and officers with a college degree					0.1266[b]	0.1117[a]		
					(0.0505)	(0.0368)		
% Employers in workforce							0.0284[c]	0.0184
							(0.0153)	(0.0141)
% Self-employed in workforce							−0.0148[a]	−0.0135[a]
							(0.0044)	(0.0037)
Constant	7.2338[a]	6.6545[a]	7.3371[a]	6.6233[a]	7.3566[a]	6.6860[a]	7.9530[a]	7.3628[a]
	(0.2321)	(0.1990)	(0.2495)	(0.3063)	(0.2418)	(0.2803)	(0.2733)	(0.2938)
Observations	1,505	1,499	446	441	476	471	551	546
Number of countries	105	105	27	27	28	28	35	35
Within R^2	39%	43%	49%	58%	48%	56%	49%	56%
Between R^2	54%	61%	64%	83%	63%	82%	76%	84%

Notes. Country fixed effects regressions of (log) regional income per capita. Robust standard errors are shown in parentheses. The table reports the number of observations, the number of countries, the R^2 within, and the R^2 between. All variables are described in Appendix B.

[a]Significant at the 1% level. [b]Significant at the 5% level. [c]Significant at the 10% level.

1 percentage point the fraction of the workforce classified as directors and officers is associated with an 8% increase in GDP per capita. This finding is robust to including the level of education. Focusing on the share of directors and officers that also have a college degree yields similar results: a percentage point increase in the fraction of college-educated directors and officers is associated with an increase in GDP per capita of 11% to 12%, depending on the specification. Consistent with our model, the incidence of doctors and government bureaucrats is uncorrelated with regional income per capita (see Online Appendix).

As an alternative way of looking at occupations, we include in the regressions the share of the workforce classified as employers. The results for employers suggest that increasing by 1 percentage point the share of employers in the workforce is associated with a 3% increase in GDP per capita when we control for educational attainment but the estimated coefficient drops in value (from .03 to .02) and becomes insignificant when we control for the level of education.

VI. Calibration

Can the effects estimated from firm-level regressions account for the large role of schooling in the regional regressions? How do these effects compare with the calibrations performed in development accounting? We first discuss the predictions of our model under a set of standard calibration values for the labor share α, the capital share $(\delta + \beta)$, and the housing income share θ, but also consider a range of parameter values (particularly for the labor share α). The standard calibration for the U.S. labor share is about $\alpha = .6$. We, however, calibrate $\alpha = .55$ to reflect the fact that in developing countries the labor share tends to be lower than in the United States, in part because a fraction of labor income remunerates entrepreneurship (Gollin 2002). This number is close to the estimate of the labor share obtained from our firm-level regressions (where α is around .6). For our exercise, we focus on the value calibrated using national account statistics, and thus target $\alpha = .55$ as our main benchmark. We perform a sensitivity analysis with respect to different values of α.

We follow the standard calibration for the overall capital share and set it to .35, which falls between our firm level and panel estimates. These calibrations imply that managerial/

entrepreneurial input accounts for $(1-\alpha-\beta-\delta) = (1-.55-.35) = .1$ of value added.

From our estimated regressions we impose the following restrictions:

(i) $\alpha\,\overline{\mu}_W = .03$ and $(1-\alpha-\beta-\delta)\,\overline{\mu}_E = .025$ (from Table V, column (4)).
(ii) $\gamma = .05$ (from Table V, column (4)).
(iii) $\gamma\,\psi\,\overline{\mu} = .074$ (from Table V, columns (1), (2), (3)).
(iv) $\gamma - \frac{\beta}{(1-\delta)} = .01$ (from Table IV, column (2)).
(v) $[1+\gamma\psi-\frac{\beta}{(1-\delta)}]\,\overline{\mu} = .27$ (from Table IV, column (2)).

These specifications should not be viewed as "structural estimates" of model parameters but as a means of finding parameter values in the ballpark of our regressions estimates. Note that our starting estimates for regional externalities in the firm-level regressions do not come from the Levinsohn-Petrin method, which yields zero. We come back to this issue later.

Using these calibrated parameters, the foregoing equations can be solved to yield:

$$\overline{\mu}_W = .055; \quad \overline{\mu}_E = .25; \quad \overline{\mu} = .20; \quad \delta = .32; \quad \psi = 7.25; \quad \beta = .03.$$

At these parameter values and a housing share θ of .4, the spatial equilibrium is stable, since $(\beta-\psi\gamma)(1-\theta)+\theta(1-\delta) = (-.33)(.6) + (.4)(.68) > 0$. Interestingly, some of these parameter values fall in the ballpark of existing micro estimates. The land share β is just below estimates based on income accounts (Valentinyi and Herrendorf 2008). The return to worker schooling of 5%–6% is consistent with micro evidence on workers' Mincerian returns (Psacharopoulos 1994). This finding suggests that our firm-level productivity regressions reduce identification problems at least as far as firm-level variables are concerned. Indeed, note that in (i) our estimates of the return to education are assessed independently from our coefficient estimates for externalities, which are subject to more severe endogeneity concerns.

