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The Macroeconomics of Managers: Supply, Selection, and Competition

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ABSTRACT
Good management practices are important determinants of firm success. It is unclear, however, to what extent pro-management policies can shape aggregate outcomes. We use data on corporations and their top managers in Hungary during and after its post-communist transition to document a number of salient patterns. First, the number of managers is low under communism when most employment is in large conglomerates. After the transition to capitalism, the number of managers increased sharply. Second, economics and business degrees became more popular with capitalist transition. Third, newly entering managers tended to run smaller firms than incumbent managers. We build a dynamic equilibrium model to explain these facts. In the model, the number and average quality of managers react to schooling and career choice. We use the model to evaluate hypothetical policies aiming to improve aggregate productivity through management education and corporate liberalization. Our results suggest that variations in the supply of good managers are important to understand the success of management interventions.

JEL codes: E24, O15, O40
Keywords: management, productivity

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A menedzserek makroökonómiája: Kínálat, szelekció és verseny

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ÖSSZEFOGLALÓ

A jó menedzsment a vállalati siker fontos meghatározója. Nem világos azonban, hogy milyen menedzsmentbarát intézkedésekkel lehet az aggregált termelékenységet növelni. Magyarországi vállalatok és felsővezetőik adatainak segítségével számos mintát dokumentálunk a rendszerváltásról és az azt követő időszakról. Először is, szocializmus alatt a vezetők száma alacsony, mert a legtöbb dolgozót nagy konglomerátumok foglalkoztatják. A rendszerváltás után a menedzserek száma meredeken emelkedett. Másodszor, a közgazdasági és üzleti diplomák népszerűbbé váltak a rendszerváltás után. Harmadszor, az újonnan belépő menedzserek általában kisebb cégeket vezettek, mint a hivatalban lévő menedzserek. Dinamikus egyensúlyi modellt építünk e tények magyarázatára. A modellben a menedzserek száma és átlagos minősége az iskolázottságtól és a pályaválasztástól függ. A modell alapján olyan hipotetikus szakpolitikákat vizsgálunk, amelyek célja az aggregált termelékenység javítása a menedzserképzés és a vállalati liberalizáció révén. Eredményeink azt sugallják, hogy a jó menedzserek kínálatának változása fontos annak megértéséhez, hogy egy adott szakpolitikai beavatkozás sikeres lesz-e.

JEL: E24, O15, O40
Kulcsszavak: menedzsment, termelékenység

The Macroeconomics of Managers: Supply, Selection and Competition*

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Abstract

Good management practices are important determinants of firm success. It is unclear, however, to what extent pro-management policies can shape aggregate outcomes. We use data on corporations and their top managers in Hungary during and after its post-communist transition to document a number of salient patterns. First, the number of managers is low under communism when most employment is in large conglomerates. After the transition to capitalism, the number of managers increased sharply. Second, economics and business degrees became more popular with capitalist transition. Third, newly entering managers tended to run smaller firms than incumbent managers. We build a dynamic equilibrium model to explain these facts. In the model, the number and average quality of managers react to schooling and career choice. We use the model to evaluate hypothetical policies aiming to improve aggregate productivity through management education and corporate liberalization. Our results suggest that variations in the supply of good managers are important to understand the success of management interventions.

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1 Introduction

Good management is understood as one of the key determinants of firm performance (Bloom et al. (2014)). Trainings are an effective way of improving management practices (Bloom et al. (2013), Bruhn, Karlan, and Schoar (2010), Bruhn, Karlan, and Schoar (2018)), and they have a lasting effect on firms and managers (Bloom et al. (2020), Giorcelli (2019), Giorcelli (2021)).

It is unclear, however, what policies can improve management in the aggregate. Think about a subsidy program that encourages people to join management training, for instance. How many individuals will join the program? Will their choice be based on natural management skills? How will the newly trained individuals compete with current managers? Answering these questions is key to understand the aggregate effects of the program.[1]

We propose a dynamic equilibrium model to study the *supply*, *selection*, and *competition* of managers in the macroeconomy. Manager skills are a combination of innate abilities and skills acquired through education. The expected demand for managers determines both the schooling choice as well the career choice of young people. In times when managers are in high demand, more people go to business schools and, among graduates, more people choose a managerial career. We call the first effect *supply* and the second *selection.* After entering, young managers *compete* with old ones who have entered the market under different conditions, leading to complex dynamics of aggregate management skills.

The main result of the model is that even large-scale interventions targeting management skills, such as a tax incentive for managerial occupations or a universal improvement in business education, will have slow effects on aggregate productivity. In the case of tax incentives, all three equilibrium mechanisms mentioned above dampen the effects of pro-management policies. First, entry into business school is not completely elastic, so tax incentives may have a low impact on the potential supply of managers. Second, after a pro-management intervention, the average *innate* ability of new managers will decline due to weaker selection. And third, competition from incumbent managers reduces entry of new ones. In the case of education reforms, however, selection can magnify the effects of the policy, because individuals with better innate skills will be more likely to take advantage of the new opportunities.

We use data on the universe of Hungarian firms and their CEOs between 1985 and 2019, as well as a limited sample of manager biographies to calibrate the model and to evaluate the quantitative importance of its mechanisms. Because the supply, selection, and competition of managers all depend on general equilibrium feedbacks, it is important to

[1] Lerner (2009) discusses the challenges of turning individual business success in innovation and venture capital into successful macro policies. We similarly argue that the aggregate effects of management policies are difficult to predict without a model of the market for managers.

study the universe of businesses and their leaders and not just a select top managers of publicly listed firms. The long panel, in turn, helps us study the long-run dynamics of the manager market.

We exploit the rapid transition of Hungary from communism to capitalism as a sudden and large shock increasing the demand for managers. As markets, prices, and entrepreneurship became liberalized, the number of business enterprises exploded from 21,000 in 1989 to 115,000 in 1992. This sudden increase in economic activity put more than 160,000 people, many of them without prior management experience, in top managerial positions. This large increase in the demand for managers helps us trace out their supply curve. Our work is motivated by case studies and interviews with business leaders during this period (Laki and Szalai (2004), Laki and Szalai (2013)).

Following Lucas (1978), we assume there are differences in innate manager skills. There is evidence that CEOs differ in their effects on firm performance, estimated from CEO fixed effects as they move across firms (Bertrand and Schoar (2003), Custódio, Ferreira, and Matos (2013), Quigley and Hambrick (2015), Schoar and Zuo (2016)) and CEO characteristics (Graham, Li, and Qiu (2012)), but also from quasi-experimental variation from CEO sickness (Bennedsen, Pérez-González, and Wolfenzon (2020)) and death (Fee, Hadlock, and Pierce (2013), Becker and Hvide (2022), Sauvagnat and Schivardi (forthcoming)).[2]

In the model, people make an occupation choice: those who are skilled enough become managers, while everyone else works for a fixed wage. The cutoff between workers and managers depends on the demand and supply of managerial services. We enrich the Lucas (1978) model by embedding it in a school choice framework with overlapping generations. Workers choose a degree and then a career. Different degrees yield different managerial skills, but also different non-pecuniary benefits. The latter is important because it implies that the supply of managers is not infinitely elastic.

To calibrate the distribution of manager talent, we use the prediction of the model that, in a given year, firm revenue is directly proportional to manager skills. To validate the model, we first check how the distribution of manager skills depends on the fraction of the population entering as managers. We compare the number of CEOs to the number of university graduates in their cohort. The model predicts that when a relatively larger fraction of managers enter, their average skill level declines, leading to smaller firms. This is indeed what we find in the data.

[2]We assume a single-dimensional measure of manager skill, differentiating good managers from bad ones. This simplification is necessary because manager quality is difficult to measure in administrative and observational data (Gottesman and Morey (2010)). The approximation of the multitude of skills necessary to run a firm with a single index is relevant, however, because general management skills have become more important in recent decades (Frydman and Saks (2010), Custódio, Ferreira, and Matos (2013), Quigley and Hambrick (2015)).

We then use the model to conduct policy exercises. First, we simulate the communism-capitalism transition with a simple policy change. We calibrate the model parameters to match the capitalist economy, but start from a suppressed stock of managers, calibrated to the numbers observed under communism.[3] After liberalization, many new managers will enter, but aggregate GDP will not increase as much, because new entrants are, on average, less skilled than old managers. New entrants are more likely to go to business school, but the increase in business education is not large enough to offset the decline in average quality.

Qualitatively, the patterns of fast entry, stronger interest in business education and lower average quality of new managers are consistent with data from the transition period in Hungary. Relative to the size of the age cohort, the number of managers increased by a factor of 14 in the space of a few years. The ratio of economics and business graduates to the number of 23-year-olds have increased from 3.5 percent in 1985 to 10.5 percent in 2005. And the average size of firms run by managers entering after 1992 was 34 percent smaller than those run by managers entering before 1992.

