Regulation and Taxation in a Model of Growth

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Abstract

In this paper we construct a growth model with increasing returns stemming from product variety to explore the different effects of regulations and taxes on economic activity. Regulations primarily raise fixed costs, while taxes primarily increase variable costs. This is key because fixed costs determine the extent of specialization, which in our model plays an important role in human capital accumulation. Growth, then, is more severely impacted by regulations than by taxes. Empirical tests using panel data across countries provides support for the theory. (*JEL Codes: O41, O33, O14, E24, E23*)

1 Introduction

We construct a model of growth with increasing returns to scale based on variety in production and monopolistic competition to analyze the effect of regulations and taxes on the level of output per capita and its rate of growth. The key difference between regulation and taxation is that regulations have a fixed-cost component – potentially very large — in addition to a variable-cost component, whereas taxes are essentially variable costs. In addition to the cost of inputs, labor, and capital, businesses must pay taxes and shoulder the costs of complying with various regulations. Taxes depend, generally, on how much the firm produces or how much income it earns. Regulations, on the other hand, usually impose at least some costs that do *not* depend on the scale or success of the operation. For example, the cost of financial compliance, expenses for complying with environmental standards, health and safety costs, and licensing fees can impose annual costs on businesses that are at least partly independent of the amount produced. To investigate the effect of fixed costs, it is useful to use a model with increasing returns to scale.

Our model has two stages of production. In the first stage, intermediate inputs are produced by monopolistically competitive firms using skilled labor. In the second stage, these inputs are combined with additional skilled labor to produce the consumable good. We use it to show that, while both regulations and taxes reduce the *level* of per capita output, only regulations reduce the *growth rate* of output per capita. The reason for the difference is that fixed costs, in the form of

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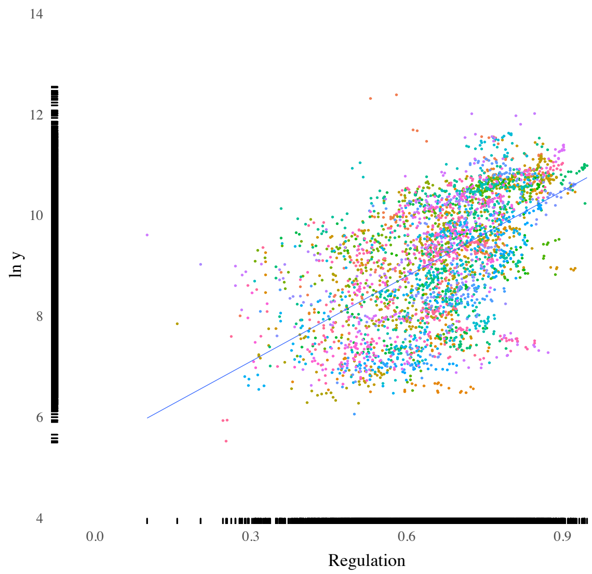
regulations, reduce the degree of specialization in the economy. This has two effects: it directly reduces output due to increasing returns in production and it indirectly reduces the return to human capital, which depends on the complexity of the economy. Taxes do not have this effect. On the other hand, because both taxation and regulation reduce the demand for every intermediate input, both policies reduce the productivity of labor so real wages and output fall. It follows, then, that if a country has a choice between regulating and taxing to achieve a policy outcome – say, clean water – it is better to tax than to regulate.

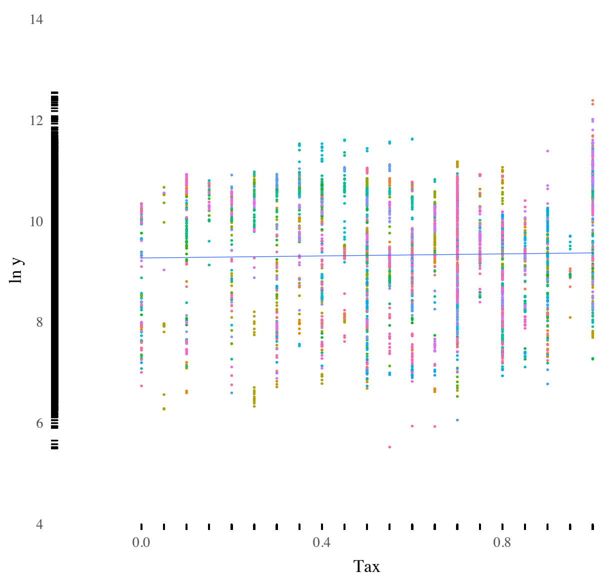
The second part of the paper tests the predictions of the model using a panel data set going back to 1970 (for some countries). To measure regulation and taxation, we rely primarily on the data from the *Economic Freedom in the World* database constructed by the Fraser Institute. It constructs a *regulation score* and *tax score*, both of which go from 0 to 1, where 1 is the *least restrictive* regulatory and tax environment. There are other sources of data to measure the liberality of the regulatory and tax environment, so we also use data from the World Bank's *Doing Business in the World Index* (for regulation) and the *International Tax Competitiveness Index* from the Tax Foundation (for taxation). We prefer the *EFW* data because it has greater coverage, both across countries and over time. For real GDP per capita, we use the *Penn World Table* v. 10.0 (depending on the context, we use either the series $RGDP^E$ or $RGDP^{NA}$, divided by the population).

