Economic Development and the Organization of Production

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Motivation

- Explaining the disparity in income per capita across countries is an important question
- Growing literature looks at the contribution of the allocation of resources, physical capital and human capital, across firms within a country
  (Banerjee and Duflo, 2005; Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009)

Motivation

- in most countries, larger firms have persistently higher average products of labor and capital
- developing countries are characterized by a large number of less productive, smaller firms and a general lack of firm growth
- higher dispersion of factor inputs productivity in poorer countries

What is the role of the acquisition of human capital?

What is the role of worker and manager skills?

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What is the role of worker and manager skills?

Misallocation

Dispersion of factor inputs productivity has been interpreted as misallocation by Hsieh and Klenow (2009).
Possible Sources:

- physical capital and finance: Buera, Kaboski and Shin (2010), Xu and Midrigran (2013), ...
- labor market regulations: Hopenhayn and Rogerson (1993), ...
- size-dependent policies: Guner, Ventura and Xu (2008), ...
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We propose a model without misallocation where human capital and sorting endogenously lead to

1. dispersion in firm productivity and labor productivity
2. richer countries having lower dispersion of TFP and labor productivity across firms

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Motivation

This paper considers how the accumulation and allocation of human capital and worker quality affect firm-level and cross-countries outcomes.

- Lucas (1978) occupational choice model (worker/manager)

with two extensions:

1. deviation from efficiency units - Garicano and Rossi-Hansberg (2006)
2. endogenous distribution of human capital - Ben-Porath (1967)

Quantitative Exercise

- calibration of the model to the U.S economy
- vary aggregate efficiency across countries
- look at the implications for the organization of production within and across countries

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Preview of the Results

- Labor Productivity is not equalized across firms due to differences in worker quality

A higher aggregate efficiency of the economy affects the organization of production:

- lower dispersion in TFP and labor productivity across firms
- larger firms
- lower fraction of managers
- higher firm growth

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Some Related Literature

- Misallocation: Banerjee and Duflo (2005), Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Buera, Kaboski and Shin (2011), Midrigan and Xu (2013), ...
- Sorting: Becker (1963), Sattinger (1975), Kremer (1993), Garicano (2000), Garicano and Rossi-Hansberg (2006), Eeckhout and Kircher (2012), ...
- Firm Size and Development: Lucas (1978), Tybout (2000), Gollin (2007), Alfaro, Charlton and Kanczuk (2008), Hsieh and Klenow (2012), Poschke (2014), ...
- Managerial Talent: Bloom and Van Reenen (2007, 2012, 2013), Bhattacharya et al. (2013), ...
- Human Capital and Development: Caselli (2005), Manuelli and Seshadri (2010), Erosa, Koreshkova, Restuccia (2010), Gennaioli et al. (2013), ...

Model Overview

Heterogeneous agents, overlapping generations economy with

- Knowledge Hierarchy (Garicano 2000, Garicano and Rossi-Hansberg 2006)
- Human Capital Accumulation (Ben-Porath 1967)
- Occupational Choice: Workers or Managers (Lucas 1978)

Model: Production

A firm consists of a manager $\theta_m = (h_m, n_m)$ and l_s workers $\theta_w = (h_w, n_w)$. Production involves problem solving.

- agent with human capital h can solve a fraction $G(h)$ of the problems that he draws where G is a cdf.
- Workers
  - draw n_w problems
  - solve $G(h_w) n_w$ problems
- Manager
  - workers communicate problems they can't solve to the manager
  - communication cost per problem in unit of time $c > 0$

Model: Production

Size of the firm l_s is constrained by manager time:

$$c\left(1 - G\left(h_w\right)\right) n_w l_s = n_m$$

then

$$l_s = \frac{n_m}{c\left(1 - G\left(h_w\right)\right) n_w}$$

$$\text{Problems Solved} = G\left(h_m\right) n_w l_s$$

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  - firm size l_s increases with worker skills h_w

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- Manager endows his workers with his human capital h_m

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- Endogenous span of control
  - firm size l_s increases with worker skills h_w
- Manager endows his workers with his human capital
- Complementarities lead to positive sorting
  - more skilled managers have larger teams of more skilled employees
- Larger firms are more productive

Human Capital Accumulation

- Overlapping Generations, individuals have finite life: $t = 1, \ldots, T$.

Human capital production function

$$h_{t+1} = s^j \left((1 - n_t) h_t\right)^{\gamma_1} x^{\gamma_2} + (1 - \delta) h_t, 1 < t \leq T - 1$$

where

- h - stock of human capital, initial human capital distribution is given by F_{h_1}
- $n \in [0, 1]$ - allocation of time
- $s^j, j = 1, \ldots J$ - heterogeneous ability to learn
- x: intermediate inputs

Interpretation:

- $n = 0$ - schooling
- $n \in (0, 1)$ - on-the-job training

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Manager Problem

Manager decides workers' type h_w, raw labor l_u, physical capital k, how to allocate his time n_m, intermediate inputs x_m, and

$$\begin{aligned} V_{it}^{m}(h_m) = \max_{n_m, x_m, h_w, l_u, k} \Bigg(& z\left(\frac{G(h_m)n_m}{c\,(1-G(h_w))}\right)^{\alpha\theta} l_u^{(1-\alpha)\theta} k^{1-\theta} \\ & - w(h_w)\frac{n_m}{c\,(1-G(h_w))} - w_u l_u - p_k(r+\delta_k)k - p\cdot x_m \\ & + \beta W_{it+1}\left(s^i\left((1-n_m)h_m\right)^{\gamma_1} x_m^{\gamma_2} + (1-\delta)\,h_m\right)\Bigg) \end{aligned}$$

FOC wrt h_w:

$$w'(h_w) = g(h_w)\frac{A\,G(h_m) - w\,(h_w)}{1-G(h_w)}$$

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Worker Problem

Worker decides how to allocate his time n_w and intermediate inputs x_w

$$V_{it}^{w}(h_w) = \max_{n_w, x_w} \Bigg(n_w w(h_w) - p \cdot x_w + \beta W_{it+1} \left(s^i \left((1 - n_w) h_w \right)^{\gamma_1} x_w^{\gamma_2} + (1 - \delta) h_w \right) \Bigg)$$