The second set of policy exercises concern management education. Given the evidence on the effectiveness of management training (Bloom et al. (2013), Bruhn, Karlan, and Schoar (2018), Giorcelli (2019), Bloom et al. (2020)), we allow two interventions to increase the average management skill of university graduates. First, governments can subsidize business schools, which have a higher causal effect on management skills than other disciplines. (These effects are estimated from the data in a model-consistent way.) This increases average quality, but requires large reallocations of the student body. Second, governments can directly reform the curriculum of schools. This is relevant in our context, because under communism, most economics curriculum was derived from Marxism. Samuelson's and Nordhaus's three-volume economics textbook was translated to Hungarian and published in 1987 (Samuelson and Nordhaus (1987)) and became widely adopted. The new curriculum was arguably more useful for running a company in a capitalist economy.

We find that education reforms need to be large to result in a significant increase in aggregate productivity. In our baseline calibration, business students increase their management skills by a factor of more than two relative to high school graduates. Yet it would take almost two thirds of the student body to be enrolled in business schools to increase aggregate GDP by 5 percent. Direct curriculum reforms may be more feasible, because they do not require large reallocations of students. We find that a 50 percent increase in the management skills of business graduates would increase aggregate GDP by 5 percent.

We are not the first to include managerial skills or organizational capital in macroeconomic

[3] We need not take a stand on why entrepreneurship and management are suppressed under communism, but Appendix 8.1 offers a potential explanation in which the communist party favors pro-employment policies at the expense of managerial income.

models. Most models, however, are set up at the aggregate (or regional) level.[4] There is no role for heterogeneity and selection of managers of different talent. Our model is similar to Luttmer (2011), but we focus on management and not innovation and calibrate the model to micro data. The approach we take with micro data is very similar to Akcigit, Pearce, and Prato (2020), who emphasize selection and equilibrium response of *innovators* in response to policy changes. We make similar points about managers.

Sedláček and Sterk (2017) study whether business cycle conditions at the time of firm birth have any persistent effects on firm employment, finding that firms born during downturns start out larger. Schoar and Zuo (2017), in turn, study how exposure to the business cycle shapes manager careers and philosophy. There is, however, no work on how business cycles matter for firm dynamics through a selection of managers. This is relevant because managers are an important input to firms.

This literature studies firm entry and entrepreneurship over the business cycle. We cover a much larger shock: the transition from communism to capitalism, with business activity increasing 20-fold over a few years. Our setting is more similar to Fuchs-Schündeln and Masella (2016) and Fuchs-Schündeln and Schündeln (2020), who explore the effects of the German reunification.

Our contribution is to build a unified framework to study schooling and career choice of managers in a way that permits the evaluation of different policy changes. We also contribute to the literature by calibrating the model to micro data in a period of large economic change.

2 Data and stylized facts

2.1 Data

Manager data comes from the *Hungarian Manager Database* (CEU MicroData (2019)), which we compiled from detailed records in the *Cégjegyzék* (corporate registry). This records, for the universe of corporations, the officers of the firm as specified in corporate law, including their name, mother's name, address, position, and exact dates at the firm. We have completed a name-based matching to identify managers moving across firms and can also use the name to infer the nationality of the manager (Koren and Telegdy (2022)).

We create an annual panel of CEOs, by taking a snapshot of the firm's main directors on June 21 of each year. We only keep the chief executive officers for each business. Some firms may have more than one CEO.We merge balance sheets and financial statements for each firm for the same period. The coverage of financial data is nearly universal (Table 1).

[4]Burstein2009-kj, Gennaioli et al. (2012), Akcigit, Alp, and Peters (2021), Hjort, Malmberg, and Schoellman (n.d.)

Table 1: Our sample of firms and managers

Year	Number of firms	Number of CEOs	Of whom in Hübner	Average firm size
1985	2,055	2,051	89	447.6
1986	2,254	2,251	99	418.1
1987	2,575	2,572	115	374.8
1988	2,969	2,963	133	337.9
1989	6,209	6,140	332	245.6
1990	16,791	16,369	1,008	83.6
1991	32,458	31,232	2,026	45.4
1992	84,118	79,962	4,438	20.6
1993	107,469	101,970	5,535	16.5
1994	137,447	129,653	6,922	14.7
1995	155,842	146,273	7,908	12.9
1996	178,964	167,240	9,204	11.4
1997	200,649	186,692	10,344	10.4
1998	232,892	214,541	12,132	9.5
1999	241,556	222,410	13,003	9.1
2000	261,078	239,831	14,273	8.6
2001	284,192	260,349	15,598	8.1
2002	283,267	258,233	15,736	8.0
2003	286,036	259,673	15,816	7.9
2004	302,312	272,639	16,591	7.7
2005	309,078	277,128	16,941	8.9
2006	318,678	284,076	17,296	8.8
2007	324,668	286,667	17,717	8.5
2008	337,920	294,036	18,685	7.8
2009	347,163	298,473	19,142	7.2
2010	360,806	306,923	19,686	7.1
2011	373,624	315,235	20,017	7.1
2012	379,319	316,140	19,632	7.0
2013	411,963	336,419	21,244	7.1
2014	413,236	336,185	21,075	7.2
2015	414,023	335,763	20,604	10.5
2016	409,671	331,850	20,042	6.9
2017	402,949	324,600	19,509	7.2
2018	399,898	320,454	19,090	7.4
2019	389,188	311,191	18,366	7.4

We use data from Hübner (2007) to measure the schooling of managers. This is an almanac of business leaders and other prominent Hungarian personalities. There is non-random selection into this sample, for example, large firms are over-represented in Who is Who (fig. 1). The benefit of this data is that we observe the education history of each manager. We classify degrees into economics (including finance and business), engineering (including science), and others.

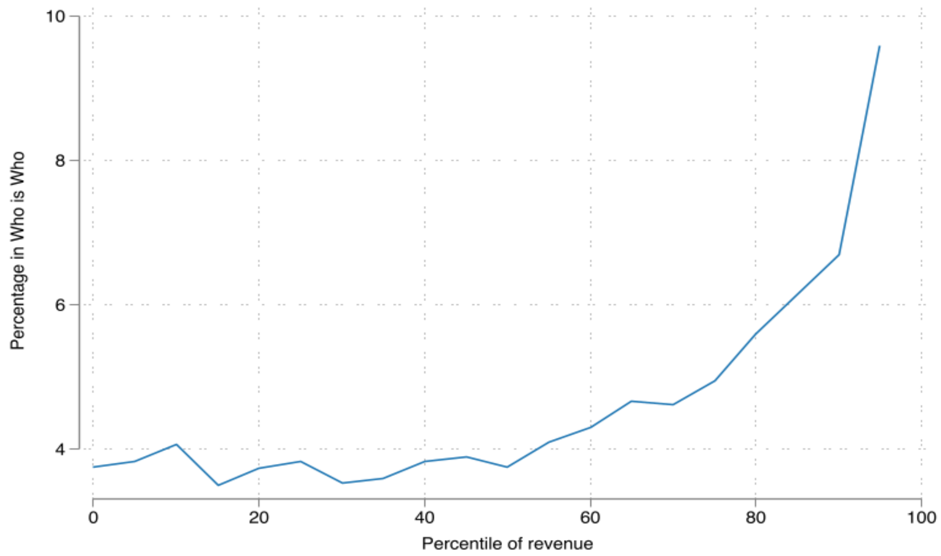

Figure 1: Large firms are over-represented in Who is Who

In Hübner, we also see in which year the manager graduated. Comparing this to the overall number of graduates in that year (*Statisztikai Tájékoztató Felsőoktatás* (various years)), we can check how selective certain degrees are. We see that business degrees have become relatively more popular over time, although there is a general increase in college degrees. The calibrated model will match these patterns in the data.

2.2 Measuring manager quality

We do not have any direct measure of manager skills. Our model implies, however, that good managers run larger firms. To measure the average manager quality of a cohort c, we estimate the average firm size of managers entering in year c from the following regression. The log revenue of firm i in year t in industry s, with a mananager having entered in cohort c is

$$\ln R_{icst} = \beta_1 \text{manager\_age}_{ict} + \beta_2 \text{firm\_age}_{ict} + \mu_c + \xi_{st} + \epsilon_{ict}. \tag{1}$$

We control for manager and firm age and include industry-year fixed effects. In other words, we are comparing firms in the same industry-year cell, with similarly aged managers and firms. The coefficient μ_c captures the average firm size of managers entering in cohort c. This regression is estimated on firms whose manager started between 1985 and 2010 and who have valid manager age observations.