We can summarize our results as follows, using Figure 1 for reference. This figure shows the nature of the relationship between the natural logarithm of per capita real output ($\ln y$) and the regulation score in Panel (a) and the tax score in Panel (b). The straight lines are the simple, pooled OLS regression lines, and the colors identify different countries. Low regulation (a *high* regulation score) appears to have a strong, positive association with $\ln y$ in Panel (a). This result is very robust: whether using pooled OLS or panel methods, with and without controls, and using different data, the regulation score is highly and positively associated with $\ln y$. The same is true for the relationship between the *growth rate* of per capita real output ($\Delta \ln y$) and the regulation score (not shown). These results fit the model's predictions well. On the other hand, in Panel (b) the association between $\ln y$ and the *tax score* is barely perceptible, when it should be positive. When we use panel methods, however, we *do* find a significant, positive relationship: low tax rates and high tax brackets (a *high* tax score) are associated with a higher $\ln y$. Even so, this relationship is not nearly as strong or as robust as that between the regulation score and $\ln y$. On the other hand, as predicted by the model, the tax score appears to have *no* discernible relationship to the *growth rate* of real per capita output.

One consistent result is that using country within-effects explains more of the variation in $\ln y$ than does pooled OLS, which suggest that differences across countries are influenced by unobservable nation-level characteristics. Such characteristics may be proxied with the *absolute value of latitude*, which contains information on culture, climate, and technology that is relevant to real output. Interestingly, countries far from the equator behave differently from those close to the equator in terms of our policy variables. The correlation between our measure of latitude and the regulation score is *positive*, but between latitude and taxation it is *negative*. Sweden, as an example,



(a) Regulation



(b) Taxation

Figure 1: Taxation Regulation and the Log of y

has a very low tax score (again, meaning high taxes that kick in a low levels of income) but a high regulation score (that is, regulations that do not burden the economy). This correlation is consistent with the model's prediction that countries that tax rather than regulate to accomplish goals have a smaller negative impact on output per capita and growth. Interestingly, overall, taxation and regulation are slightly positively correlated.

We are aware that regulation and taxation are subject to reverse causality that makes them endogenous to some extent. We address this issue and make the case that our results still suggest that independent variation in regulation and taxation scores have the predicted effects. We do not use an instrumental variable technique to address this issue, since the use of instrumental variables can lead to severe bias if the strict assumptions do not hold. Instead, we make the case that any bias from OLS is in the direction that underestimates the true effect.

Our growth model does not consider any positive benefit for either regulation or taxation. Some level of both are certainly necessary for the functioning of government and the maintenance of public order, but it is not difficult to imagine that many of the benefits do not show up as increases in real output or growth. For example, environmental regulations are very important to maintain and enhance quality of life, but place burdens on job creation and productivity gains. Taxation is often redistributionist, which can be a huge benefit to low-income workers and those who cannot work, but probably reduces output in both the short run and the long run. Most of the work discussed next takes the view, either explicitly or implicitly, that regulation and taxation on balance reduce economic activity.

An early treatment of regulation was by Stigler (1971), who showed that industry often had the ability to use regulation for its own benefit. Later empirical work seemed to confirm that regulations are often not in the public interest, but rather serve to reward business or politicians. In their work, Djankov et al. (2002) showed that the data was more consistent with what they called the "public choice" view of regulation than the "public interest" view. That is, that businesses were able to use the regulatory structure to reduce competition and increase market share and profit. Dawson and Seater (2013) use the number of pages in the US *Code of Federal Regulations* as their measure of the extent and complexity of regulation in the United States since 1949. They show that the US growth rate could have been two percentage points higher per year if not for the increase in regulation. Our work is more in line with a recent theoretical and empirical contributions by Bento (2020) and Coffey et al. (2020), in which a particular economic structure is proposed to explain why regulations can have negative effects.[1]

Taxation has also been examined for effects on economic activity. Probably more so than regulation, taxation is subject to simultaneous causality: changes in income certainly lead to changes in *tax revenue*, but also might lead to changes in top marginal tax rates and tax brackets – which our tax score measures. Thus, much of the empirical literature is concerned with identifying exogenous shocks to tax policy to see the subsequent effect on per capita output and growth. In a recent paper, Nguyen et al. (2021) use data from the United Kingdom to show that income tax reductions

[1] See also Nicoletti et al. (2003) for similar work using OECD data.

(unlike consumption tax reductions) have strong positive effects on output and growth. See also Zidar (2019), Mertens and Montiel Olea (2018), Barro and Redlick (2011), and Romer and Romer (2010); all of which show a negative impact of taxes on economic activity. Jaimovich and Rebelo (2017) propose a model, based on a distribution of ability among entrepreneurs, in which increases in taxes have little impact on growth when initial taxes are low, but very pronounced negative effects when taxes are already at a high level. They suggest that the effects of raising taxes when they are in this zone are so harsh that no developed countries ever raise taxes so high — so the data does not show a strong negative correlation between growth and taxes.

There is also a recent literature that focuses on the effect of taxation and regulation on innovation. Aghion et al. (2021) use a Schumpeterian model to show that a "regulatory tax" that applies only to firms that employ more than 50 workers discourages innovation most strongly for firms just below the threshold. Stantcheva (2021) shows that taxes affect innovation negatively, so that optimal tax rates that account for innovation are lower than those that do not. Akcigit and Stantcheva (2020) provides an overview of this literature, with an emphasis on the margins upon which innovators respond to taxation. This literature, like ours, ignores the possible benefits of regulation and taxation. It does not, however, model regulation as having a fixed-cost component.

The paper is organized as follows. In Section 2 we set out the production technology and in Section 3 we describe how human capital is accumulated. Then, in Section 4 we solve the static production equilibrium for the firms. In Section 5 we solve for the households' saving and consumption over time and calculate the closed-form solution for the growth rate. We look at the model's predictions of regulatory and tax policy for both level effects and growth effects in Section 6. There, we provide some examples to show that regulation, unlike taxation, typically has a large fixed-cost component. We also calibrate the model to the US economy to illustrate that regulation has more severe effects on the path of output compared to taxation. Then, we use our model in Section 7 to set up an empirical framework and present baseline result. Section 8 considers various robustness checks, including adding different controls and considering simultaneity explicitly. Section 9 concludes the paper.