Occupational Choice

An individual chooses the occupation that gives him the highest utility

$$W_{it}(h) = \max\left\{V_{it}^{w}(h), V_{it}^{m}(h)\right\}, 0 < t \leq T$$

The occupational choice is static

$$\max\left\{\frac{A\,G(h) - w\,(h_w)}{c\,(1 - G(h_w))}, w(h)\right\}$$

- h^*: threshold below which an individual becomes a worker
- $\tilde{h}$: threshold below which an individual supplies raw-labor

Labor Market Equilibrium

Competitive labor markets where workers and managers re-match every period (no-long term contracts)

- $m(h_w) = h_m$: allocation of workers to managers

$$m'(h) = c(1 - G(h)) \frac{\sum_{i=1}^{J} \sum_{\tau=1}^{T} f_h^{\tau i}(h) \times n_{w\tau i}(h)}{\sum_{j=1}^{J} \sum_{t=1}^{T} f_h^{tj}(m(h)) \times n_{mtj}(m(h))}$$

Two boundary conditions:

$$\begin{aligned} m(\tilde{h}) &= h^* \\ m(h^*) &= \overline{h} \end{aligned}$$

Equilibrium

Definition

An equilibrium is characterized by

1. $h^*, \tilde{h}$: occupational choice
2. $n_{wtj}, x_{wtj}, n_{mtj}, x_{mtj}, l_s, l_u, k$: policy functions
3. f_h^{tj}: distribution of human capital
4. m: matching function
5. w: wage function

Numerical Solution:

- Given policy functions, solve the allocation m and prices w
- Given allocation m and prices w, solve the policy function n_w, n_m, x_w, x_m, h^*

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Model: Equilibrium

Proposition

If the working time-weighted distribution of human capital is absolutely continuous and compact-valued and if an assignment function m exists, there exists $\tilde{c}$ such that if $c < \tilde{c}$,

1. *equilibrium features positive sorting: $h_m = m(h_w)$ with $m' > 0$.*
2. *the set of managers and the set of workers is connected*

- sorting is based on h_w and h_m only at the equilibrium
- Manager (h_m, n_m) will be matched with worker of type (h_w, n_w) independently of (n_w, n_m)

Calibration to the US Economy

Moments	Data	Model
Gini coefficient of lifetime earnings	0.3	0.3
Average years of schooling	12.5	12.6
Schooling expenditures	4.2	4.1
Wage Rate at Age 55/ Wage rate at age 25	1.9	1.7
Average plant size	10.7	11.2
Entrepreneurship rate	7.7	7.9
Average Plant Size at age 40 / Age 5	4	4.1
Firm-Size - Wage Premium	0.04	0.05