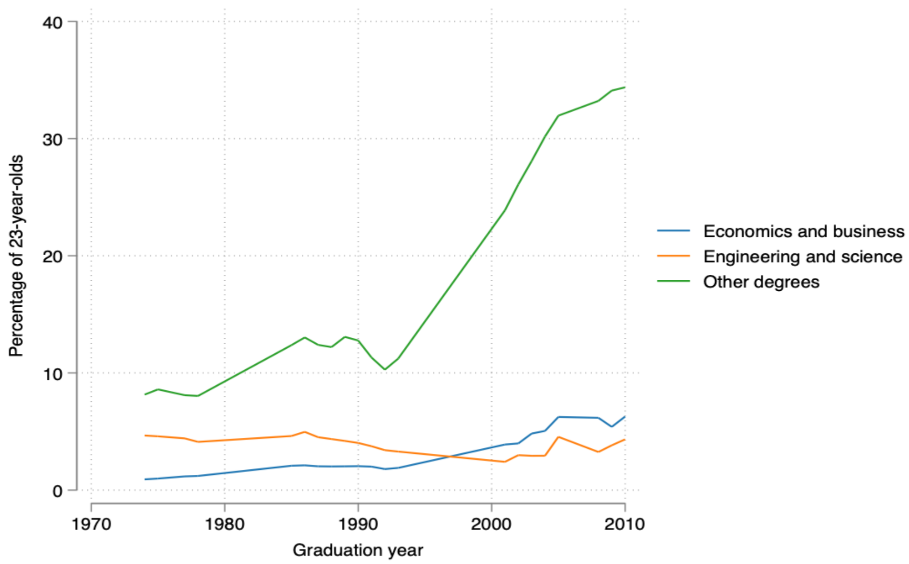

Figure 2: The share of economics and business graduates increased

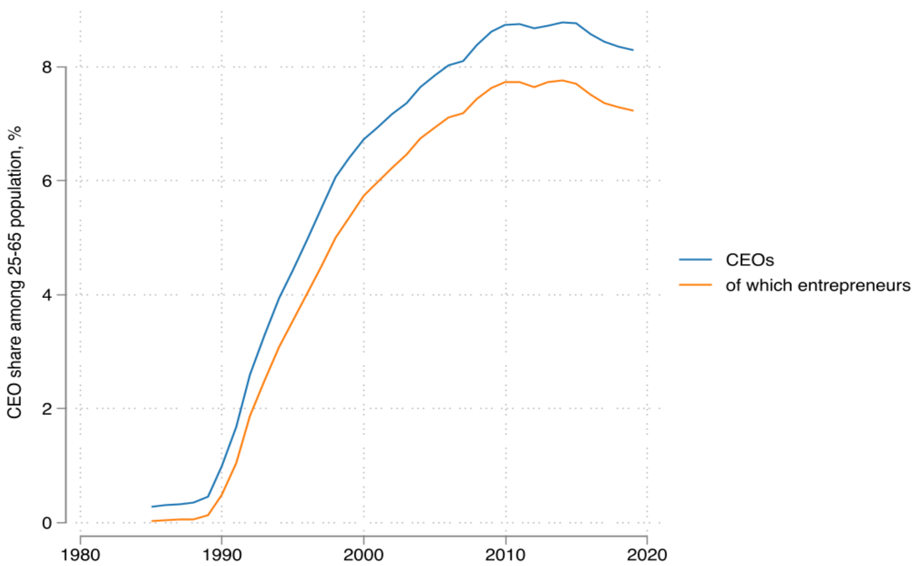

Figure 3: The stock of managers increased sharply

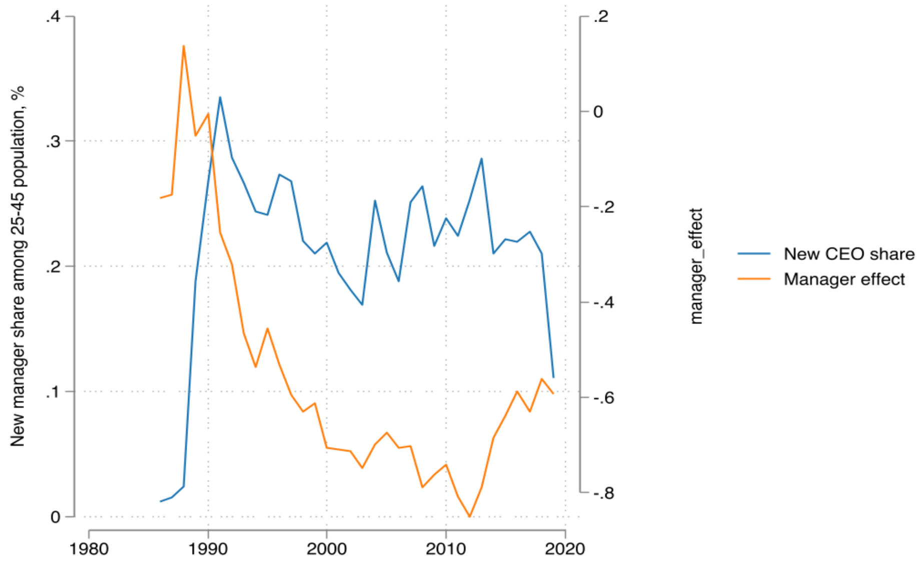

Figure 4: The inflow of managers jumped suddenly

2.3 Manager demographics

We compare the stock of CEOs to the number of people in the age-appropriate group, between 35 and 60 years of age. The share of CEOs has increased from around 1 percent in the 1980s to around 14 percent by the end of the sample (fig. 3). Note that the vast majority of CEOs are also owners in their firm. In our model, there is no special role for owners, because there is no corporate governance friction. We will henceforth use the term "manager" to refer to all CEOs, whether or not they own their business.

Similarly, we can compare the inflow of new CEOs to the size of the age 25-45 cohort. Here we only look at non-owner CEOs. The share of new CEOs has gone up from a small fraction of a percent to above 0.3 percent in the space of four years. It has gradually declined to 0.1 percent.

On the same graph, we also plot the average quality of a manager cohort, as estimated from the fixed-effect regression explained above. There is a strong negative correlation between the fraction of the cohort becoming managers and their average quality. As we will make it clear later, this pattern is consistent with our model.

3 An OLG model of managers

We build a model to study the supply, selection and competition of managers. Each individual makes two key decisions. What degree to choose? And should they become a manager or remain a worker? The higher the wages of managers relative to workers, the more people will choose a manager career. Policy can influence this relative wage by setting occupation-specific taxes and subsidies. And schooling can be subsidized to increase the supply of managers.

As people differ in their innate manager skill, there is a Roy-model of selection into management. We are interested in the distribution of the manager skills of new entrants. Policy also affects the degree of selection: if a manager career is very attractive, even less skilled individuals will become managers.

We assume an overlapping generations (OLG) structure, where career choice is made when young, and managers of different ages compete with one another in the market.[5] To make career choice a dynamic decision, we assume that occupations cannot be switched once chosen. Managers always remain managers, workers always remain workers. This is an extreme assumption, but is motivated by the fact that old managers and entrepreneurs are often unwilling to give up control of their firm(Bennett, Lawrence, and Sadun (2017)).

We characterize the steady state of the model, and study transitional dynamics in response to various policy changes.

3.1 Manager and worker demographics

Time is continuous. At each point in time, a mass l of workers enter the labor market and contemplate whether to become a manager. A mass $n(t) \leq l$ will do so. This endogenous variable will be a key object of interest.

Workers and managers earn wages throughout their productive lifetime, which ends with a Poisson arrival rate δ. Occupations can only be chosen at age 0. We denote the *stock* of population as

$$L := \int_{-\infty}^{t} e^{\delta(s-t)} l ds = l/\delta.$$

Note that this is time invariant. By contrast, because managers enter endogenously, the number of active managers will vary over time. We denote the mass of active managers by

$$N(t) := \int_{-\infty}^{t} e^{\delta(s-t)} n(s) ds.$$

Workers and managers are risk neutral and discount the future at rate ρ.

3.2 Production function

We first characterize the static decisions and equilibrium conditions. In this part, we omit the time index (t) for brevity. We will reintroduce it later, when we discuss dynamics.

Managers differ in their innate skill level. A manager with skill z can hire h workers to

[5] Workers of different ages also compete, but because worker skills are homogeneous, this competition is simple.

produce output with the production function

$$q = z^{\nu} h^{1-\nu}. \tag{2}$$

The parameter $\nu \in (0, 1)$ captures the returns to management.

Workers are hired in competitive labor markets. Their value marginal product is equal to their wage,

$$(1 - \nu)(z/h)^{\nu} = w,$$

and, without loss of generality, we have normalized the price of output to one. This pins down the employment of a firm with manager z as

$$h(z) = zw^{-1/\nu}(1 - \nu)^{1/\nu},$$

so that firm revenue is

$$r(z) = q(z) = zw^{1-1/\nu}(1 - \nu)^{1/\nu-1}.$$

Employment, wage bill, and revenue are all linear in z.