2 Production Technology

There is one fundamental input, labor enhanced by human capital, that is used to produce both a final good Y and several intermediate input goods x_i. The final good is produced by competitive firms while the inputs are produced by M distinct monopolistic competitors.[2] The household's decision at each instant is to chose how much to work e_w and how much to study e_l to accumulate more human capital. Work is further subdivided into work in the final-goods sector e_y and work in the intermediate-goods firms e_x. Individuals are endowed with one unit of effort per time period

[2]The model of this paper is the same as the "conventional-only" economy model in Goodfriend and McDermott (2021). Here, however, we use it to explore a very different set of questions. Our approach is based on the product variety model of Paul Romer, especially Romer (1987). Earlier important work includes Dixit and Stiglitz (1977), Krugman (1980), and Ethier (1982).

so the time constraint is:

$$1 = e_w + e_l = e_y + e_x + e_l \tag{1}$$

.

The production technology is given by:

$$Y = \left(e_y \bar{h} N\right)^{1-\alpha} \int_0^M (x(i))^\alpha \, di \tag{2}$$

where $0 < \alpha < 1$. The amount used of each intermediate input i is $x(i)$. The inputs are combined into the final good with the help of *effective labor*, $e_y \bar{h} N$, where N is the number of workers, $\bar{h}$ is average human capital per worker[3], and, as noted above, e_y is the effort devoted to tasks in the competitive final-goods sector. The limit in the integral M stands for the range of different intermediate goods that are used.

The intermediate goods x_i are distinct inputs, each produced by a unique monopolistically competitive firm using effective labor. The cost function for producing the quantity x of any input good, in units of effective labor, is the same for all intermediates and is given by:

$$V(x) = v_0 + v_1 x \tag{3}$$

where v_0 and v_1 are constants. The amount of labor effort e_x is related to $V(x)$ in a manner specified below.

Aggregate consumption is $C = Y$. There is no difference between the population and the workforce, so per capita consumption and output are given by: $c = \frac{C}{N} = \frac{Y}{N} = y$.

3 Learning Technology

To accumulate human capital, the representative individual spends time learning e_l. A key feature of the model is that the degree of specialization in the economy M raises the productivity of e_l (see Goodfriend and McDermott, 1995, 1998, 2021). In particular, we model the learning technology as follows:

$$\dot{h} = L^\gamma h^{1-\gamma} e_l - \eta h \tag{4}$$

where $0 < \gamma < 1$ and η is the population growth rate. Population growth η enters (4) because of our assumption that parents must spend time to educate the newly born. The *specialization spillover* L is defined to be:

$$L \equiv \frac{M}{\bar{e}_w N} \tag{5}$$

[3] It is important to distinguish between an agent's own human capital – which she accumulates to increase her real wage — and the economy-wide average human capital $\bar{h}$, which the individual does not regard as something over which she has any influence. Eventually, we equate the two, but not before we derive the conditions for intertemporal equilibrium.

so that specialization enters proportionally, but we divide M by $\bar{e}_w N$ to account for a negative effect of congestion on the learning externality.[4] In (4) the effect of own human capital h and the spillover through M are sufficient to generate steady growth, as we show below.

The fact that specialization M raises learning productivity is a key component of the model. As we shall see, it provides the link from fixed cost of producing intermediate goods v_0 to the growth in human capital, and to the growth in y.

There is a long tradition of incorporating human capital spillovers into growth models, although usually in the production of output, not human capital itself. A notable example is Robert Lucas (1988). In that same paper, however, Lucas conjectures that the quantity and variety of human capital, especially in large cities, spills over to help others generate new, individual knowledge (Section 6). The larger the city, the greater the specialization of activity at all levels, and the larger the spillover to new knowledge formation. He credits Jane Jacobs (1969, 1984) for the key idea that such spillovers raise creativity within and between occupations. In later work, using a framework developed by Kortum (1997), he expanded on the idea that people learn from each other, largely via externalities from random encounters (Lucas 2009, 2015), perhaps facilitated by trade (Alvarez et al. 2013). We can think of specialization – a measure of goods variety – as a stand-in for the scale of exchange within a country. In his model of population and growth, Michael Kremer linked population size to the generation of knowledge by arguing that ideas arrive randomly through people (Kremer, 1993). Learning-by-doing across different industries is another way of relating specialization to the growth of individual human capital (Arrow 1962). Ehrlich and Kim (2007) construct a model in which human capital spillovers to new knowledge generation account for some key facts of structural change and the demographic transition.

Our spillover L can be thought of as a reduced-form way of accounting for the effect that complexity and variety of modern economies have on the generation of new knowledge. Later, we will see that M depends directly on the size of the effective population.

4 Production Equilibrium

Final firms operate in a purely competitive market, so factor prices are equal to marginal products. In this section, we solve for the equilibrium values of quantities and prices, taking as given overall effort e_w and the stocks h and N.

Final firms demand the input x from each of M distinct monopolistically competitive firms. The price p that they pay reflects the marginal product of each x in the production of the final good given by (2). This yields:

$$p = \alpha \left(\frac{e_y \bar{h} N}{x} \right)^{1-\alpha} \tag{6}$$

The intermediate firms, though different, enter final production symmetrically, so the inverse de-

[4]Desmet et al. (2018) incorporate negative congestion externalities into their utility function.

mand curves (6) are the same for each input. The wage of a unit of *effective* labor $e_y\bar{h}N$ is likewise equal to its marginal product. From the symmetry of intermediate firms and (2) this yields:

$$w_b = \frac{\partial Y}{\partial \left(e_y\bar{h}N\right)} = (1-\alpha)\left(\frac{e_y\bar{h}N}{x}\right)^{-\alpha} M \tag{7}$$

We call w_b the *base wage*; it rises with M because labor is combined with all of the different inputs into the final good. The actual wage of a worker w_s is the product of the base wage w_b and that worker's human capital, h: $w_s = w_b h$.