The critical new finding is that our estimation results point to a Mincerian return $\overline{\mu}_E = .25$ for entrepreneurs. This 25% estimate is higher than those found by Goldin and Katz (2008) for returns to college education for workers. However, entrepreneurial returns might be ignored in surveys focusing on wages as returns to education. The few existing analyses of entrepreneurial education document substantially higher returns to education for managers than for workers (Parker and van Praag 2006; van Praag, van Witteloostuijn, and van der Sluis 2009).[27] The high returns to entrepreneurial education, compared to the relatively low returns to worker education, might explain the difficulty encountered by the development accounting literature when trying to use human capital to explain productivity differences across space (Caselli 2005; Hsieh and Klenow 2010). Individuals selected into entrepreneurship appear to have vastly more human capital than workers, driving up productivity. Of course, entrepreneurial talent may be more important than schooling in explaining this finding. Our analysis cannot address this issue (which would require better data and an endogenous determination of the connection between schooling and talent), but it still identifies a critical role of management and entrepreneurship in determining productivity.

The spatial differences in the stocks of human capital implied solely by returns to worker education are considerably lower than those implied by blended returns of workers and entrepreneurs. The average population-wide Mincerian return $\overline{\mu}$ of 20% is in fact substantially above the return to workers and lies in between our estimates of workers' and entrepreneurs' values.[28]

27. Using U.S. and Dutch individual-level data, these studies find that one extra year of schooling increases entrepreneurial income by 18% and 14%, respectively. This is much higher than the 3% found in our firm-level data (in our model entrepreneurial income is a constant share of a firm's output), implying gigantic Mincerian returns under an entrepreneurial share of .1. Note, however, that these studies rely on small start-ups (in the Dutch data) or on self-employed individuals (in the U.S. data). In both cases, the entrepreneurial share is likely to be higher than .1, moving Mincerian returns closer to our benchmark of 25%. Millan et al. (2011) also find a complementarity between entrepreneurial return and education in a locality where entrepreneurs operate.

28. Although we lack direct data on the number of entrepreneurs in the economy, we can make a back-of-the-envelope calculation to assess whether our firm-level evidence is consistent with a population-wide 20% Mincerian return. If (a) an average entrepreneur is as educated as the entrepreneurs in the enterprise survey on average, that is, has 14 years of schooling; and (b) an average worker in the economy is as educated as the average worker in the sample, that is, has roughly 7 years of schooling, then to obtain an average population-wide Mincerian return of 20% entrepreneurs need to account for 10.14% of the workforce. Formally, the fraction of entrepreneurs f solves the equation: $\exp[0.2^*(14^*f + 7^*(1-f))] = f^* \exp(14^*.25) + (1-f)^* \exp(7^*.055)$.

Now consider the role of externalities. The education externality parameter ψ we use is 7.25, although recall that Levinsohn-Petrin estimate is 0. This implies that a given increase in regional human capital generates 7.25 times more externalities if it is due to an increase in the average amount of human capital than to a larger number of people with average education. These estimates imply that raising the educational level from the sample mean of 6.58 years by 1 year increases regional TFP by about 7.5%. The magnitude of human capital externalities has been heavily discussed in the literature. As Lange and Topel (2006) indicate in their survey, the results have been fairly diverse. For instance, Caselli (2005) and Ciccone and Peri (2006) find externalities to be unimportant. Rauch (1993) estimates a 3%–5% effect, somewhat lower than our estimate. Acemoglu and Angrist (2000) estimate that a one-year increase in average schooling is associated with a 1%–3% increase in average wages. Moretti (2004) examines the impact of spillovers associated with the share of college graduates living in a city and finds that a 1% increase in the share of college graduates in the population leads to an increase in output of roughly half a percentage point. By way of comparison, under our variable definitions, a 1% increase in the share of college graduates in the population is associated with (at most) an additional 0.16 year of education and thus with a 1.2% (= 0.16×0.075) increase in regional TFP. Iranzo and Peri (2009) estimate that one extra year of college per worker increase the state's TFP by a very significant and large 6%–9%, whereas the effect of an extra year of high school is closer to 0%–1%. These estimates suggest a potentially sizable effect of schooling for productivity via social interactions or R&D spillovers, consistent with Lucas (1988, 2009) as well as with the literature in urban economics (e.g., Glaeser and Mare 2001; Glaeser and Gottlieb 2009). Externalities (whose empirical identification is admittedly much harder) may also improve the explanatory power of human capital, although we will show that they only help a lot when entrepreneurial returns are high.