Workers are paid a $1 - \nu$ fraction of revenue. The remaining fraction goes to owners who use this rent to bid for managers in a competitive labor market. Managers capture all the rents in equilibrium, and can hence be treated *as if* they were owners of the firm.

More formally, the wage of a manager with skill level z is $\omega(z)$. The zero-profit condition of firms implies that

$$r(z) - wh(z) - \omega(z) = 0,$$

so that

$$\omega(z) = \nu r(z) = \nu zw^{1-1/\nu}(1 - \nu)^{1/\nu-1}.$$

3.3 Competition between firms

Let $G(z)$ denote the equilibrium distribution of manager skills. We will characterize this distribution later. For now, we assume that it is given. Recall that the total population is fixed at L. Of this, L_p work in production and N work as managers.

Because firm-level labor demand is linear in z, labor market clearing can be written as

$$L_p = Nw^{-1/\nu}(1 - \nu)^{1/\nu} \int zdG(z).$$

Let $Z := N \int zdG(z)$ denote the *sum* of all manager skills. Then the wage of production workers can be written as

$$w = (1-\nu)\left(\frac{L-N}{Z}\right)^{-\nu},$$

where we have used static labor market clearing to substitute in the amount of production labor in the economy.

Firm revenue is

$$r(z) = z\left(\frac{L-N}{Z}\right)^{1-\nu}.$$

Total revenue in production is

$$Y = N\int r(z)dG(z) = Z^{\nu}[L-N]^{1-\nu}. \tag{3}$$

Give our normalization of output prices to one and the fact that there are not other inputs and sectors, this is also total GDP in the economy.

Because of the Cobb-Douglas production function, a constant ν fraction of revenue is paid as manager wages. The wage of a manager with skill z is

$$\omega(z) = \nu z\left(\frac{L-N}{Z}\right)^{1-\nu}.$$

This is increasing in z but decreasing in Z. Better managers make higher wages, but competition from other managers reduces the wage available to each individual manager. This competitive effect is bigger the more managers there are and the better they are, on average.

3.4 Manager value

Manager wages at a given point in time depend on z and $Z(t)$. The value of a manager with skill z is the discounted sum of future wages,

$$V(t,z) := \int_{s=t}^{\infty} e^{-(\rho+\delta)(s-t)}\omega[z, Z(t)]ds.$$

Discounting takes account of the fact that managers leave the labor force with arrival rate δ.

Manager value will be characterized by the following Bellman equation:

$$\rho V(t,z) = \omega[z, Z(t)] - \delta V(t,z) + V_t(t,z).$$

The flow wage depends on z and Z. The manager will die with arrival rate δ, losing all the firm value. (There is no bequest in the model.) Finally, the value may change if aggregate state variables change. The manager skill z is assumed to remain constant.

Because $\omega[z, Z(t)]$ is linear in z, we will conjecture that the value function is of the form

$$V(t, z) = v(t)z.$$

If this is the case, the Bellman can be rewritten as

$$\rho v(t) = \nu \left[\frac{L - N(t)}{Z(t)}\right]^{1-\nu} - \delta v(t) + v'(t).$$

This is a functional equation for $v()$ with no z left in it, so our initial guess for the functional form proved correct.

3.5 Dynamics

Potential new managers have a time invariant skill distribution $F(z)$. As we show below, only the more skilled managers will enter and compete with existing older managers. The skill distribution of each cohort is hence a truncated distribution, with potentially different truncation points across cohorts. The distribution of skill among the *stock* of managers is a mixture of these truncated distributions. The resulting skill distribution, denoted by $G(t, z)$, is crucial for understanding aggregate dynamics.

The set of managers will be a slowly moving state variable. At each point in time, $n(t)$ new managers enter the market with average quality $\tilde{z}(t)$. (These will be made endogenous later.) When they enter, the cohort's contribution to total manager skills is $n(t)\tilde{z}(t)$. Existing managers die with a Poisson rate δ per unit of time. The skill of surviving managers remains constant at z.

Once someone enters as a manager, they will remain one until they die. This is the key friction of the model, which stops inferior old managers from selling their firms to better young ones. Note that old managers are not worse because of age. They *may* be worse if they entered during a boom when even worse managers could be competitive. This will be the main subject of the analysis.

The set of active managers is a cumulated sum (integral) of all past cohorts:

$$Z(t) := \int_{-\infty}^{t} e^{-\delta(t-s)} n(s)\tilde{z}(s) ds.$$

At time s, $n(s)$ managers entered, of whom a fraction $e^{-\delta(t-s)}$ survived to time $t > s$. The average manager quality did not change over time, because death is independent of manager quality.

The change in the overall skill of managers follows from differenaing the above expression with respect to t:

$$Z'(t) = n(t)\tilde{z}(t) - \delta Z(t). \tag{4}$$

The *number* of managers changes according to the law of motion

$$N'(t) = n(t) - \delta N(t). \tag{5}$$

3.6 Education and career choice

At the beginning of their productive life, young people choose between different degrees. After graduation, they can become workers or managers. Each degree offers a pathway to managerial positions, but the likelihoods of becoming a manager differ across degrees.

Students differ in their innate manager skill z, which they do not know when choosing a degree. They are, however, aware of the distribution of manager skills $F(z)$ and the likelihood of becoming a manager with a given degree. More specifically, we assume that z is distributed Pareto,

$$1 - F(x) = \Pr(z > x) = \left(\frac{x}{z_0}\right)^{-\theta},$$

for $\theta > 1$ (so that the distribution has a finite mean).

Attending school i costs P_i (may be subsidized) and increases the manager skill of each student by a factor of $\lambda_i > 1$. The manager skill of a student with degree i is hence $\lambda_i z$. Note that this is a multiplicative increase, so that the distribution of manager skills remains Pareto with the same θ shape parameter and scale parameter $\lambda_i z_0$. After graduation, manager skills are revealed and students make a career choice based on their own level of skill and the distribution of manager skills across schools anc cohorts.

Degrees differ also in their non-pecuniary benefits to the student. This implies that the cost of education and the expected income are not the only determinants of school choice. We assume that the fraction of students choosing school i is a logit function of the expected value of the degree,

$$x_i = \frac{\exp(\alpha_i - P_i + \ln E_i/\gamma)}{\sum_j \exp(\alpha_j - P_j + \ln E_j/\gamma)},$$

where α_i is a common non-pecuniary benefit making one degree more attractive than another, P_i is the total cost of education, E_i is the expected wage income from the degree, and γ is a parameter capturing the importance of non-pecuniary benefits. Notice that γ indirectly affects the elasticity of supply of managers. Business degrees may offer higher expected wages and a higher likelihood of landing in a managerial position, but students will only respond to these incentives with semi-elasticity $1/\gamma$. We assume that expected wage income enters in a logarithmic form. This will prove convenient in the analysis.

To determine the value of a degree, we need to study the career choice of students after graduation. They can become workers and earn a lifetime value of

$$J(t) := \int_{s=t}^{\infty} e^{-(\rho+\delta)(s-t)w(s)ds}.$$

For simplicity, we assume that degrees do not differ in the wages workers can expect to earn. If they choose to become a manager, they will earn a lifetime value of

$$(1-\tau)v(t)z,$$

which depends on their level of manager skills. We allow for a tax $\tau \in [0,1)$ on manager wages. If the government wishes to subsidize managers, $\tau < 0$. The net value of becoming a manager is hence $(1-\tau)v(t)z$.[6]

This leads to a selection on manager skill. Only those who have good-enough manager skills will become manager

$$z > z_{\min}(t) := \frac{J(t)}{(1-\tau)v(t)}.$$

Note that this threshold depends on the aggregate state variables $v(t)$ and $J(t)$, but not on school-specific variables λ_i or P_i.[7]

Given the Pareto distribution of post-graduation manager skills, the probability of becoming a manager with degree i is

$$\pi_i(t) = \left(\frac{z_{\min}(t)}{\lambda_i z_0}\right)^{-\theta} = (\lambda_i z_0)^{\theta}(1-\tau)^{\theta}v(t)^{\theta}J(t)^{-\theta}.$$

We assume that z_0 is small enough so that this probability is always below one for each degree. Note that schools with higher λ_i will have a higher probability of producing managers.