Intermediate firms exploit the demand (6) and produce the quantity x to maximize their profit

$$\pi = px - w_b V(x) \tag{8}$$

taking the base wage w_b as given. It is well known that profit maximization requires setting the price as a mark-up over marginal cost $v_1 w_b$:

$$p = \left(\frac{1}{\alpha}\right) v_1 w_b \tag{9}$$

where the gross mark-up is $1/\alpha$.[5]

At all times, the following constraint must hold:

$$e_x\bar{h}N = MV(x) \tag{10}$$

This says that the supply of effective labor to the intermediate firms $e_x\bar{h}N$ must equal the economy-wide demand for those inputs by all intermediate firms $MV(x)$.

In our baseline model, we assume that entrepreneurs can costlessly enter and hire labor to produce a new intermediate good. We use Figure 2 to illustrate the nature of the equilibrium that results from this assumption. The EQ curve shows the amount of input x that each intermediate firm would produce to maximize profit, as a function of the range of intermediate firms M, given the amount of work in efficiency units, $e_w\bar{h}N$. The ZP locus shows the set of (M, x) points such that the representative intermediate firm makes zero profit. Profit is positive for all points in the shaded area below the ZP locus. The ZP curve crosses the EQ curve from above and they only cross once. The two equations are derived in Appendix A.

If M is small, output x as determined by EQ is relatively high and intermediate-good firm profits are positive. This creates an incentive for entrepreneurs to enter and produce a new, distinct intermediate good. If entry is costless, and there are no legal barriers, then entry will take place and lead to an increase in M and a fall in profit to zero. The *zero-profit equilibrium* number of firms is M^* in Figure 2. Allowing firms to enter costlessly and quickly to drive profit to zero delivers a simple equilibrium. This is what we assume in the rest of the paper.

[5] To derive the markup, put (3) and (6) into the profit expression (8), then take the derivative with respect to x, and set to zero.

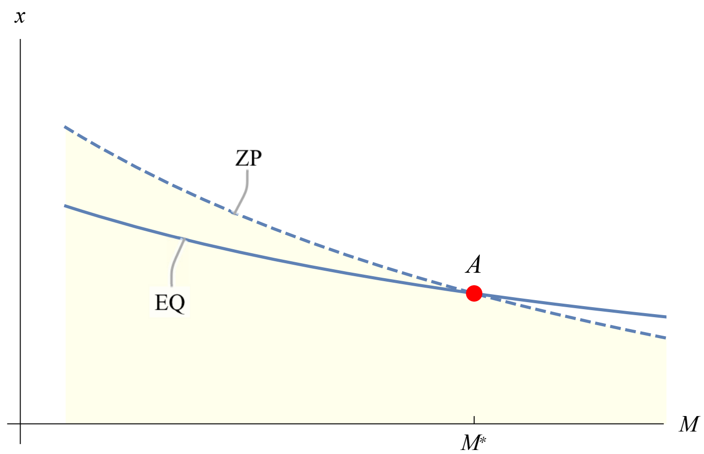


Figure 2: Monopolistically Competitive Equilibrium

In the symmetric, zero-profit equilibrium each input is produced in the same quantity:[6]

$$x^* \equiv \frac{\alpha v_0}{(1-\alpha)v_1} \tag{11}$$

Labor effort, in this equilibrium, is allocated proportionally between the two stages of production:[7]

$$e_x = \alpha e_w \tag{12}$$

$$e_y = (1-\alpha)\, e_w \tag{13}$$

Free entry of intermediate firms means that the range of inputs is endogenous. Use (10), (11), and (12) to see that in the zero-profit equilibrium M is:

$$M^* = \left(\frac{\alpha\,(1-\alpha)}{v_0}\right) e_w \bar{h} N \tag{14}$$

It is important in what follows that specialization — the number of intermediate goods M^* — is inversely related to fixed cost v_0 but not to variable cost v_1.[8] It is convenient to think of the degree of specialization M^* as depending on two parts, the *fixed-cost component* $(\alpha\,(1-\alpha)\,/v_0)$ and the *scale component* $(e_w \bar{h} N)$.

The equilibrium base wage can be found by taking (7) and substituting the equilibrium values for x^*, e_y, and M^* found in this section:

[6]To derive (11), substitute the cost function (3) and the mark-up (6) into the profit equation (8), set to zero and solve for x. Krugman (1980) derives the same, constant amount in his model based on utility variety.

[7]To see this, substitute the base wage (7) and the input price (6) in the markup equation (9). Then use the constraint (10) and the work relationship $e_w = e_x + e_y$ in the result.

[8]A fixed cost $v_0 > 0$ is necessary for equilibrium. This principle can be illustrated with a simpler model in which output is produced according to $Y = Mx^\alpha$ and a unit of any intermediate good is produced with one unit of labor. The latter means that the cost constraint is $Mx = N$, where N is labor. Without a fixed cost, given N, it is possible to increase Y to infinity by continuously raising M and reducing x in the same proportion. In our model, (11) and (14) illustrate the principle. That is, if $v_0 \to 0$, then M^* rises to infinity while x^* goes to zero. See Romer (1987).

$$w_b = B\left(e_w \bar{h} N\right)^{1-\alpha} \tag{15}$$

where:

$$B \equiv x^{*\alpha}\left(\frac{\alpha(1-\alpha)}{v_0}\right)(1-\alpha)^{-\alpha} = \frac{\alpha^{1+\alpha}(1-\alpha)^{2(1-\alpha)}}{v_0^{1-\alpha}v_1^{\alpha}} \tag{16}$$

The object B represents the effects on the real wage in (7) that are independent of scale $e_w hN$. That is, B shows the effect on the real wage from the quantity of intermediates used x^* and the *fixed-cost portion* of specialization M^*, which is $(\alpha(1-\alpha)/v_0)$. The other term, $(1-\alpha)^{-\alpha}$ represents the relation of e_y to e_w, insofar as it affects the wage. Below, we separate out the effects of policy change on the effects coming through B and those coming through the scale variable $\left(e_w \bar{h} N\right)^{1-\alpha}$.