We now assess the explanatory power of entrepreneurial inputs and externalities by using our parameter estimates to perform a standard development accounting exercise. To do so, define a factor-based model of national income as $\hat{Y} = E(h)^{\psi\gamma} L^{\gamma} H^{1-\beta-\delta} K^{\delta+\beta}$, which is national income predicted by our model when (a) all regions in a country are identical and all countries are equally productive, and (b) in line with standard development accounting we consider only physical and human capital, thereby attributing land rents to physical capital. This model with no regional mobility provides a benchmark to assess the role of physical and human capital when productivity differences are absent. Following Caselli (2005), one measure of the success of the model in explaining cross-country income differences is

$$success = \frac{\mathrm{var}(\log(\hat{Y}))}{\mathrm{var}(\log(Y))},$$

where Y is observed GDP per worker. Using Caselli's data set, the observed variance of (log) GDP per worker is 1.32. Ignoring human capital externalities (i.e., assuming $\psi = \gamma = 0$) and using the standard 8% average Mincerian return on human capital for both workers and entrepreneurs (i.e., setting $\overline{\mu} = 8\%$), the variance of $\log(\hat{Y})$ equals 0.76, that is, physical and human capital explain 57% ($\frac{0.76}{1.32}$) of the observed variation in income per worker. This calculation reproduces the standard finding that under standard Mincerian returns, a big chunk of the cross country income variation is accounted for by the productivity residual.

To isolate the role of entrepreneurial capital, we compute $\hat{Y}$ assuming no human capital externalities (i.e., $\psi = \gamma = 0$) while still keeping a population-wide Mincerian return $\overline{\mu}$ of 20%, consistent with our firm-level estimates. It is not surprising that average Mincerian returns of about 20% greatly improve the explanatory power of human capital. Indeed, under this assumption *success* rises to 81%. This improvement is solely due to accounting for managerial schooling. We note that this result is quite sensitive to our assumption of labor share of 55%. If the labor share were lower, the residual income share allocated to entrepreneurial rents would be correspondingly higher. This would reduce our estimate of the returns to entrepreneurial education, and therefore of average Mincerian returns. Finally, to assess the incremental explanatory power of human capital externalities, we compute $\hat{Y}$ assuming our estimated values (i.e., $\psi = 7.25$ and $\gamma = .05$), while retaining the assumption that the average Mincerian return equals 20%. Under these new assumptions,

TABLE VII
CALIBRATION EXERCISE

Panel A: $(1-(\alpha+\beta+\delta)) * \mu_E = 0.030$ and $\alpha * \mu_W = 0.030$

α	50.0%	51.0%	52.0%	53.0%	54.0%	55.0%	56.0%	57.0%	58.0%	59.0%	60.0%
μ_E	20%	21%	23%	25%	27%	30%	33%	38%	43%	50%	60%
μ_W	6.0%	5.9%	5.8%	5.7%	5.6%	5.5%	5.4%	5.3%	5.2%	5.1%	5.0%
μ_{avg}	11%	12%	13%	15%	18%	21%	26%	33%	42%	55%	74%
$\frac{\text{Wage entrepreneur}}{\text{wage worker}}$	10.8	13.3	16.9	22.3	30.9	45.5	73.1	131.8	280.9	768.2	3133.8
Without externalities											
$\sigma^2_{\hat{Y}}$	0.83	0.85	0.87	0.93	0.98	1.10	1.23	1.48	1.84	2.46	3.57
σ^2_{Y}	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
$\frac{\sigma^2_{\hat{Y}}}{\sigma^2_{Y}}$	62%	64%	66%	70%	74%	83%	93%	112%	139%	186%	269%
With externalities											
$\sigma^2_{\hat{Y}}$	0.91	0.95	1.00	1.09	1.20	1.42	1.67	2.17	2.93	4.24	6.63
σ^2_{Y}	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
$\frac{\sigma^2_{\hat{Y}}}{\sigma^2_{Y}}$	69%	72%	75%	83%	91%	108%	127%	164%	221%	320%	501%

TABLE VII

(CONTINUED)

Panel B: $(1-(\alpha+\beta+\delta)) * \mu_E = 0.020$ and $\alpha * \mu_W = 0.020$

α	50.0%	51.0%	52.0%	53.0%	54.0%	55.0%	56.0%	57.0%	58.0%	59.0%	60.0%
μ_E	13%	14%	15%	17%	18%	20%	22%	25%	29%	33%	40%
μ_W	4.0%	3.9%	3.8%	3.8%	3.7%	3.6%	3.6%	3.5%	3.4%	3.4%	3.3%
μ_{avg}	6%	7%	7%	8%	9%	10%	12%	14%	19%	26%	37%
$\frac{\text{Wage entrepreneur}}{\text{wage worker}}$	4.9	5.6	6.6	7.9	9.8	12.7	17.5	25.9	42.9	83.9	214.1
Without externalities											
$\sigma^2_{\hat{Y}}$	0.71	0.71	0.73	0.73	0.76	0.78	0.83	0.90	1.01	1.23	1.63
σ^2_{Y}	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
$\frac{\sigma^2_{\hat{Y}}}{\sigma^2_{Y}}$	54%	54%	55%	55%	57%	59%	62%	68%	76%	93%	123%
With externalities											
$\sigma^2_{\hat{Y}}$	0.71	0.71	0.74	0.74	0.78	0.82	0.91	1.05	1.25	1.67	2.49
σ^2_{Y}	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
$\frac{\sigma^2_{\hat{Y}}}{\sigma^2_{Y}}$	53%	53%	56%	56%	59%	62%	69%	79%	95%	127%	188%

Notes. We let the labor share α take values between 50% and 60%. We set $(1-(\alpha+\beta+\delta))*\mu E$ and $\alpha*\mu W$ equal to 0.03 in Panel A and to 0.02 in Panel B. We report the fraction of the variance of income per capita explained by the model both without externalities ($\psi=\gamma=0$) and with them ($\psi=7.25$ and $\gamma=0.05$).

the model generates too much productivity variation, and s*uccess* rises to 103%.