We also know that for the Pareto distribution, the conditional mean above a truncation threshold is a constant multiple of the threshold, so the expected level of manager skills of those who become managers is independent of the degree,

$$\tilde{z}_i(t) = \frac{\theta}{\theta-1} z_{\min}(t) = \frac{\theta}{\theta-1}\frac{J(t)}{(1-\tau)v(t)}$$

The expected labor income from a degree is hence

$$\pi_i(t)(1-\tau)v(t)\tilde{z}(t) + [1-\pi_i(t)]J(t) = J(t)\left[1 + (\lambda_i z_0)^{\theta}(1-\tau)^{\theta}v(t)^{\theta}J(t)^{-\theta}/(\theta-1)\right]$$

[6]We assume that the tax is wasted and not spent in the economy.

[7]Our assumption that graduates compare future wage profiles when choosing a career, is motivated by evidence that changes in wage opportunities affect occupation choice. Berkhout, Hartog, and Praag (2016) show that entry into entrepreneurship depends on the expected foregone wages of the worker.

We are ready to write the expected benefit from degree i as

$$E_i = J(t)\left[1 + (\lambda_i z_0)^\theta (1-\tau)^\theta v(t)^\theta J(t)^{-\theta}/(\theta-1)\right].$$

The fraction of students choosing degree i is

$$x_i = \frac{e^{\alpha_i - P_i}\left[1 + (\lambda_i z_0)^\theta (1-\tau)^\theta v(t)^\theta J(t)^{-\theta}/(\theta-1)\right]^{1/\gamma}}{\sum_j e^{\alpha_j - P_j}\left[1 + (\lambda_j z_0)^\theta (1-\tau)^\theta v(t)^\theta J(t)^{-\theta}/(\theta-1)\right]^{1/\gamma}}.$$

This is increasing λ_i, the impact on manager skills, in α_i, the non-pecuniary benefits, and decreasing in P_i, the cost. Notice that the dependence on λ_i is strong when the benefit of becoming a manager, v/J is greater. This makes more business-oriented degrees more attractive.

The total mass of new managers that come with degree i is

$$l x_i(t)\pi_i(t),$$

reflecting both the school choice and the career choice of students. Hence the inflow of new managers from all degrees is

$$n(t) = l\sum_i x_i(t)\pi_i(t) = l z_0^\theta (1-\tau)^\theta v(t)^\theta J(t)^{-\theta}\Lambda[v(t)/J(t)]^\theta.$$

We have introduced a notation for the business training of the average student,

$$\Lambda(t) = \left[\sum_i x_i \lambda_i^\theta\right]^{1/\theta}. \tag{6}$$

This notation makes it explicit that the average manager training varies over time.

Note that when λ_is are different across degrees, Λ is greater than a simple arithmetic average because $\theta > 1$. The economic intuition is that degrees that provide more business education are going to send more managers to the market, distorting the average upwards. Policy can change Λ either by intervening in the curriculum directly (changing λ_i), or by steering students to different degrees by changing the cost P_i. There is also the indirect of effect of making manager positions more or less attractive in equilibrium.

Similarly, the total contribution to the stock of manager skills from recent graduates with degree i is

$$l x_i(t)\pi_i(t)\tilde{z}(t),$$

so that the overall inflow of skills from all degrees is

$$n(t)\tilde{z}(t) = \frac{\theta}{\theta-1} l z_0^\theta (1-\tau)^{\theta-1} v(t)^{\theta-1} J(t)^{1-\theta}\Lambda(t)^\theta.$$

3.7 Characterizing the dynamic system

There are four state variables changing over time: manager number $N(t)$ and manager skill $Z(t)$ are slowly-moving stocks, manager value $v(t)$ and worker value $J(t)$ are co-states that can jump if parameters change.

These are characterised by the following system of ordinary differential equations:

$$\begin{aligned}
v'(t) &= (\rho+\delta)v(t) - \nu\left[\frac{L-N(t)}{Z(t)}\right]^{1-\nu} \\
Z'(t) &= \frac{\theta}{\theta-1} l z_0^\theta (1-\tau)^{\theta-1} v(t)^{\theta-1} J(t)^{1-\theta} \Lambda(t)^\theta - \delta Z(t) \\
N'(t) &= l z_0^\theta (1-\tau)^\theta v(t)^\theta J(t)^{-\theta} \Lambda(t)^\theta - \delta N(t) \\
J'(t) &= (\rho+\delta)J(t) - (1-\nu)\left[\frac{L-N(t)}{Z(t)}\right]^{-\nu}
\end{aligned}$$

The *steady state* of this economy is when $v'(t) = Z'(t) = N'(t) = J'(t) = 0$,

$$\begin{aligned}
(\rho+\delta)v_* &= \nu\left(\frac{L-N_*}{Z_*}\right)^{1-\nu} \\
\delta Z_* &= \frac{\theta}{\theta-1}\delta L z_0^\theta (1-\tau)^{\theta-1} v_*^{\theta-1} J_*^{1-\theta} \Lambda_*^\theta \\
\delta N_* &= \delta L z_0^\theta (1-\tau)^\theta v_*^\theta J_*^{-\theta} \Lambda_*^\theta \\
(\rho+\delta)J_* &= (1-\nu)\left(\frac{L-N_*}{Z_*}\right)^{-\nu}.
\end{aligned}$$

To solve for the steady state, note that the average earning of managers, relative to workers, is

$$\frac{Z_*}{N_*}\frac{(1-\tau)v_*}{J_*} = \frac{\theta}{\theta-1}.$$

This follows from dividing the second and third equations above. Intuitively, the marginal manager makes, after taxes, the same amount as a worker. The average manager is $\theta/(\theta-1)$ better than the marginal by the properties of the Pareto distribution. In steady state, earnings are constant, so the ratio of flow wages is also the same, $\theta/(\theta-1)$.

We also know that the income share of managers, before taxes, is ν so that

$$\frac{\nu}{1-\nu} = \frac{Z_* v_*}{J_*(L-N_*)}.$$

Combining the two equations, we get the ratio of managers to production workers in steady state,

$$\frac{N_*}{L-N_*} = (1-\tau)\frac{\nu}{1-\nu}\frac{\theta-1}{\theta}.$$

The share of managers is high when doing business taxes are low, when management is important, and when managers are similar. Intuitively, when managers are taxed, there is less incentive to become one. By contrast, if managers are important in production, they can capture a large share of income. And finally, if managers are similar, their wage premium relative to workers is low, so firms are more willing to hire them.

As fraction of total population, express the steady-state number of managers as

$$\frac{N_*}{L} = \frac{1}{1 + \frac{1-\nu}{(1-\tau)\nu}\frac{\theta}{\theta-1}}.$$

Notice that this does not depend on z_0, Λ, ρ and δ. The dynamic variables ρ and δ affect the present value of manager and workers wages the same way, hence it they do not affect manager entry. It is less intuitive why z_0 and Λ do not matter for the share of population that become managers. There are two forces at play. A higher Λz_0 means that managers, including the marginal manager, are more skilled. There is more incentive to enter. Manager entry, however, drives up worker wages, which reduces the relative value of managers. With a Cobb-Douglas production function and a Pareto distribution of manager skills, the two effects cancel out.

Once we know what fraction of the population becomes a manager, we can solve for the relative value of managers and workers with the following equation,

$$\frac{v_*}{J_*}\Lambda[(1-\tau)v_*/J_*] = (1-\tau)^{-1}z_0^{-1}\left(\frac{N_*}{L}\right)^{1/\theta}.$$

The left-hand side is strictly increasing in v_*/J_*, so there is a unique solution. We have used the fact that Λ is increasing in v_*/J_*.

Relative value is important because it pins down the skill cutoff above which people choose to become a manager. The relative value of managers is increasing in ν, decreasing in θ (for the same reasons as discussed above), and decreasing in τ. It is also increasing in δ and decreasing in z_0.

We can finally solve for the steady-state stock of manager skills Z_* and GDP per capita. We can use equations 1 and 4 from the steady-state definition

$$(\rho+\delta)v_* = \nu\left(\frac{L-N_*}{Z_*}\right)^{1-\nu}$$
$$(\rho+\delta)J_* = (1-\nu)\left(\frac{L-N_*}{Z_*}\right)^{-\nu}.$$

and divide them to get

$$\frac{Z_*}{L} = \frac{\nu}{1-\nu}\frac{1-N_*/L}{v_*/J_*} = \frac{\nu}{1-\nu}(1-\tau)\Lambda_* z_0\left(\frac{N_*}{L}\right)^{-1/\theta}\left(1-\frac{N_*}{L}\right)$$

Substitute this in the aggregate production function to get per capita GDP as

$$\frac{Y_*}{L} = \left(\frac{\nu}{1-\nu}\right)^{\nu} (1-\tau)^{\nu} (\Lambda_* z_0)^{\nu} \left(\frac{N_*}{L}\right)^{-\nu/\theta} \left(1 - \frac{N_*}{L}\right).$$

Policy can increase steady-state GDP per capita with pro-management policies in a number of ways. First, it can increase the number of managers by lowering the taxes on manager positions (lowering τ). Second, it can subsidize schools offering more management training, by lowering P_i for those with high λ_i. Third, it can directly change the curriculum and introduce more business education in certain schools (increasing λ_i). And finally, any policy change that affects the value of managerial positions relative to being a worker will change the incentive to attend business-relevant training.