Table : Data Moments

c	λ	α	μ_s	σ_s	σ_h	γ_1	γ_2
0.82	0.06	0.75	-2.07	1.14	2.46	0.54	0.39

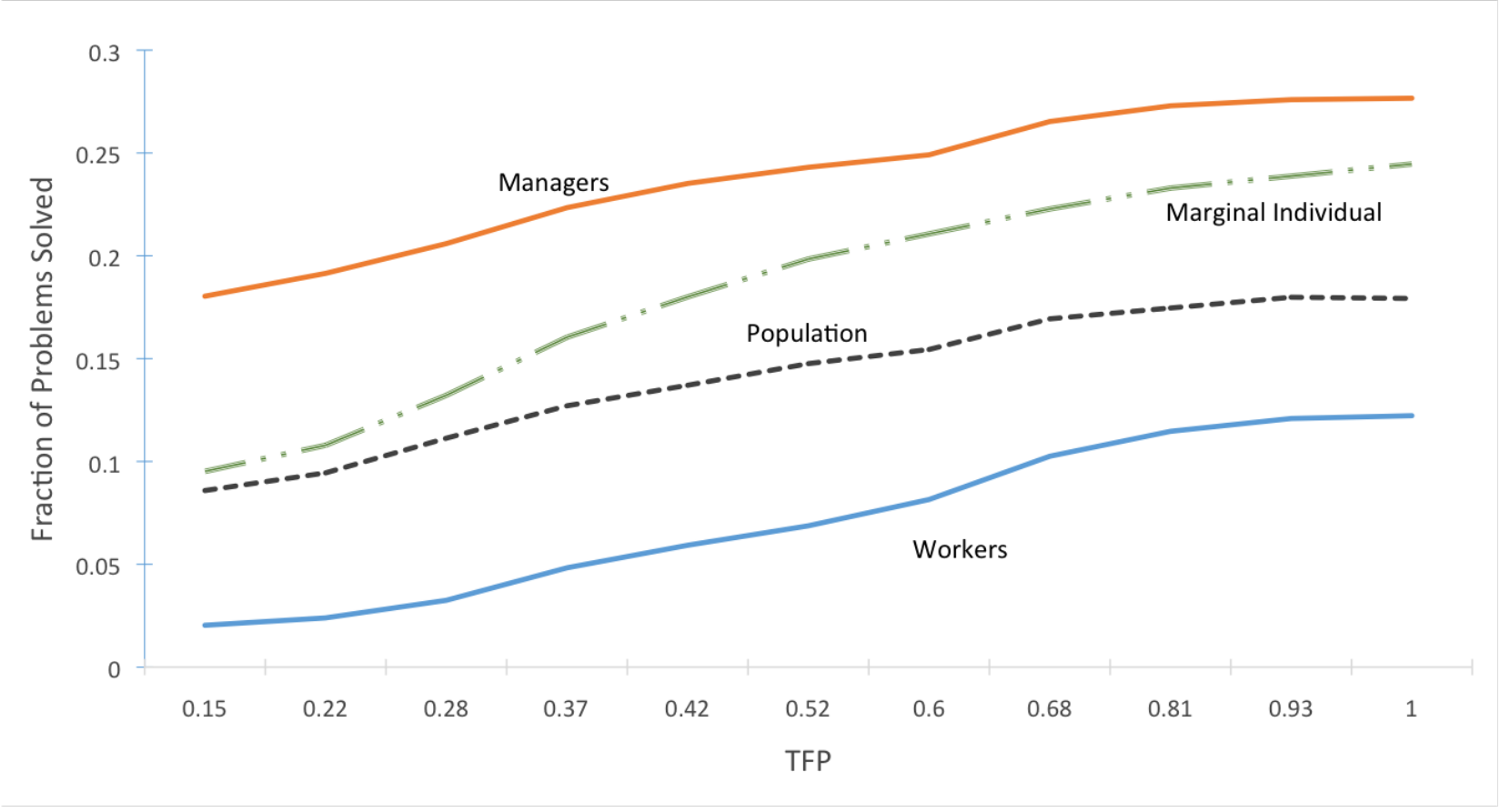
Table : Parameters

$$G(h) = 1 - e^{-\lambda h}; \log h_1 \sim \mathcal{N}(\mu_h, \sigma_h); \log s \sim \mathcal{N}(\mu_s, \sigma_s) \text{ (truncated)}$$

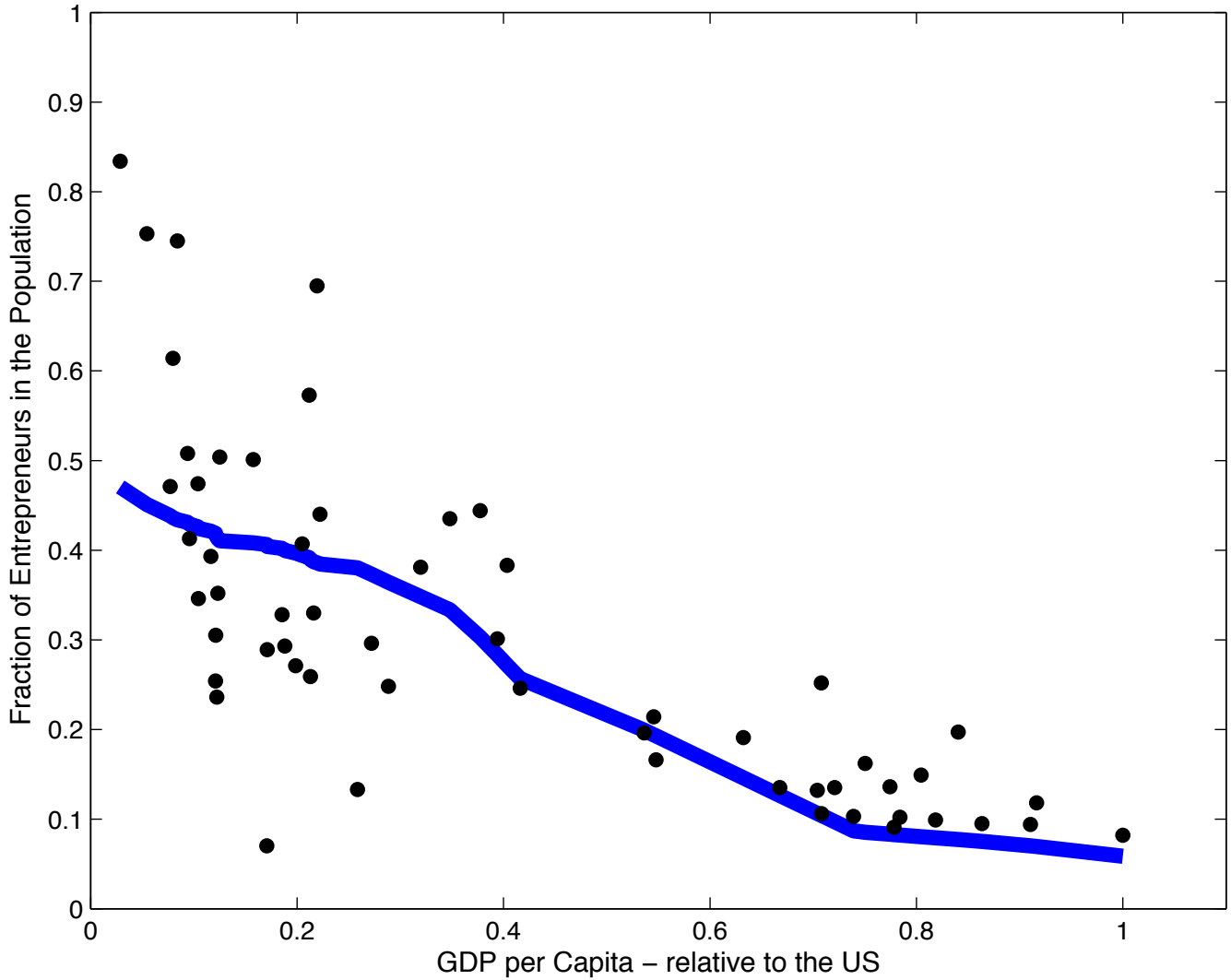
Cross-Countries Differences in GDP and TFP

Decile	GDP	Lifespan	Fertility	p_k	TFP
US	1	77	2.07	1.00	1
90-100	0.87	80	1.65	1.00	0.93
80-90	0.74	79	1.87	0.97	0.81
70-80	0.51	76	1.45	1.14	0.68
60-70	0.35	74	1.91	1.23	0.60
50-60	0.25	70	1.87	1.35	0.52
40-50	0.19	71	2.41	1.10	0.42
30-40	0.12	66	2.69	1.47	0.37
20-30	0.08	62	3.58	1.44	0.28
20-10	0.04	54	4.44	1.34	0.22
0-10	0.02	53	4.79	1.22	0.15