Table VII presents sensitivity results for the calibration exercise in this section. We focus on the predictions of the model when the labor share ranges between 50% and 60% while keeping the capital share $\beta + \delta$ constant at 35%, that is, increases in the labor share of workers are offset by reductions in the labor share of entrepreneurs. Panel A presents results under the assumption that both $(1 - \alpha - \beta - \delta)\ \overline{\mu}_E$ and $\alpha\ \overline{\mu}_W$ equal to 0.03, whereas Panel B presents results under the assumption that they equal 0.02. In both panels, we assume that entrepreneurs are 5% of the workforce and have 14 years of education and workers have 7 years. We continue to use $\gamma = .05$, $\psi = 7.25$, $\beta = .03$, and $\delta = .32$. Table VII shows that the average Mincerian return increases sharply with α. As α rises from 50% to 60%, the average Mincerian return rises from 11% to 74% in Panel A (i.e., when $\alpha\ \overline{\mu}_W = .03$) and from 6% to 37% in Panel B (i.e., when $\alpha\ \overline{\mu}_W = .02$). These changes in Mincerian returns take place because $\overline{\mu}_E$ compounds during 14 years and it triples as the labor share rises from 50 to 60, while $\overline{\mu}_W$ compounds for 7 years and falls modestly (from 6% to 5% in Panel A and from 4% to 3.3% in Panel B).

It is clear from Table VII that $\overline{\mu}_E$ needs to be high (i.e., in excess of 25%) for our model to add meaningful explanatory power beyond that of models that do not account for entrepreneurial inputs. Externalities play second fiddle; they have a minor impact on the success ratio when $\overline{\mu}_E$ is low and, conversely, they only come into play when $\overline{\mu}_E$ is high. This raises the question of how plausible are high levels of $\overline{\mu}_E$. To assess this issue, Table VII reports the ratio of the entrepreneur-to-worker income for different Mincerian returns. When $\overline{\mu}_E$ is 25%, the entrepreneur-to-worker income ratio equals 22.3 in Panel A and 25.9 in Panel B. This ratio rises to 73.1 in Panel A and 83.9 in Panel B when $\overline{\mu}_E$ equals 33%. Such levels of income inequality seem plausible for developing countries (Towers and Perrin 2005). In contrast, income inequality is too low when $\overline{\mu}_E$ is 20% (i.e., 10.8× and 12.7×).

To appreciate the importance of entrepreneurial inputs in understanding cross-country income difference, compare Mozambique and the United States. Income per worker is roughly 33 times higher in the United States than in Mozambique

(\$57,259 versus \$1,752), while the stock of physical capital per capita is 185 times higher in the United States than in Mozambique (\$125,227 versus \$676). The average number of years of schooling for the population 15 years and older is 1.01 years in Mozambique and 12.69 years in the United States. These large differences in schooling imply that the (per capita) stock of human capital is 10.3 higher ($\frac{H_{US}}{H_{MOZ}}$. $= e^{.20*(12.69-1.01)}$) in the US than in Mozambique if the average Mincerian return is 20%. In contrast, the (per capita) stock of human capital is only 2.5 times higher ($\frac{H_{US}}{H_{DRC}} = e^{.08*(12.69-1.01)}$) in the United States than in Mozambique if the average Mincerian return is 8%. Using weights of $\frac{1}{3}$ and $\frac{2}{3}$ for physical and human capital, these differences in physical and human capital imply that income per capita should be 27 times higher in the United States than in Mozambique ($27 = 10.3^{\frac{2}{3}} \times 185^{\frac{1}{3}}$), which is much closer to the actual value of 33 times than the 10.6 multiple implied by 8% Mincerian return ($10.6 = 2.5^{\frac{2}{3}} \times 185^{\frac{1}{3}}$).

In sum, our firm-level and regional regressions suggest that (a) in line with the development accounting literature, workers' human capital is an important but not a large contributor to productivity differences; (b) entrepreneurial inputs are a fundamental and relatively neglected channel for understanding the role of schooling in shaping productivity differences; and (c) human capital externalities may magnify the impact of entrepreneurial inputs. Our parameter estimates point to very large returns to entrepreneurial schooling (perhaps due to entrepreneurs' general talent) and to large social returns to education at the regional level.

VII. Conclusion

Evidence from more than 1,500 subnational regions of the world suggests that regional education is a critical determinant of regional development, and the only such determinant that explains a substantial share of regional variation. Using data on several thousand firms located in these regions, we have also found that regional education influences regional development through education of workers, education of entrepreneurs, and perhaps regional externalities. The latter come primarily from the level of education (the quality of human capital) in a region, not from its total quantity (the number of people with some education).