Proposition

The system is saddle-path stable.

To show this, log-linearize the ODEs around the steady state,

$$\begin{pmatrix} \hat{v} \\ \hat{Z} \\ \hat{N} \\ \hat{J} \end{pmatrix} = \begin{bmatrix} \rho+\delta & (1-\nu)(\rho+\delta) & (1-\nu)(\rho+\delta)(1-\tau)\frac{\nu}{1-\nu}\frac{\theta-1}{\theta} & 0 \\ (\theta-1)\delta & -\delta & 0 & (1-\theta)\delta \\ \theta\delta & 0 & -\delta & -\theta\delta \\ 0 & -\nu(\rho+\delta) & -\nu(\rho+\delta)(1-\tau)\frac{\nu}{1-\nu}\frac{\theta-1}{\theta} & \rho+\delta \end{bmatrix} \begin{pmatrix} \tilde{v} \\ \tilde{Z} \\ \tilde{N} \\ \tilde{J} \end{pmatrix},$$

and note that the matrix has two negative and two positive eigenvalues.

4 Calibration and policy counterfactuals

We calibrate the parameter values as follows.

The parameters λ_i and θ are estimated from the relationship between the average firm size of a cohort and the selectivity of the managers' degree (economics, engineering, other college, or no college).

Given our estimate μ_c from regression (1), we can estimate the degree of selection. Recall that average firm size for those entering in year c is proportional to the average manager skill, $\tilde{z}(c)$, so that $\mu_c = \ln \tilde{z}(c)$ up to a consant. We can rewrite the selection equation for degree i as

$$\ln \pi_i(c) = \theta \ln \lambda_i - \theta \mu_c + \epsilon_i(c).$$

The share of graduates with degree i who become CEOs is $\pi_i(c)$. This is increasing in λ_i, the impact on manager skills, and decreasing in μ_c, the average firm size of the cohort. The relationship between selection and average firm size captures the shape of the manager skill distribution and identifies θ.

Table 2: Selection by CEO degree

VARIABLES	(1) Share of CEOs, log
Average firm size, log	-4.380***
	(0.736)
Degree = economics	3.447***
	(0.364)
Degree = engineering	3.425***
	(0.362)
Degree = other	2.190***
	(0.371)
Constant	-7.935***
	(0.246)
Observations	82
R^2	0.668

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We measure the share of graduates becoming CEO as the ratio of CEOs with a given degree who graduated in the ten years preceding year c, divided by the total number of graduates in that time period. We use the 10-year rolling sum of graduates to smooth out fluctuations in our sample and college admissions.[8] Notice that the numerator of this ratio only counts those CEOs from whom we have education information. This is a small fraction of all CEOs, but it is not a problem because we are interested in the relative share of managers with different degrees.

We recover λ_i and θ from this equation with an OLS regression with fixed effects. We expect λ_i to be high for business-relevant degrees and θ to be positive, implying that for degrees and time periods that are very selective of managers (relatively few of the graduates become managers), the average firm size is larger.

The estimates imply that economics degrees produce exp(3.447) = 31.4 times more managers per graduate than schools in the control group (secondary schools). The estimated θ is 4.38. This means that if the share of managers in a school cohort increases by 1 percent (not pp), the average quality of this cohort drops by 1/4.38 = 0.228 percent. This is a relatively large degree of selection. All college degrees are associated with a higher share of managers, with economics and engineering having the highest impact.

We next estimate the non-pecuniary benefits α_i and the inverse elasticity γ for school

[8] We have degree-level graduation counts for years 1975, 1975, 1977, 1978, 1985-93, 2001-10, we linearly interpolate in between. Given our long moving average, the interpolation does not affect the results.

choice.[9] We estimate a logit for the share of students choosing a degree i in cohort c, with the expected wage income from the degree as the explanatory variable. Because expected wages are endogenous in the model, we need to compute the model steady state for a set of candidate parameters. The steady-state depends on α_i and γ, so this becomes a fixed point problem. Notice, however, that the steady-state only depends on these parameters through Λ, the average business training of graduates. This we can compute from λ_i and θ, which already have been estimated, and the actual school choice of students $x_i(c)$.

We then estimate α_i and γ to match the steady state division of students across different degrees, using maximum likelihood

$$x_i(t) = \frac{e^{\alpha_i}\left[1 + (\lambda_i z_0)^\theta \tilde{z}(t)^{-\theta}\theta^\theta(\theta-1)^{-\theta-1}\right]^{1/\gamma}}{\sum_j e^{\alpha_j}\left[1 + (\lambda_j z_0)^\theta \tilde{z}(t)^{-\theta}\theta^\theta(\theta-1)^{-\theta-1}\right]^{1/\gamma}}.$$

We use two time periods. The years 1983-85 are still under communism, so expected manager income (and manager entry) is low. We take the average graduation shares in these three years to capture the school choice in the communist steady state. The years 2003-05 are already under capitalism, so we take the average graduation shares in these three years to capture the school choice in the capitalist steady state.

Estimating this logit regression yields an $\alpha = -2.23$ for business degrees (the α of secondary schools is normalized to zero) and $\gamma = 0.059$. This γ implies a relatively elastic response of school choice to monetary incentives, as we will see below.

We calibrate $\delta = 0.033$ to match the average life cycle of managers in the data with 30 years of activity. We calibrate $\tau = 0.929$ to match the suppressed headcount share of managers under communism, which is about 1/14 of the steady-state level in capitalism. The model can only reconcile this with a very large tax of managerial positions.

The estimated and calibrated parameter values are shown below.

4.1 Post-communist liberalization

As a validation of the model, we check what happens as the economy transitions from communism to capitalism. Some of the parameters were calibrated to this transition, but the different mechanisms of the model are still interesting to explore.

Take a communist steady state with a low number of firms, stemming from high cost of doing business τ. How does the economy adjust to a new, capitalist steady state with low τ?

As the economy liberalizes, the pre-tax value of being a manager drops. This is because managers expect competition from all future cohorts of new entrants, thereby reducing

[9] Because α_i and P_i cannot be separately identified, we normalize the latter to zero.

Table 3: Calibrated parameter values under communism

Parameter	Explanation	Value
ν	Steady-state ratio of managers to workers	0.174
τ	Tax rate	0.929
ρ	Discount rate	0.050
δ	Retirement rate	0.033
θ	Skill distribution, shape	4.380
λ_1	Skill multiplier in business schools	2.197
λ_2	Skill multiplier in engineering	2.185
λ_3	Skill multiplier in other college	1.649
α_1	Relative preference for business schools	-2.23
α_2	Relative preference for engineering	-2.02
α_3	Relative preference for other college	-0.204
γ	Importance of non-pecuniary education benefits	0.059

their present discounted value of wages. This competition becomes more and more intense as the *stock* of managers gradually increases. This further reduces manager value towards the steady state.

Entry will closely track the value of being a manager. Initially, there is a jump in entry, because the *post-tax* value is higher than before. As this value declines, so does manager entry, before reaching its steady state (fig. 5). The figure also plots two alternative calibrations, with γ calibrate to 10 times and 0.1 times its original value. This makes school choice less and more elastic to expected managerial income. Manager entry is not very sensitive to this parameter. The reason is that managers enter from all schools, not just business schools, so the number of managers is not very sensitive to the elasticity of school choice.

Because of the large entry, the average skill of entrants will drop sharply (fig. 6). Even in the steady state, the average manager is much less skilled than under communism. This is because the number of managers is much higher, so the average manager is closer to the margin. The drop is smaller when school choice is elastic, because additional training by business schools partially offsets the selection effect.

School choice is shown on fig. 7, which plots the share of students choosing business schools. This share increases sharply at the beginning of the transition, but then declines as the economy converges to the new steady state. The reason is that business schools become more attractive as the value of managerial positions increases, but then become less attractive as the number of managers and hence competition increases. The share of students choosing business schools is higher when school choice is more elastic. Notice, however, that this highly elastic demand for business education may not be met by actual supply (this friction is missing from the model). The share of students choosing business schools is still below 10 percent in the new steady state.