Human Capital and TFP

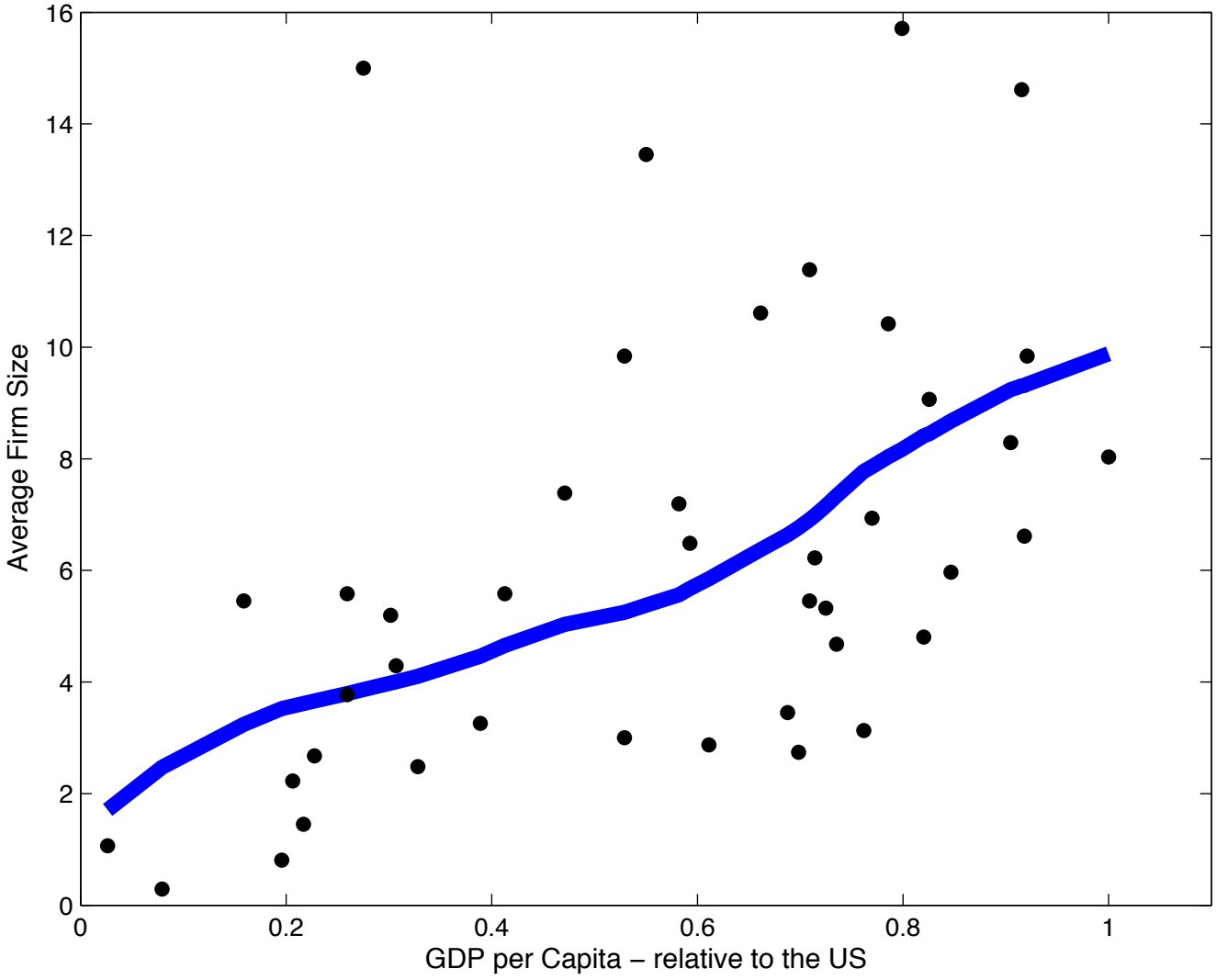


Fraction of Entrepreneurs and TFP



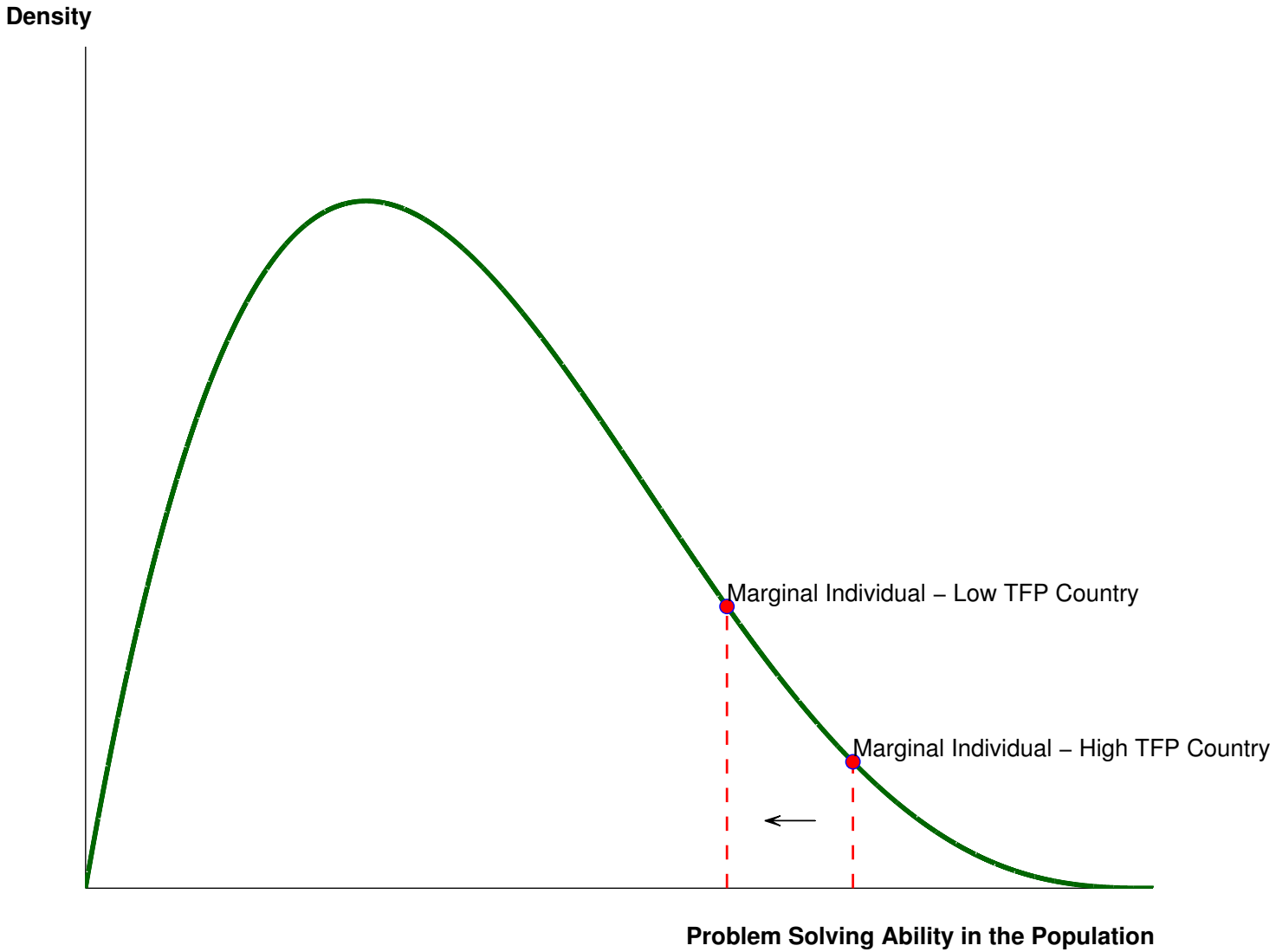
Source: International Labor Organization