A simple Cobb-Douglas production function specification used in development accounting would have difficulty accounting for all this evidence. As an alternative, we presented a Lucas-Lucas model of an economy, which combines the allocation of talent between work and entrepreneurship, human capital externalities, and migration of labor across regions within a country. The empirical findings we presented are consistent with the general predictions of this model and provide plausible values of the model's parameters. In addition, we follow Caselli (2005) in assessing the ability of the model to account for variation of output per worker across countries. The central message of the estimation/calibration exercise is that although private returns to worker education are modest and close to previous estimates, private returns to entrepreneurial education (in the form of profits), and possibly also social returns to education through external spillovers, are large. To the extent that earlier estimates of return to education have missed the benefits of educated managers/entrepreneurs, they may have underestimated the returns to education.

Our data point directly to the role of the supply of educated entrepreneurs for the creation and productivity of firms. From the point of view of development accounting, having such entrepreneurs seems more important than having educated workers. Consistent with earlier observations of Banerjee and Duflo (2005) and La Porta and Shleifer (2008), economic development occurs in regions that concentrate entrepreneurs, who run productive firms. These entrepreneurs may also contribute to the exchange of ideas, leading to significant regional externalities. The observed large benefits of education through the creation of a supply of entrepreneurs and through externalities offer an optimistic assessment of the possibilities of economic development through raising educational attainment.

Appendix A: Solution of the Model and Proof of Proposition 1

Given equation (6) for regional output, we can determine wages, profits, and capital rental rates as a function of regional factor supplies via the usual (private) marginal product pricing. That is:

$$w_i = \frac{\partial Y_i}{\partial H_i^W} = \alpha \cdot A_i \left(\frac{H_i^E}{H_i^W}\right)^{1-\alpha-\beta-\delta} \left(\frac{K_i}{H_i^W}\right)^{\delta} \left(\frac{T}{H_i^W}\right)^{\beta},$$

$$\pi_i = \frac{\partial Y_i}{\partial H_i^E} = (1-\alpha-\beta-\delta) \cdot A_i \left(\frac{H_i^W}{H_i^E}\right)^{\alpha} \left(\frac{K_i}{H_i^E}\right)^{\delta} \left(\frac{T}{H_i^E}\right)^{\beta},$$

$$\rho = \frac{\partial Y_i}{\partial K_i} = \delta \cdot A_i \left(\frac{H_i^E}{K_i}\right)^{1-\alpha-\beta-\delta} \left(\frac{H_i^W}{K_i}\right)^{\alpha} \left(\frac{T}{K_i}\right)^{\beta}.$$

Thus, profit $\pi_i(h)$ is equal to π_i (the marginal product of the entrepreneur's human capital in region i), times the entrepreneur's human capital h, namely, $\pi_i(h) = \pi_i \cdot h$.

By exploiting the breakdown of human capital into its different components in equation (7), one finds that ρ is constant across regions provided:

$$\frac{K_P}{K_U} = \left(\frac{A_P}{A_U}\right)^{\frac{1}{1-\delta}} \left(\frac{H_P}{H_U}\right)^{\frac{1-\beta-\delta}{1-\delta}}.$$

Using this condition and equation (3), it is easy to see that the relative wage is given by equation (9).

Consider now the determinant of spatial mobility. By equation (A.1), labor moves from unproductive to productive regions. Formally, equation (11) implies that an agent with human capital h_j migrates if $\frac{w_P^{1-\theta}(h_j-\varphi)}{H_P^{\theta}} \geq \frac{w_U^{1-\theta}h_j}{H_U^{\theta}}$, where φ captures migration costs. This identifies a human capital threshold h_m such that agent j migrates if and only if $h_j \geq h_m$. By exploiting the wage equation in (6) and the equilibrium condition (9), threshold h_m can be implicitly expressed as:

$$h_m \cdot \left[1 - \left(\frac{w_U}{w_P}\right)^{1-\theta} \left(\frac{H_P}{H_U}\right)^{\theta}\right] = \varphi. \quad \text{(A.1)}$$

To pin down the equilibrium, note that the aggregate resource constraint is given by:

$$pH_P + (1-p)H_U = \underline{H}. \quad \text{(A.2)}$$

After accounting for externalities, the equilibrium condition (A.1) can be written as:

$$h_m \cdot \left[1 - \left(\frac{A_U}{A_P}\right)^{\frac{1-\theta}{1-\delta}} \left(\frac{L_P}{L_U}\right)^{\gamma(\psi-1)\frac{1-\theta}{1-\delta}} \left(\frac{H_P}{H_U}\right)^{\frac{(\beta-\gamma\psi)(1-\theta)+(1-\delta)\theta}{1-\delta}}\right] = \varphi. \tag{A.3}$$

The previous migration-threshold implies that the human capital stock in each productive region is:

$$\begin{aligned} H_P &= \underline{H}_P + \frac{1-p}{p}\int_{h_m}^{+\infty} h \cdot (\mu_B \underline{h}^{\mu_B} h^{-\mu_B - 1}) \cdot dh \\ &= \underline{H}_P + \underline{H}_U \frac{1-p}{p}\left(\frac{h}{h_m}\right)^{\mu_B - 1}. \end{aligned} \tag{A.4}$$