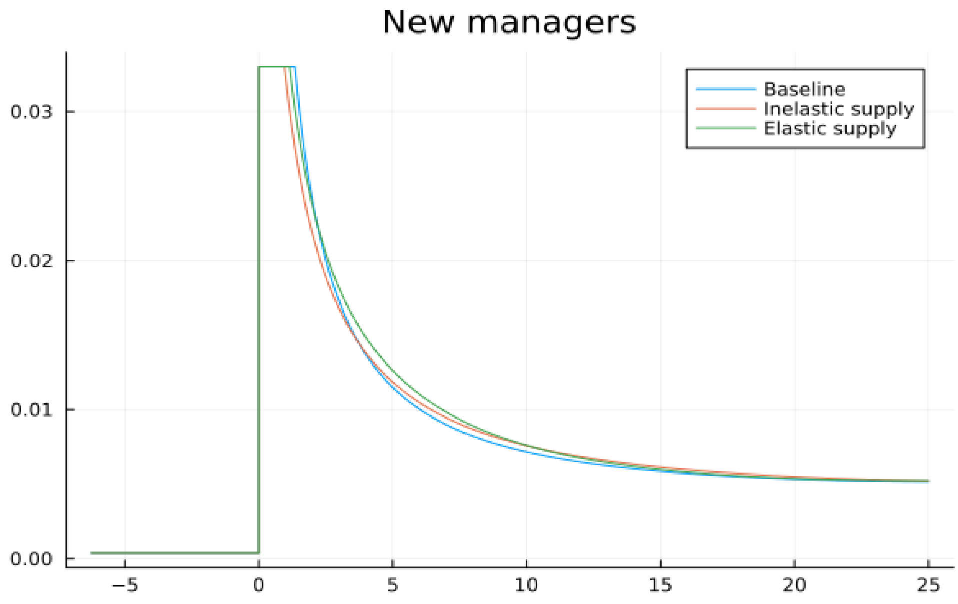

Figure 5: Manager entry increases suddenly

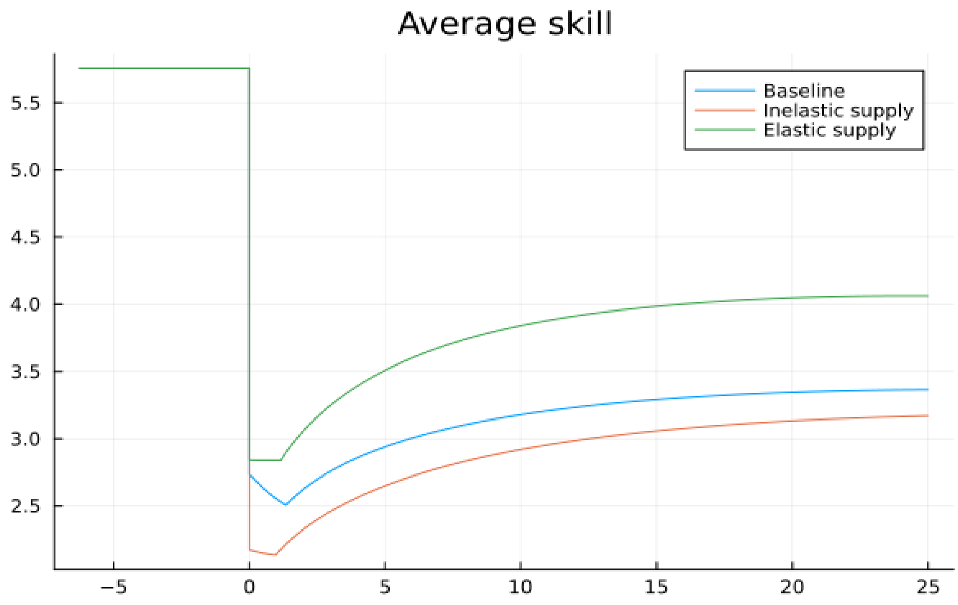

Figure 6: Entrant skill drops sharply

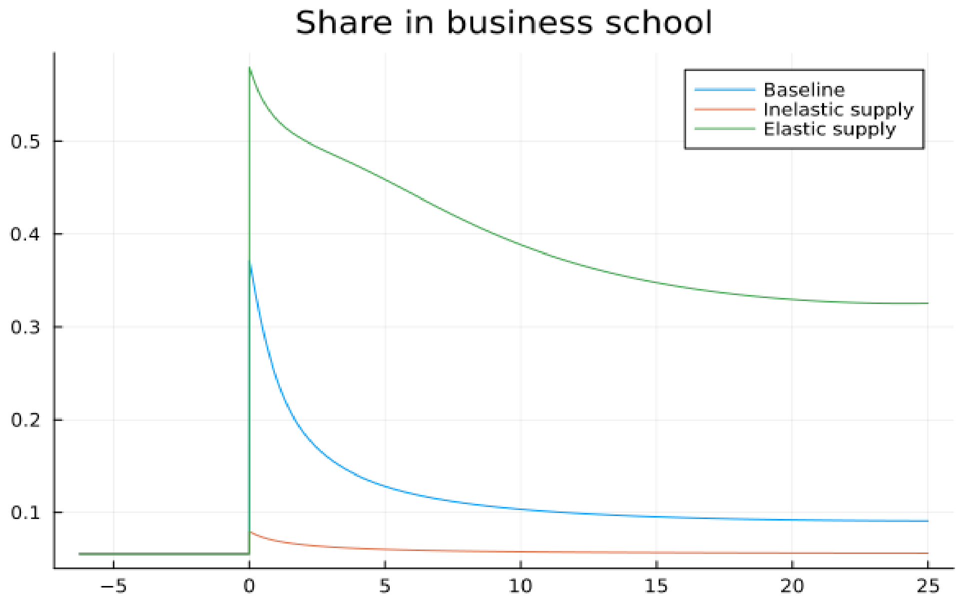

Figure 7: Business schools become more popular

The combined effect of entry, selection, and additional business training yield a path for aggregate GDP (fig. 8). Note that GDP is higher in the new steady state, both becayse there are more managers and because more of them went to business schools. There are offsetting forces of selection and competition. Selection reduces GDP because the average manager is less skilled. Competition reduces GDP because the typical firm can hire only fewer workers.

The table below decomposes GDP change to four components. Manager entry captures the 14-fold increase in the steady-state number of managers and their effect on total manager skills. This contributes 58.4 percent to GDP change. Average education of managers increases because more of them go to business schools, which are now more attractive. This is a smaller effect, contributing only 2.3 percent to GDP increase. Selection captures the fact that a larger fraction of the cohort becomes managers, hence, the average manager is less skilled. This effect actually reduces GDP by 9.5 percent. And competition measures the substitution away from production workers towards managers, reducing GDP by 13 percent. The overall increase in GDP per capita due to the change in manager taxes is 27.6 percent.

After the transition, the model predicts 10.8 percent of students going to business schools, up from 3.3 percent under communism.

4.2 Three policy reforms

We consider three policy interventions to increase per capita GDP through management. The first is reducing taxes facing managers. The second is increasing the attractiveness of

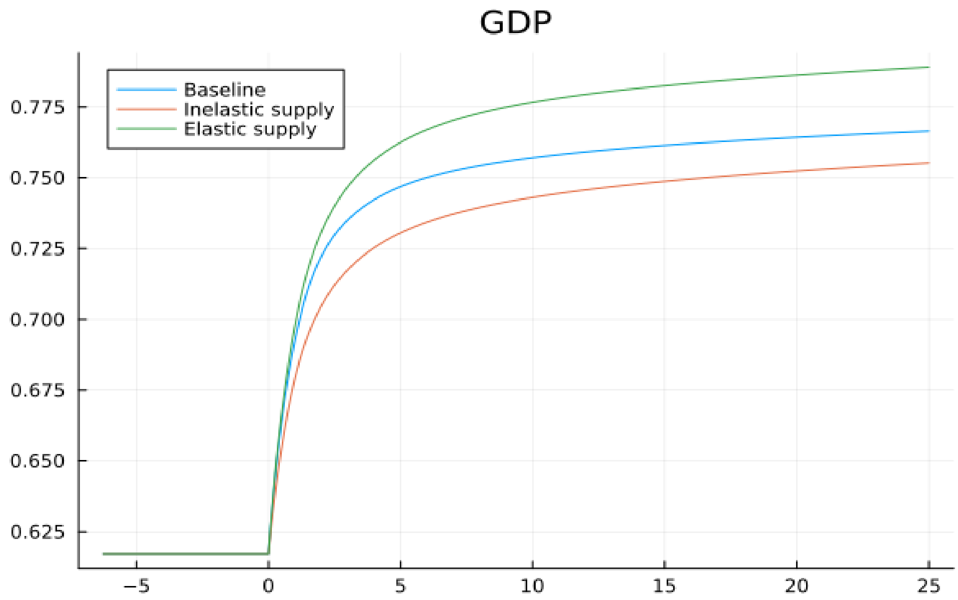

Figure 8: GDP converges to a higher steady state

business education. The third is directly changing the curriculum of business education to increase management skills.

All three interventions are calibrated to yield a 5 percent increase in GDP per capita relative to the communist steady state. Their mechanisms are, however, drastically different.