Average Firm Size and TFP



Source: The Global Entrepreneurship Monitor (GEM) survey- Poschke (2013)

Dispersion in Firms TFP: Selection Effect



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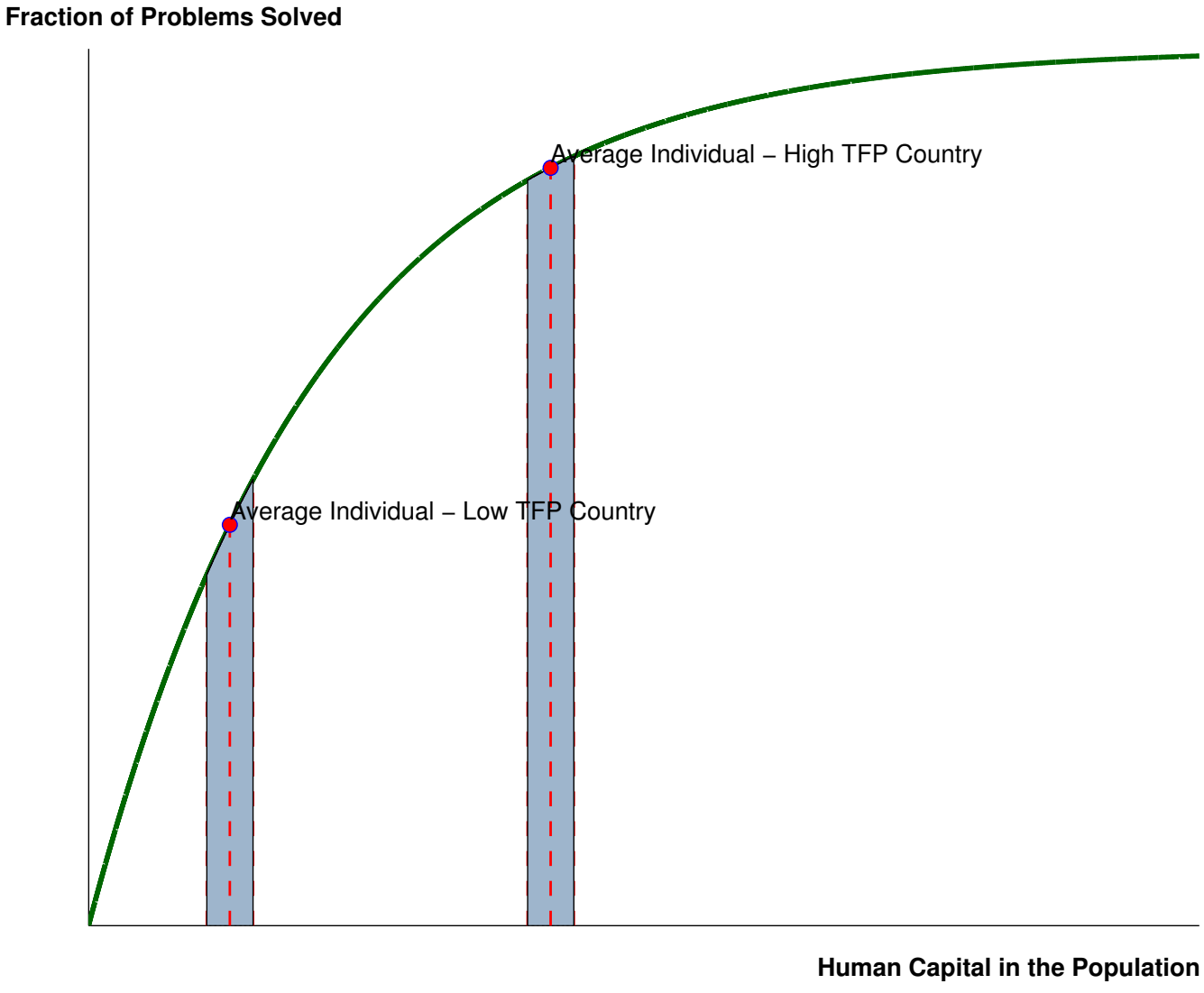

Labor Productivity at 90th/10th Percentiles and GDP

	Labor Prod.	(u. wage bill)	Revenue Prod. (Hsieh/Klenow)
USA	1.98	2.11	3.28
China	2.75	2.58	4.90
India	3.52	2.79	4.95
	normalized	normalized	normalized
China	1.39	1.23	1.49
India	1.78	1.32	1.50