Using equations (A.4) and (A.3), it is immediate to express h_m as a function of H_P and thus recover:

$$\frac{L_P}{L_U} = \frac{1 + \frac{p}{1-p} \cdot \left(\frac{H_P - \underline{H}_P}{\underline{H}_U} \cdot \frac{p}{1-p}\right)^{\frac{\mu_U}{\mu_U - 1}}}{1 - \left(\frac{H_P - \underline{H}_P}{\underline{H}_U} \cdot \frac{p}{1-p}\right)^{\frac{\mu_P}{\mu_P - 1}}}. \tag{A.5}$$

Under full mobility ($\varphi = 0$), using equation (A.3) one finds that the equilibrium is determined by the condition:

$$\left(\frac{A_P}{A_U}\right)^{\frac{1-\theta}{1-\delta}} \left[\frac{1 - \left(\frac{H_P - \underline{H}_P}{\underline{H}_U} \cdot \frac{p}{1-p}\right)^{\frac{\mu_U}{\mu_U - 1}}}{1 + \frac{p}{1-p} \cdot \left(\frac{H_P - \underline{H}_P}{\underline{H}_U} \cdot \frac{p}{1-p}\right)^{\frac{\mu_P}{\mu_P - 1}}}\right]^{\gamma(\psi-1)\frac{1-\theta}{1-\delta}} = \left[\frac{(1-p)H_P}{\underline{H} - pH_P}\right]^{\frac{(\beta-\gamma\psi)(1-\theta)+(1-\delta)\theta}{1-\delta}}. \tag{A.6}$$

The left side is decreasing in H_P. If $(\beta - \psi\gamma)(1-\theta) + \theta(1-\delta) > 0$, the right side—which captures the cost of migrating to productive regions—increases in H_P. As a result, when $(\beta - \psi\gamma)(1-\theta) + \theta(1-\delta) > 0$ even under full mobility in the stable equilibrium there is no universal migration to productive regions. Indeed, if all human capital moves to productive regions, then $H_P = \frac{\underline{H}}{p}$ and the right side of (A.6) becomes infinite. Full migration is not an equilibrium. No migration is not an equilibrium either, as in this case (A.1) implies that (A.10) cannot hold. When $\psi = 1$ (and $\varphi = 0$) the equilibrium has:

$$H_i = \frac{A_i^{\frac{1-\theta}{(\beta-\gamma)(1-\theta)+\theta(1-\delta)}}}{E\left[A^{\frac{1-\theta}{(\beta-\gamma)(1-\theta)+\theta(1-\delta)}}\right]} \cdot \underline{H}. \tag{A.7}$$

With imperfect mobility $\varphi > 0$, the equilibrium fulfills the condition:

$$\frac{\varphi}{\underline{h}}\left(\frac{p}{1-p}\right)^{\frac{1}{\mu-1}}\left(\frac{H_P-\underline{H}_P}{\underline{H}_U}\right)^{\frac{1}{\mu-1}} = 1$$

$$-\left(\frac{A_U}{A_P}\right)^{\frac{1-\theta}{1-\delta}}\left[\frac{1+\frac{p}{1-p}\left(\frac{H_P-\underline{H}_P}{\underline{H}_U}\cdot\frac{p}{1-p}\right)^{\frac{\mu_P}{\mu_P-1}}}{1-\cdot\left(\frac{H_P-\underline{H}_P}{\underline{H}_U}\cdot\frac{p}{1-p}\right)^{\frac{\mu_U}{\mu_U-1}}}\right]^{\gamma(\psi-1)\frac{1-\theta}{1-\delta}}\left[\frac{(1-p)H_P}{\underline{H}-pH_P}\right]^{\frac{(\beta-\gamma\psi)(1-\theta)+(1-\delta)\theta}{1-\delta}}.$$

When $(\beta - \psi\gamma)(1-\theta) + \theta(1-\delta) > 0$, an increase in $\underline{H}_P$ (holding $\underline{H}$ constant) shifts down the left side and shifts up the right side above. As a result, the equilibrium is unique.

APPENDIX B

Variables, Descriptions, and Sources

Variable	Description
Panel A: GDP per capita, population, employment, and human capital	
Income per capita	Income per capita in PPP constant 2005 international dollars in the region in 2005. We use GDP as a measure of income for all countries except 20. For those 20 countries, we use data on income (6 countries), expenditure (8 countries), wages (3 countries), gross value added (2 countries), and consumption, investment, and government expenditure (1 country). For each country, we scale regional income per capita values so that their population-weighted sum equals the World Development Indicators (WDI) value of GDP in PPP-constant 2005 international dollars. Similarly, for each country, we adjust the regional population values so that their sum equals the country-level analog in WDI. For years with missing regional income per capita data, we interpolate using all available data for the period 1990–2008. When interpolating income values is not possible, we use the regional distribution of the closest year with regional income data. Population data for years without census data are interpolated and extrapolated from the available census data for the period 1990–2008. At the country level, we calculate this variable as the population-weighted average of regional income. Sources: (a) *Regional Income*: see Online Appendix, “Appendix GDP Sources”; (b) “Regional population: City Population”, http://www.citypopulation.de/; (c) *Country-level GDP per capita and PPP exchange rates*: World Bank (2010). Data retrieved on March 2, 2010, from World Development Indicators Online (WDI) database, http://go.worldbank.org/6HAYAHG8H0