Scale – whether through $\bar{h}$ or N – has a positive effect on the base wage (15) after we endogenize M. New intermediate firms enter the market when effective labor rises and this increases the base wage since the productivity of labor is enhanced when any input increases in quantity or there are more inputs. The effect of h on *skilled* wages $w_s = w_b h$ is even larger, since h raises productivity proportionally.

In this model there is only one input, labor enhanced by human capital. In the symmetric, zero-profit equilibrium, per capita output y – which is the same as consumption c — is equal to the earnings of the representative worker:[9]

$$y = c = w_b h e_w = B(e_w h)^{2-\alpha} N^{1-\alpha} \tag{17}$$

The term after the third equality uses (15) and (16) for w_b. Increasing returns to scale shows up clearly in (17): an increase in population N raises wages – as specialization increases — and increases in human capital per worker $\bar{h}$ raise wages more than proportionally.

5 Consumer Equilibrium and Growth

The infinitely-lived representative household maximizes:

$$\int_0^\infty N(t)\,u(c(t))\,e^{-\rho t}dt = \int_0^\infty u(\ln c(t))\,e^{-(\rho-\eta)t}dt \tag{18}$$

by choosing how much to work and learn at each moment. In (18), $u(c(t)) = \ln c(t)$ is instantaneous utility and ρ is the subjective rate of discount. We choose logarithmic utility for tractability. Initial population $N(0)$ is normalized to 1; and population grows at the rate η.

The only asset in the economy is human capital, and the only form of saving is *learning*. Individuals spend time studying to accumulate h to raise the *skilled* wage $w_s = w_b h$, taking w_b to be given. In reality, w_b rises with h, as we have seen, due to the scale effect that raises specialization

[9]The easiest to way to see this is to multiply (7) by e_w and h, then compare it to (2) after dividing by N and assuming symmetry to eliminate the integral in (2).

M, but individuals are not aware of their own impact on the aggregate scale effect.

The allocation of effort between work e_w and learning e_l is determined by the instantaneous value of h and the instantaneous value of the *shadow utility price* of human capital λ. In Appendix B we show how the first-order conditions for the dynamic optimization problem reduce to two differential equations in h and λ. The learning technology, (4) and (5), controls the change in h over time. The shadow utility price λ must change instantaneously to equate the cost and benefit of accumulating h: $\dot{\lambda} = (\rho - \eta)\,\lambda - \frac{\partial \mathcal{H}}{\partial h}$, where $\mathcal{H}$ is the Hamiltonian equation for the optimization problem. Finally, the transversality condition:

$$\lim_{t\to\infty} \lambda(t)\, h(t)\, e^{-(\rho-\eta)t} \equiv \lim_{t\to\infty} z(t)\, e^{-(\rho-\eta)t} = 0 \tag{19}$$

assures that the utility value of the stock is zero by the end of time. In (19), we define $z \equiv \lambda h$. We work with the dynamic system in h and $z \equiv \lambda h$, since z is constant in balanced growth (see Appendix B).

The representative household considers the economy-wide averages $\bar{h}$ and $\bar{e}_w$ to be given, but these change as individual behavior evolves over time. To ensure a consistent equilibrium, we force the representative household's choices to match economy-wide averages. That is, we only consider equilibria where $\bar{h} = h$ and $\bar{e}_w = e_w$.

To begin, note that the learning productivity externality L, expressed relative to h, is a constant in this model. Put (14) into (5) and divide both sides by h to obtain:

$$A \equiv \left(\frac{L}{h}\right)^{\gamma} = \left[\frac{\alpha(1-\alpha)}{v_0}\right]^{\gamma} \tag{20}$$

In what follows, we refer to A as the "learning productivity". It is important that A depends on the fixed cost v_0 of producing inputs. Above, we called $\frac{\alpha(1-\alpha)}{v_0}$ the "fixed-cost component" of specialization M^* in equilibrium. We now see that this fixed-cost component – raised to the power γ — is all that matters for learning productivity.

In Appendix B, we show that equilibrium work effort e_w and learning e_l are given by :

$$e_w = \frac{1}{zA} \tag{21}$$

$$e_l = 1 - \frac{1}{zA} \tag{22}$$

This allows us to express the dynamic system with the following two equations:

$$\dot{h} = h\left(A - \frac{1}{z} - \eta\right) \tag{23}$$

$$\dot{z} = z\left[\rho - \eta + \gamma A\right] - \left[\gamma + 1\right] \tag{24}$$

The representative household selects the initial value $z(0)$, given the initial $h(0)$, then must follow the (h, z) system of first-order differential equations (23) and (24). The solution must satisfy transversality (19) to be optimal. The optimal $z(0)$ is unique – and, in this case, it is such that balanced growth is achieved immediately. There are no transitional dynamics, so the equilibrium values of e_w and e_l are constant.

We first note that if z is constant, the transversality condition (19) will be satisfied. If we set (24) to zero and solve for z, we get the following constant:

$$z^* \equiv \frac{1+\gamma}{\rho-\eta+\gamma A} \tag{25}$$

It follows that the optimal policy is to set $z(t) = z^*$ for all t. Using (21) we find the constant work effort to be:

$$e_w^* = \frac{\rho-\eta+\gamma A}{(1+\gamma)\,A} = \frac{\rho-\eta}{(1+\gamma)\,A} + \frac{\gamma}{1+\gamma} \tag{26}$$

Substituting z^* from (25) into (23) shows that the growth of per capita human capital h is constant at the rate:

$$g_h = \frac{A-\rho-\gamma\eta}{1+\gamma} \tag{27}$$

From (17) we calculate the growth rate of per capita output to be:

$$g_y = (1-\alpha)\,\eta + (2-\alpha)\,g_h \tag{28}$$

where g_h is given in (27).