- Burdett (1996): $\frac{d}{dc} V(X|X > c) \leq 0$ if and only if log-concavity of the twice integrated survivor
- Firm TFP and Labor Productivity are one-to-one in the Model
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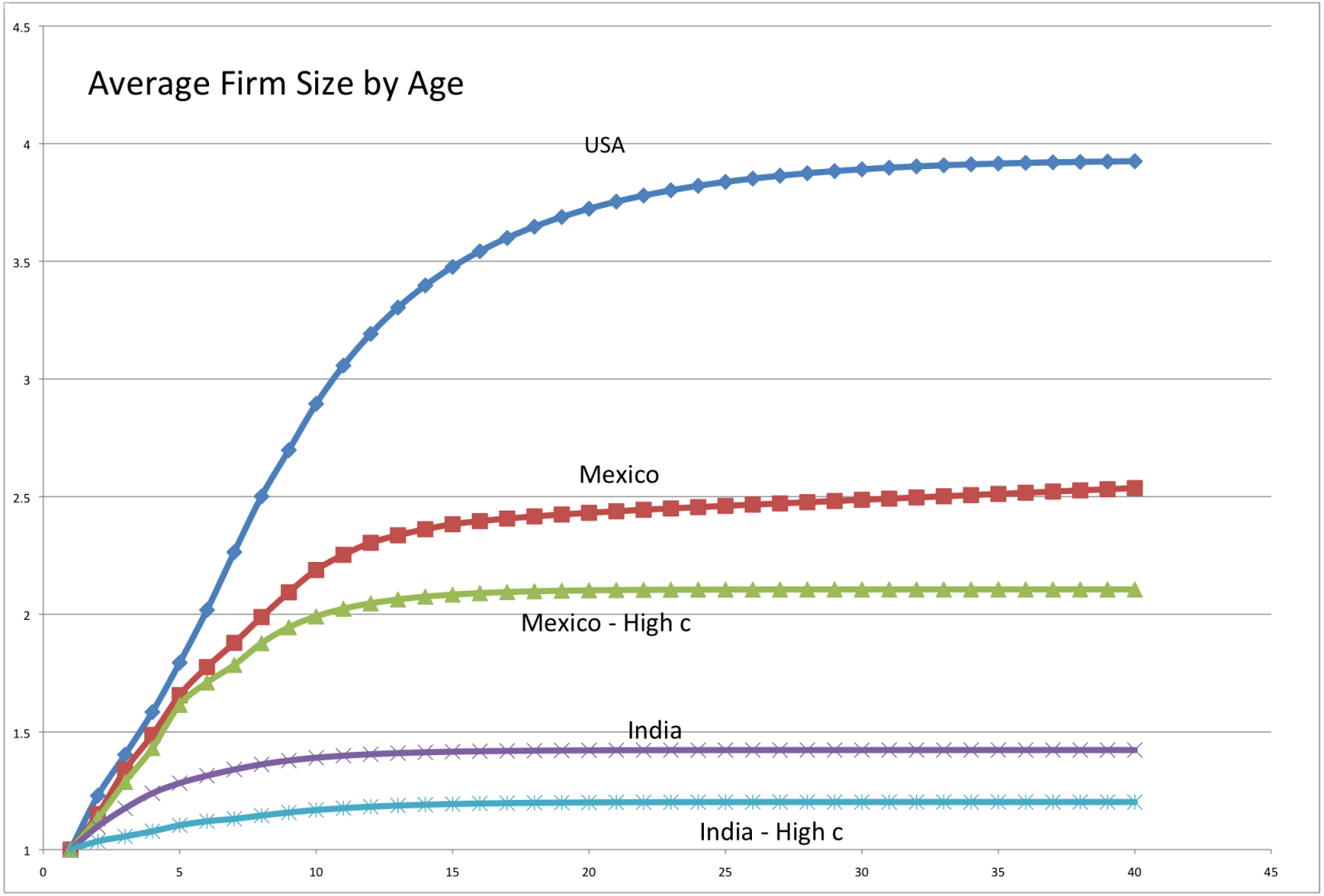
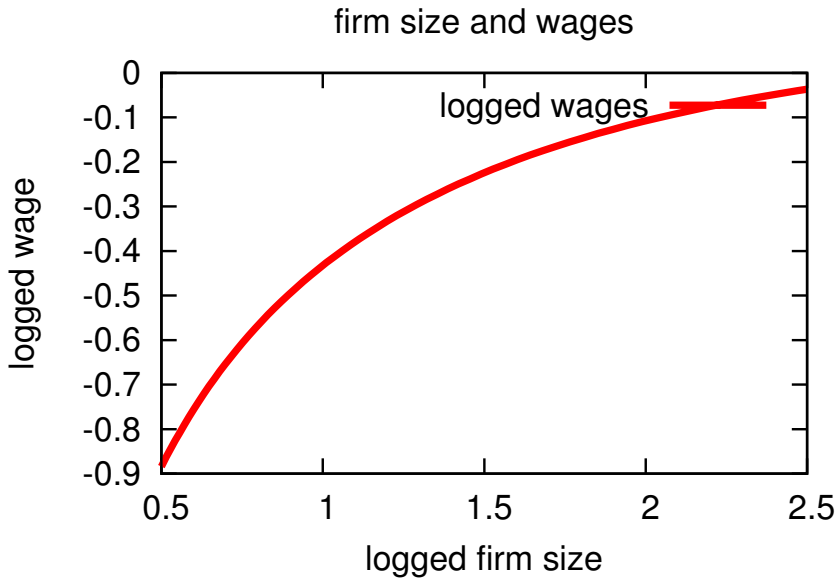
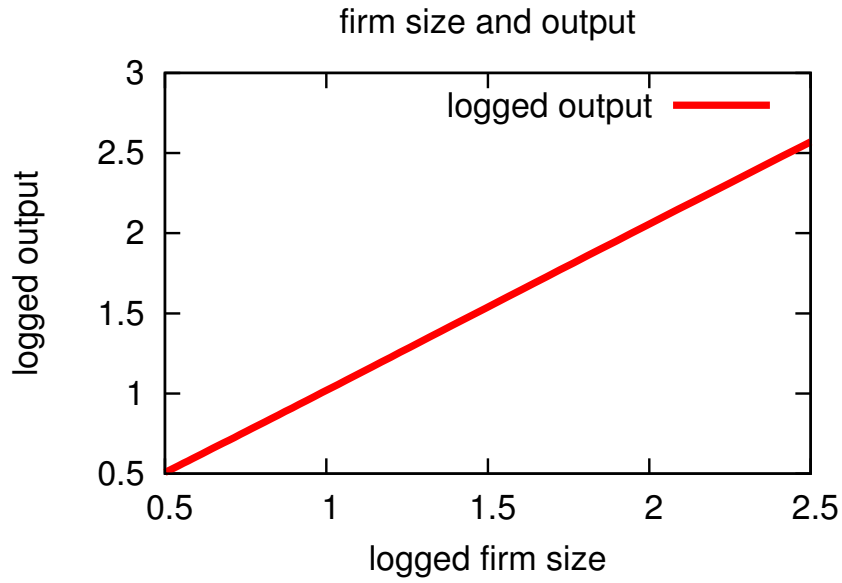
Firms' Growth across Countries