APPENDIX B

(CONTINUED)

Variable	Description
Years of education	The average years of schooling from primary school onward for the population aged 15 years or older. Data for China and Georgia is for the population 6 years and older. We use the most recent information available for the period 1990–2006. To make levels of educational attainment comparable across countries, we translate educational statistics into the International Standard Classification of Education (ISCED) standard and use UNESCO data on the duration of school levels in each country for the year for which we have educational attainment data. Eurostat aggregates data for ISCED levels 0–2 and we assign such observations an ISCED level 1. Following Barro and Lee (1993): (1) we assign 0 years of schooling to ISCED level 0 (i.e., preprimary); (2) we assign 0 years of *additional* schooling to (a) ISCED level 4 (i.e., vocational), and (b) ISCED level 6 (i.e., postgraduate); and (3) we assign 4 years of additional schooling to ISCED level 5 (i.e., graduate). Since regional data are not available for all countries, unlike Barro and Lee (1993), we assign 0 years of *additional* schooling: (a) to all incomplete levels; and (b) to ISCED level 2 (i.e., lower secondary). Thus, the average years of schooling in a region is calculated as (1) the product of the fraction of people whose highest attainment level is ISCED 1 or 2 and the duration of ISCED 1; plus (2) the product of the fraction of people whose highest attainment level is ISCED 3 or 4 and the cumulative duration of ISCED 3; plus (3) the product of the fraction of people whose highest attainment level is ISCED 5 or 6 and the sum of the cumulative duration of ISCED 3 plus 4 years. At the country level, we calculate this variable as the population-weighted average of the regional values. Source: See Online Appendix, "Appendix on Education Sources."
Share pop with high school degree	Share of the population aged 15 years or older whose highest educational level is ISCED 3 or 4. Source: See "Years of education" above.
Share pop with college degree	Share of the population aged 15 years or older whose highest educational level is ISCED 5 or 6. Source: See "Years of education" above.
Years of education 65+	The average years of schooling from primary school onward for the population over 65 years old. To compute this variable, we follow the procedure used for the previously described years of education variable. Source: https://international.ipums.org/international/.
Ln(population)	The log of the number of inhabitants in the region in 2005. Population data for years without census data is interpolated and extrapolated from the available census data for the period 1990–2008. For each country, we adjust the regional populations so that the sum of regional populations equals the country-level analog in WDI. At the country level, we calculate this variable following the same methodology but using country boundaries. Sources: http://www.citypopulation.de/ and Collins-Bartholomew World Digital Map.
% Directors and officers in workforce	Percentage of the economically active population aged 15–65 that most closely matches the employment category of company officers and general directors in the most recent population census. Source: https://international.ipums.org/international/.
% Directors and officers with a college degree	Percentage of the economically active population aged 15–65 with a college degree that most closely matches the employment category of company officers and general directors in the most recent population census. Source: https://international.ipums.org/international/.
% Employers in the workforce	Percentage of the economically active population aged 15–65 classified as employers in the most recent population census. Source: https://international.ipums.org/international/.

APPENDIX B

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Variable	Description
Panel B: Climate, geography, and natural resources	
Temperature	Average temperature during the period 1950–2000 in degrees Celsius. To produce the regional and national numbers, we create equal area projections using the Collins-Bartholomew World Digital Map and the temperature raster in ArcGIS. For each region, we sum the temperatures of all cells in that region and divide by the number of cells in that region. At the country level, we calculate this variable following the same methodology but using country boundaries. Sources: Hijmans (2005) and Collins-Bartholomew World Digital Map.
Inverse distance to coast	The ratio of 1 over 1 plus the region's average distance to the nearest coastline in thousands of kilometers. To calculate each region's average distance to the nearest coastline we create an equal distance projection of the Collins-Bartholomew World Digital Map and a map of the coastlines. Using these two maps we create a raster with the distance to the nearest coastline of each cell in a given region. Finally, to get the average distance to the nearest coastline, we sum the distance to the nearest coastline of all cells within each region and divide that sum by the number of cells in the region. At the country level, we calculate this variable following the same methodology but using country boundaries. Sources: Collins-Bartholomew World Digital Map.
Ln(oil production per capita)	Log of 1 plus the estimated per capita volume of cumulative oil production and reserves by region, in millions of barrels of oil. To produce the regional measure, we load the oil map of the World Petroleum Assessment and the Collins-Bartholomew World Digital map onto ArcGIS. On-shore estimated oil in each assessment unit was allocated to the regions based on the fraction of assessment unit area covered by each region. Off-shore assessment units are not included. The World Petroleum Assessment map includes all oil fields in the world except those in the United States. Data for the United States are calculated using the national-level information on cumulative production and estimated reserves, available from the World Petroleum Assessment 2000 (USGS), and the United States regional production and estimated reserves for 2000 from the U.S. Energy Information Administration (USEIA). The national level data for this variable are calculated following the same methodology outlined but using the data on national boundaries. The national level numbers for the United States are those available from the World Petroleum Assessment. Sources: Collins-Bartholomew World Digital Map; http://energy.cr.usgs.gov/oilgas/wep/products/dds60/export.htm and http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm.
Panel C: Institutions	
Informal payments	The average percentage of sales spent on informal payments made to public officials to "get things done" with regard to customs, taxes, licenses, regulations, services, etc., reported by the respondents in the region. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are from the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Ln(tax days)	The logarithm of one plus the average number of days spent in mandatory meetings and inspections with tax authority officials in the past year reported by respondents in the region. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are for the most recent year