It should be emphasized that the construct A plays a critical role in the model. It determines the value of e_w through (26) and the growth rate through (27). The positions of both curves in Figure 2 depend on the value of e_w that is determined by A. We focus on A because it is directly influenced by regulatory policy through the fixed cost v_0.

6 Regulation and Taxation

6.1 Regulation and Taxation: Fixed vs Variable Cost

We distinguish regulation from taxation in that the former contains a greater element of *fixed cost* whereas the latter is more heavily weighted toward *variable cost.*

We formalize this idea as follows. In the absence of regulation and taxation, the cost function for every intermediate-good firm is given by (3). With regulation and taxation, and recognizing that firms differ across industries i and countries j, the cost function for producing x units of the intermediate good is:

$$V_{ij}(x) = \left(1+\beta_{ij}^R+\beta_{ij}^T\right) v_0 + \left(1+\tau_{ij}^R+\tau_{ij}^T\right) v_1 x \tag{29}$$

where $\beta_{ij}^R > \beta_{ij}^T \geq 0$, but $\tau_{ij}^T > \tau_{ij}^R \geq 0$. There are several things to point out about this cost function. First, for tractability, we assume that the regulation and taxation policies raise costs proportionally for both fixed (v_0) and variable (v_1) costs. Second, we assume that the fixed-cost component of regulation β_{ij}^R is strictly greater than zero and strictly greater than the fixed-cost component of taxation β_{ij}^T, which may be zero. Third, we assume that taxation has a larger variable-cost component τ_{ij}^T than does regulation τ_{ij}^R, which may be zero.

What is important for our argument is that regulations contain a fixed-cost element that is significantly greater than that of taxation. That is, that $\beta_{ij}^R > \beta_{ij}^T \geq 0$. Virtually all regulations have an important cost component that does *not* depend on scale (β_{ij}^R). Some regulations also impose costs that *do* depend on the size of the firm's operation ($\tau_{ij}^R > 0$). While this is not essential to our argument, it is strengthened the larger is τ_{ij}^R.

Examples of regulatory fixed costs include compliance costs for banks and other financial firms, tax compliance, the cost of environmental studies to secure construction permits, health and safety standards, homeland security requirements, and orders that limit numbers of customers during a pandemic. Regardless of the scale of operation, firms must employ a certain minimum number of employees to deal with compliance, or sub-contract various services to make sure they fill out the proper forms and comply with regulations for their industry. All universities must hire staff to oversee compliance with Title IX, for Equal Opportunity and other HR standards, and many more. Some of these costs do depend on scale: large universities have to hire more Diversity Officers than small colleges, but all institutions must have such an office, and probably more than one. In other words, $\tau_{ij}^R > 0$ – there are variable costs associated with regulations – but that does not mean that there is not a large element of fixed cost, too: $\beta_{ij}^R > 0$.

Consider four examples. The American Hospital Association (see AHA (2017)) has estimated that in 2017, health systems, hospitals and other providers had to comply with 629 different regulations. About half applied to hospitals and half to post-acute care providers. The regulations were mainly in the form of federal rules issued by agencies like the Centers for Medicare & Medicaid Services (CMS), the Office of the Inspector General (OIG), the Office for Civil Rights (OCR), and the Office of the National Coordinator for Health Information Technology (ONC). An average-size hospital dedicated 59 employees to regulatory compliance (see AHA, 2017). No doubt, some of these costs increase with the number of patients, but even small medical facilities incur sizable compliance costs that are essentially fixed.

As a second example, consider the cost of complying with the regulations on financial institutions. Hogan and Burns (2019) estimate that the cost of compliance with Dodd-Frank regulations was about $64.5 billion per year in non-interest cost. This can be broken down into salary expense and non-salary expense (legal fees, consulting, data processing). The non-salary expenses tended to be higher, but salaries increased by about $15 billion per year. One independent management and compliance consulting firm[10] says: "Regulations themselves are so complex, the first thing a bank should do is consult or hire someone who is an expert in compliance. Typically, a bank will have a Compliance Officer, and larger banks might even have a compliance team. This person or team should be knowledgeable about underwriting, appraisals, financial regulations, customary and

[10] The following quote is from the website of MountainSeed, a firm specializing in regulatory compliance for small banks. There are hundreds of such firms.

reasonable fees, TRID, and more. There are so many rules related to delivering reports, how quickly they need to be done, and when evaluations (versus appraisals) should be completed." Individual Registered Investment Advisors almost always hire compliance consultants, both for starting up and for ongoing work to maintain compliance. This runs typically from $10,000 to $25,000 for the start-up and $8,000 to $12,000 per year for ongoing work.[11]

Third, trucking is subject to several regulations that are independent of the number of miles driven per day. In 2021, federal proposals were introduced to raise the cost of truck purchase by mandating speed governors, limiting hours of service by drivers, mandating ELD's (electronic logging devices that make it harder for drivers to misrepresent their hours), and limiting emissions of CO_2. These regulations raise the fixed cost of any fleet size, but also raise the variable cost of moving goods. These and other rules are proposed and enforced by the Federal Motor Carrier Safety Administration (FMCSA) as well as state regulatory agencies (notably California).

Fourth, accreditation rules for universities involve substantial time for ongoing assessment and periodic report writing. These reports must be prepared, regardless of the size of the institution, although they surely involve more expense for larger universities.