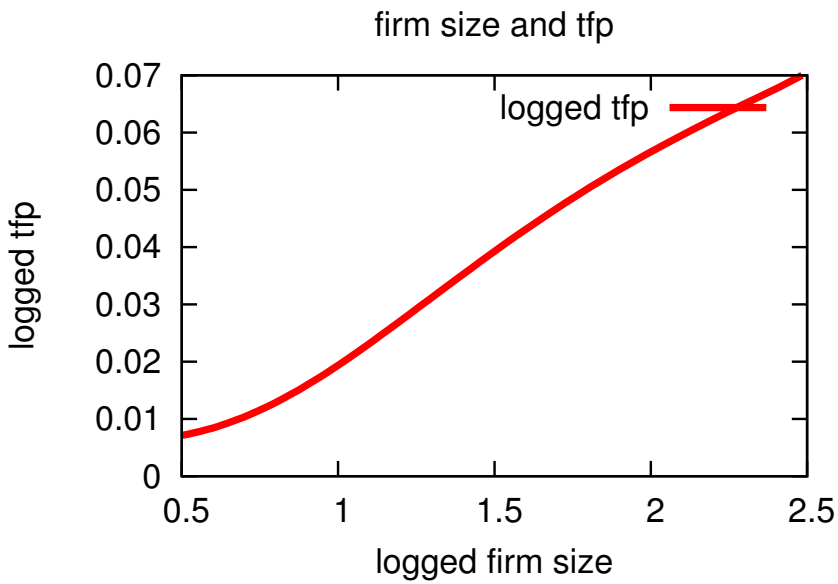


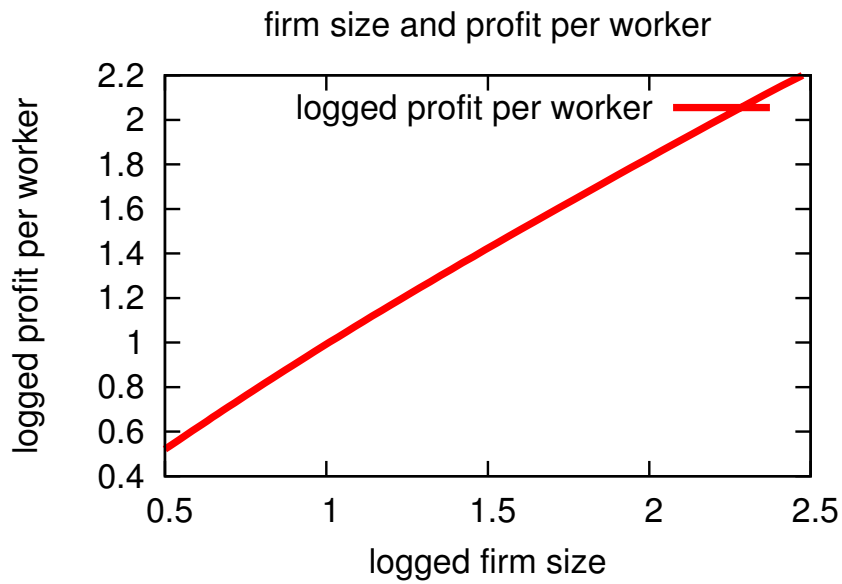
Equilibrium Properties

Firm Heterogeneity









Some Empirical Evidence

Size Category	Owners' education				
	Drop-out	High school	Some College	College	Post-College
1-24	6.02	20.17	39.00	22.61	12.20
25-99	4.41	17.50	37.77	25.76	14.57
100+	2.75	14.04	33.42	26.35	23.44
Size Category	Workers' education				
	Drop-out	High school	Some College	College	Post-College
1-24	15.17	30.65	36.52	13.68	3.97
25-99	12.78	31.08	35.97	15.45	4.72
100+	9.21	29.00	34.76	19.20	7.82

Source: Survey of Income and Program Participation (SIPP).

Some Empirical Evidence

Wage-Firm Size Premium

Variables	(1)	(2)
25-99	0.0272	0.0251
	(75.87)	(72.93)
100+	0.1741	0.1615
	(101.11)	(91.91)
Education Dummies	No	Yes
Observations	318680	318680
R^2	0.2272	0.3254

Source: Survey of Income and Program Participation (SIPP).

Equilibrium Properties

Occupational Choice

Lucas (1978): people tend to move from employee to managerial status later in their careers (as opposed to immediately upon entry to the workforce, as predicted by the theory above); those that make this transition tend to be among the most skilled employees. These facts suggest the existence of a kind of human capital which is productive both in managing and in working for others, and which is accumulated most rapidly as an employee.