APPENDIX B

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Variable	Description
	available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Ln(days without electricity)	The log of 1 plus the average number of days without electricity in the past year reported by the respondents in the region. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are for the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Security costs	The average cost of security (i.e., equipment, personnel, and professional security services) as a percentage of sales as reported by the respondents in the region. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are for the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Access to land	The percentage of respondents in the region who think that access to land is a moderate, major, or very severe obstacle to business. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are for the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Access to finance	The percentage of respondents in the region who think that access to financing is a moderate, major, or very severe obstacle to business. The country-level analog of this variable is the arithmetic average of the regions in each respective country. Data are for the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Government predictability	The percentage of respondents in the region who tend to agree, agree in most cases, or fully agree that their government officials' interpretation of regulations are consistent and predictable. The country-level analog of this variable is the arithmetic average of the regions in the country. Data are for the most recent year available, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Doing Business percentile rank	The average of the percentile ranks in each of the following five areas: (1) starting a business; (2) dealing with construction permits; (3) registering property; (4) enforcing contracts; and (5) paying taxes. Higher values indicate more burdensome regulation. Data are for the most recent year available, ranging from 2007 through 2010. Source: http://www.doingbusiness.org/reports/subnational-reports.
Institutional quality	Latent variable of: (1) (minus) Informal payments, (2) (minus) Ln(tax days), (3) (minus) Ln(days without electricity), (4) (minus) Security costs, (5) (minus) Access to land, (6) (minus) Access to finance, (7) Government predictability, and (8) (minus) *Doing Business* percentile rank. Higher values indicate better institutions. Source: Own calculations based on World Bank's Enterprise Surveys.
Expropriation risk	Risk of "outright confiscation and forced nationalization" of property. This variable ranges from 0 to 10 where higher values indicate a lower probability of expropriation. This variable is calculated as the average from 1982 through 1997. Source: International Country Risk Guide.
Panel D: Culture	
Trust in others	The percentage of respondents in the region who believe that most people can generally be trusted. The country-level analog of this variable is the arithmetic average of the regions in the country. Data is for the most recent available year, ranging from 1980 through 2005. Source: World Values Survey

APPENDIX B

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Variable	Description
Ln(no. ethnic groups)	The log of the number of ethnic groups that inhabited the region in 1964. The country-level analog of this variable is constructed using country boundaries. Source: Weidmann et al. (2010), http://www.icr.ethz.ch/data/other/greg.
Panel E: Enterprise survey data	
Ln(sales – raw materials – energy)	The log of the establishment's sales minus expenditure on raw materials and energy (in current PPP dollars). Data are for the last complete fiscal year, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Ln(expenditure on energy)	The log of the establishment's expenditure on energy (in current PPP dollars). Data are for the last complete fiscal year, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Years of education of manager	The number of years of schooling from primary school onward of the current top manager of the establishment. To compute this variable, we use data on the highest educational attainment of the top manager and follow the same procedure as used for the previously described years of schooling variable at the regional level. Source: World Bank's Enterprise Surveys.
Years of education of workers	The number of years of schooling of a typical production worker employed in the establishment. Respondents answers may take the following values: (a) 0–3 years, (b) 4–6 years, (c) 7–9 years, (d) 10–12 years, (e) 13 years and above. To compute this variable, we use the midpoint of each range or 13 years as appropriate. Source: World Bank's Enterprise Surveys.
Ln(1 + employees)	The log of 1 plus the total number of employees in the establishment. Data are for the last complete fiscal year, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Ln(property, plant, and equipment)	The log of the establishment's book value of property, plant, and equipment (in current PPP dollars). Data are for the last complete fiscal year, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Ln(1 + firm age)	The log of 1 plus the number of years that the establishment had been operating in the country at the time of the survey, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Multiple establishments	Equal to 1 if either the establishment was part of a larger firm or the firm had more than one establishment at the time of the survey; equals 0 otherwise. Source: World Bank's Enterprise Surveys.
Percent export	Percentage of the establishment's sales that were directly or indirectly exported. Data are for the last complete fiscal year, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.
Percent equity owned by foreigners	Percent of the firm's equity owned by private foreign individuals, companies, or organizations at the time of the survey, ranging from 2002 through 2009. Source: World Bank's Enterprise Surveys.

SUPPLEMENTARY MATERIAL

An Online Appendix for this article can be found at QJE online (qje.oxfordjournals.org).

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