In all cases, firms must hire (or sub-contract) people who spend time understanding existing regulations, keeping up with public comments on proposed rules and regulations, and even lobbying government at all levels to influence the creation of new rules and the interpretation of existing rules. There is little, if any, increase in these costs if the firm increases its output.

Occupational licensing fees, which are in the nature of taxes, would be considered regulations in our framework, since they are essentially fixed costs that serve to restrict entry. Licenses often have to be renewed periodically, if not annually.

We now consider taxation. Unlike regulation, the fixed-cost component of taxation is minimal: $\beta_{ij}^T \approx 0$. Most business taxes are levied on volume, revenue, or profit, all of which depend on scale (or success) of operation. Property taxes appear to be fixed in nature, but in most localities they also depend on the firm's income and expense. That is, typically property taxes are calculated as $PT = \rho * AR * MV$, where MV is the market value of the property, AR is the assessment ratio (around, say, .25) and ρ is the tax rate (say, .10). The market value usually depends on a formula that takes into account the firm's annual income and expenses, and capitalizes this net income at some standard rate of interest. In this sense, it is a local profit tax. Since MV is not calculated every year – and since AR can be changed arbitrarily – there is some element of fixed-cost to property taxes. Nevertheless, it seems to us that the fixed-cost nature of taxation is considerably smaller than that of regulation.

Taxes, however, have a major effect on intermediate-good firms' variable cost: $\tau_{ij}^T > 0$. Firms typically pay sales taxes and excise taxes on every unit sold. In addition, there are taxes on employment, which rise directly with the amount produced. The employer share of such federal taxes is about 7.5% of the payroll. Federal excise taxes on fuel and heavy trucks add another large

[11] This information came from the web page of the consultant Brad Wales. See https://transitiontoria.com/how-much-does-an-ria-compliance-consultant-cost/

item to firms' cost, most of which is variable. Sales taxes in the US are collected mainly at the state level, where they run between 4% and 7% of the value of the product sold, but when local sales taxes are added, these can get close to 10% (see Cammenga, 2021).

In light of this, it seems most plausible to us that regulations impose significant fixed *and* variable costs ($\beta_{ij}^R > 0$, $\tau_{ij}^R > 0$), whereas taxation *only* raises variable cost ($\beta_{ij}^T \approx 0$, $\tau_{ij}^T > 0$). All we really need is that the fixed-cost element of taxation is considerably lower than that of regulation: $\beta_{ij}^T < \beta_{ij}^R$.

We are interested in isolating the effects of these policies on both the level of output per capita and its growth rate. Since there are no transitional dynamics in the model, we can represent the path of output as $y(t) = y(0)\, e^{g_y t}$. We evaluate each policy in terms of what it will do to $y(0)$ and g_y separately. Next, we show that increases in τ_{ij}^k ($k = (R, T)$) only reduce $y(0)$ and leave g_y unchanged. However, increases in β_{ij}^k reduce g_y unambiguously and may reduce $y(0)$ as well.

6.2 Increase in Variable Cost in the Model

Let $\tau_j = \tau_j^R + \tau_j^T$, where τ_j^k is the *average* variable-cost component of policy k in country j. This represents the proportional increase in variable cost from both regulation and taxation in country j. Until the empirical section, we abstract from country differences and let τ be the total effect of policy on variable cost in the representative country. The effect is to raise variable cost to $(1 + \tau)\, v_1$.

This policy change does not change specialization M or A in (20), so z^*, e_w, and e_l remain at their original magnitudes and the economy continues to grow at the same rate. That is, g_y does not change.

To see what happens to the level of $y(0)$, we use (17). Although e_w does not change, B falls according to (16); that is, with an elasticity equal to $-\alpha$. We noted earlier that B is a reduced form for the influence on wages of changes in x^* and the fixed-cost component of M^*. In this case, the source of the reduction in B is the fall in x^* to $x^{*'} = \frac{\alpha v_0}{(1-\alpha)(1+\tau)v_1}$, which we see from (11). The reduction in x^* causes the productivity of labor (7) to fall — since neither overall effort e_w or its allocation to tasks in (12) and (13) is changed — which reduces the real wage w_b and per capita output y. In terms of Figure 2, the increase in v_1 shifts both curves down by the same amount and so reduces x^* without changing M^*.[12] We note that $v_1 x^* = (1 + \tau)\, v_1 x^{*'} = \frac{\alpha v_0}{1-\alpha}$ so that the constraint (10) continues to hold, without any change in the allocation of labor.

6.3 Increase in Fixed Cost in the Model

In this section we consider a policy that increases the fixed cost $(1 + \beta_j)\, v_0$, where $\beta_j = \beta_j^R + \beta_j^T$ and β_j^k is the average fixed-cost component of policy k in country j. Again, we abstract from different countries in this section, and let β be the fixed-cost component of the representative country. In this case, there is a negative growth effect as well as a negative effect on the current level of output per capita.

[12] To see this, see (37) and (38) in Appendix A.