Proposition

Managers are on average older than workers and have on average a higher human capital level

Calibration

- fraction of managers is 3% at age 20 and 9% at age 40
- With 5 learning ability types: highest (lowest) type has 27% (4%) of managers

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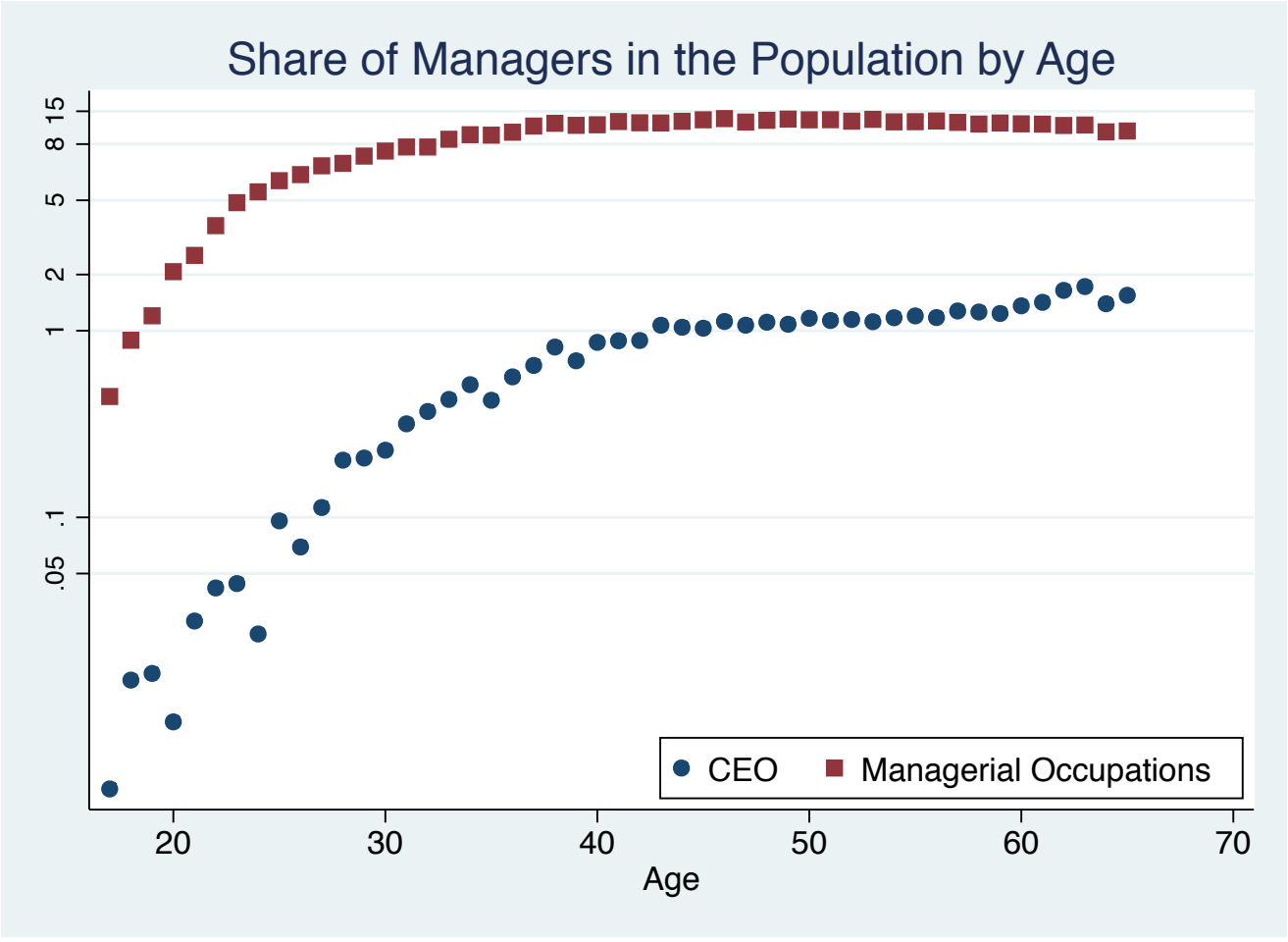

Source: American Community Survey for 2008

Equilibrium Properties

Life-Cycle of Wages

Proposition

*Wages grow over time through **3** channels:*

- *human capital accumulation* h_w
- *time spend in production* n_w
- *match with better manager* $w', m' > 0$

Equilibrium Properties

Life-Cycle of Firms

Proposition

*Young firms grow faster than old firms through **3** channels:*

- *manager's human capital accumulation* h_m
- *time spend in production* n_m
- *match with better workers over time* $m' > 0$

Conclusion

We develop a model of human capital accumulation of workers and managers with complementarities and sorting

- it yields an number of empirical implications for earnings, firm heterogeneity and occupational choice
- Varying the aggregate level of efficiency of the economy across countries to match GDP per capita differences, we find that human capital goes a long way in explaining differences in firm heterogeneity across countries.

Management Quality

ACCOUNTING FOR MANAGEMENT PRACTICES ACROSS COUNTRIES

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	Management raw score	Management raw score	Management raw score	Management raw score	Management raw score
Country is the United States	Baseline	Baseline	Baseline	Baseline	Baseline
Country is Germany	−0.045	−0.081	−0.096	−0.057	0.004
	(0.064)	(0.075)	(0.075)	(0.074)	(0.077)
Country is France	−0.202	−0.183	−0.136	−0.078	−0.033
	(0.086)	(0.104)	(0.104)	(0.103)	(0.103)
Country is the United Kingdom	−0.276	−0.276	−0.227	−0.196	−0.123
	(0.078)	(0.093)	(0.091)	(0.091)	(0.093)
Family largest shareholder, family CEO, and primogeniture			−0.637	−0.627	−0.582
			(0.101)	(0.100)	(0.098)
Number of competitors				0.149	0.158
				(0.052)	(0.051)
Ln(proportion of employees with degrees)					0.146
					(0.037)
Controls for size and listed status	No	Yes	Yes	Yes	Yes
Firms	732	732	732	732	732

Source: Bloom and Van Reenen (2007)

Human Capital and Productivity

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]	