A direct subsidy (or reduced taxation) of managerial positions leads to large entry of new managers in the steady state (even larger during the transitional dynamics, see fig. 5). Higher entry contributes to 7.1 percent higher GDP. Because of this large entry, there is also a lot of selection: new managers are, on average, 1.5 percent worse than old ones. Because there are relatively few managers under communism, the effect on education and on competition of managers for workers will be muted (0.1 percent and −0.6 percent, respectively).

The other two interventions both change the average education level of managers to the same degree (by construction). Neither change entry, selection and competition in the steady state. Subsidizing business schools can only bring about a 5 percent increase in GDP per capita, if the share of students going to business schools rises from 3.3 percent to 61.4 percent. This is an implausibly large reallocation of students. To bring about such a change, the lifetime value of going to business school should go up by 26.7 percent.

Curriculum reform works by directly changing the skills of students and hence leads to smaller reallocations. The increase GDP by 5 percent, the skill multiplier of business schools should increase by 47.4 percent. This is a more plausible change, but still a large one. Business schools become more popular because they offer higher-wage career opportunities, with enrollment increasing from 3.3 percent to 5.5 percent.

Table 4: Effects of counterfactual policies

	Transition (τ)	Manager tax	School benefit	Curriculum
Percentage change	-100.0	-3.7	26.7	47.4
Manager entry	58.4	7.1	0.0	0.0
Average education	2.3	0.1	5.0	5.0
Selection	-9.5	-1.5	0.0	0.0
Competition	-13.0	-0.6	0.0	0.0
Total GDP change	27.6	5.0	5.0	5.0
Share in business school	10.8	3.6	61.4	5.5

Note: The table shows the percentage change in GDP per capita and its components between steady states. The transition column shows the effect of reducing the tax on managerial positions to zero, to match the number of managers in the capitalist steady state. The manager tax column shows the effect of reducing the tax on managerial positions. The school benefit column shows the effect of increasing the non-pecuniary benefit of business schools. The curriculum column shows the effect of increasing the skill multiplier of business schools.

We expect these policies to also have meaningful interactions, because it may be worth subsidizing business schools when managerial positions are also liberalized. Our framework allows for the evaluation of a combination of these policies, including their dynamic patterns.

5 Conclusion

We built a dynamic equilibrium model of managers to study the demand and supply of good management and the competition between managers of heterogeneous skills. We used data on the universe of corporations and their top managers in Hungary between 1985 and 2019 to study the rapid liberalization of the 1990s through the lens of our model. Our results suggested that the inelastic supply of good managers is an important constraint to the success of management interventions.

We expect this model to be useful for studying other macroeconomic interventions in the manager market. With small modifications, one can explore the effects of policies relating to the education system, the tax system, and the international labor market.

The model also has implications for manager earnings: How much more does a manager make relative workers and how unequal are manager earnings? With data on manager earnings, the model can also be used to better understand the distribution of manager skills.

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7 Appendix

7.1 A model of communist firms

The main model was agnostic about why there were few firms and few managers under communism. We used the doing business friction τ to calibrate the level of N and Z. This appendix introduces a labor hoarding motive for large firms.

Suppose firms are jointly run by a manager who maximizes their own rent ω, and a communist party secretary who maximizes the wage paid to workers wh. The joint objective function is

$$\max_h z^\nu h^{1-\nu} - wh + \alpha wh.$$

The weight of the party secretary is $\alpha > 0$.

This problem has the first-order condition

$$(1-\nu)z^\nu h^{-\nu} = (1-\alpha)w.$$

The party preference will act as an ad-valorem subsidy on wages and each firm will employ a larger number of workers than in the capitalist case.

$$h(z) = z[(1-\alpha)w]^{-1/\nu}(1-\nu)^{1/\nu}.$$

The subsidy is not actually paid to the manager, though, so less will remain to be paid as manager wages. The manager's equilibrium wage is

$$z^\nu h(z)^{1-\nu} - wh(z) = w^{(\nu-1)/\nu} z(1-\alpha)^{1-1/\nu}(1-\nu)^{1/\nu-1}[1-(1-\nu)/(1-\alpha)].$$

This is almost the same as with capitalist firms, but there is a proportionally lower manager wage if $\alpha > 0$. Hence, fewer people will want to become managers and the average firm will be larger. We can calibrate α to match the number and size of firms under communism.

7.2 The distribution of manager skills over time

Recall that $G(z,t)$ denotes the period-t probability distribution of manager skills. In equilibrium, this is a continuous distribution, so it can also be characterized by its density function $g(z,t)$. Let $\mu(z,t) := N(t)g(z,t)$ denote the *mass* of managers with skill z at time t. We will characterize the evolution of $\mu(z,t)$ using the Kolmogorov forward equations.

There are two flows potentially changing the mass of managers of skill z. First, each manager retires with arrival rate δ. This is independent of z and leads to a loss of managers of that particular skill. Second, for skills above the entry threshold, new managers are entering from the exogenous skill distribution. This depends on z for two reasons: there is no entry below the threshold, and the distribution of entrants is also z-specific.

Recall that $z_{\min}(t)$ is the threshold at time t. Take the case when $z_{\min}$ is continuously increasing over time, converging to it steady state $z^*_{\min}$. Managers with skills $z \geq z^*_{\min}$ will always be good enough to enter, so their Kolmogorov equation is easiest to characterize:

$$d\mu(z,t) = lf(z)dt - \delta\mu(z,t)dt \text{ if } z \geq z^*_{\min}.$$

Over an infinitesimal time period dt, ldt potential managers are born, of whom $f(z)$ have exactly skill z. And a δt fraction of the existing managers retire.

For $z < z^*_{\min}$, there will come a time when managers with this skill are no longer competitive enough to enter. Denote this time by $T(z) := \max t : z \geq z_{\min}(t)$. Notice that $T(z)$ is finite for all $z < z^*_{\min}$ because the latter is the limit of the thresholds. And $T(z)$ is increasing in z because threshold increase over time. Importantly, just because managers of skill z are no longer competitive to enter, those already in the market will not exit. By assumption exit is only due to random retirement.

The Kolmogorov equation for these skill levels will be different before and after reaching time $T(z)$. After this time, there is no new entry, only random exit:

$$d\mu(z,t) = -\delta\mu(z,t) \text{ if } t > T(z).$$

Before this time, entry also needs to be take into account,

$$d\mu(z,t) = lf(z)dt - \delta\mu(z,t)dt \text{ if } t \leq T(z),$$

or

$$\frac{\partial d\mu(z,t)}{\partial t} = lf(z) - \delta\mu(z,t) \text{ if } t \leq T(z).$$

These equations are ordinary differential equations of t for each level of z. The generic solution for high-skill managers is

$$\mu(z,t) = \mu^*(z) + K_1(z)e^{-\delta t} \text{ if } t \leq T(z),$$

where $\mu^*(z) := lf(z)/\delta$ is the steady-state mass of managers of type z if entry continued forever and $K_1(z)$ is a constant of integration. Similarly,

$$\mu(z,t) = K_2(z)e^{-\delta t} \text{ if } t > T(z).$$

Because there is no endogenous exit, the mass of managers is a continuous function of time for each z. The two boundary conditions pinning down K_1 and K_2 are

$$\mu(z,0) = \mu_0(z)$$

and, at the time cutoff $T(z)$,

$$\mu^*(z) + K_1(z)e^{-\delta T(z)} = K_2(z)e^{-\delta T(z)}.$$

These pin down

$$\begin{aligned} K_1(z) &= \mu_0(z) - \mu^*(z) \\ K_2(z) &= \mu_0(z) + \mu^*(z)\left[e^{\delta T(z)} - 1\right] \end{aligned}$$

so that

$$\mu(z,t) = \begin{cases} \mu^*(z)\left[1 - e^{-\delta t}\right] + \mu_0(z)e^{-\delta t} & \text{if } t \leq T(z) \\ \mu^*(z)\left[e^{-\delta[t-T(z)]} - e^{-\delta t}\right] + \mu_0(z)e^{-\delta t} & \text{if } t > T(z) \end{cases}$$

The mass of managers with skill z is gradually increasing towards the steady state as long as $t \leq T(z)$ and gradually decreasing towards zero aftwerwards.

Proposition

If $F(z)$ is Pareto then after some finite time T, the distribution of manager skills $\mu(z,t)$ for $t > T$ will be unimodal, with the mode at $z_{\min}(t)$.

In other words, the most frequent skill in the market will be the one that is just marginal for entering today. All skills below have been gradually disappearing. The lower the skill, the longer it has been obsolete, so the skill distribution is increasing in z below the mode. Above the mode, managers have been entering and exiting, gradually converging to the Pareto steady state.