The key change is to A. By (20), the productivity of learning time falls to:

$$A \equiv \left(\frac{\alpha (1 - \alpha)}{(1 + \beta) v_0} \right)^{\gamma} \tag{30}$$

This causes e_w to rise by (26). Not only is each hour of learning less productive, but the rise in the steady-state e_w means that the equilibrium e_l falls. The reductions in A and e_l reduce the *growth rates* of h and y, which show up in (27) and (28). There is, then, an unambiguous fall in g_y; it changes by the amount:

$$\frac{\partial g_y}{\partial \beta} = \left(\frac{2 - \alpha}{1 + \gamma} \right) \frac{\partial A}{\partial \beta} = -\gamma \left(\frac{2 - \alpha}{1 + \gamma} \right) \frac{A}{1 + \beta} \tag{31}$$

The higher the value of β, the greater the fall in growth.[13]

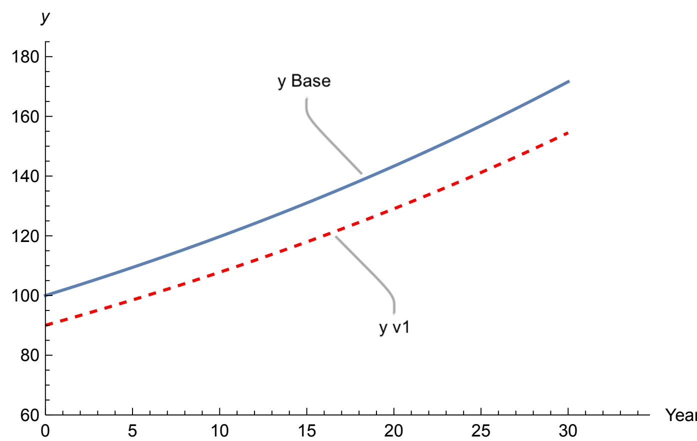
Although it is not obvious from (17) — since e_w increases — an increase in β will also cause current real output per capita $y(0)$ to fall. We demonstrate this result numerically in Appendix C. To do so, we carry out a simple, back-of-the-envelope calibration of the model to the US economy, and examine fixed-cost shocks under a variety of parameter values.

In Figure 3 the solid curves labeled "y Base" are the paths of $y(t)$ in the baseline calibration ($\tau = \beta = 0$). The other curves show the effects of permanent shocks to τ and β. We first consider a tax increase of 30%. The dashed line in Figure 3a shows the path of y if the variable cost were raised to $(1 + \tau) v_1 = 1.3 v_1$ from v_1. As we showed above, the growth rate is not affected, but the level of $y(t)$ falls according to the factor $(1 + \tau)^{\alpha} = 1.3^{.4} = .90$ for all t.

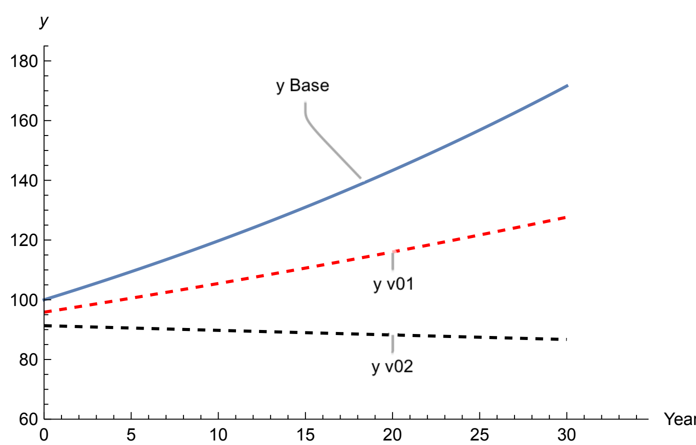
We now consider an increase in fixed cost $(1 + \beta) v_0$. In Figure 3b, the curve labeled "$y\ v01$" shows the effects of the policy in which $\beta = .30$. The growth rate g_y falls according to (31) and output $y(0)$ also falls immediately. The gap between the baseline path and the new path grows over time. A much more severe policy is shown by the curve labeled "$y\, v02$", for which $\beta = 1$, so that compliance costs and other fixed costs double. In this case, the growth rate actually turns negative: the productivity of learning is so low that human capital accumulation becomes negative.

This calibration, as noted, is basic, but the model is simple and there are only four free parameters — see Appendix C —- most of which have been identified in the literature. The main point, which is true for reasonable values of the parameters, is that an increase in β has negative level effects as well as negative growth effects. If so, the negative effect of regulation, which raises both β and τ, is likely to be much larger than that of taxation, in the short run as well as the long run. When we examine the data next, we expect regulation to have a more serious negative effect on output and growth than taxation.

[13] To derive (31), put (27) into (28), then substitute for A from (30) before differentiating.



(a) A Tax Increase



3b

(b) Increase in Regulation Cost

Figure 3: Tax and Regulatory Shocks

7 Empirics

7.1 Data and Estimation Strategy

To see if our theory has empirical support, we rely primarily on data from the *Economic Freedom in the World* (EFW) database produced by the Fraser Institute, which produces index scores for regulatory and tax environments on several countries over time. For real output per capita, we use the data from the *Penn World Table* (PWT, v, 10.0). These data sets have been used extensively in the literature and have wide coverage across time and space. We supplement these, however, with data from the World Bank and other sources, as noted below.

To compare *levels* of y, we use the measure of real output based on expenditure in the PWT; this is the variable called $RGDP^E$. To compare *growth rates* of y we use the measure based on national accounts called $RGDP^{NA}$. These are the variables suggested by the current curators of the PWT data for the different tasks (see Feenstra et al. (2015), Table 1). In addition, we check results at times using two series for real GDP constructed by the World Bank in its World Development Indicators (WDI) database: one is in units of US dollars of 2010 ($RGDP^{WB\$}$) and the other is in International dollars of 2017 ($RGDP^{WBI}$).[14] We use the *Pop* variable from the PWT as our primary measure of population, but we supplement it with population data from the United Nations to deflate some of the observations from the WDI data.

Our principal measures of taxation and regulation are taken from the EFW database. For the taxation measure, we use the variable in Area 1 ("Size of Government"), Component D2 ("Top marginal tax rate"), which is the average of two *scores*. Each of these two scores incorporates both the highest marginal tax rate (one income, one both income and payroll) and the income or wage level at which these rates kick in.[15] We call this variable Tax. For regulation, we use the average of all the Components in Area 5 ("Regulation").[16] We call this variable *Reg*. Both Tax and *Reg* are scores that run from 0 to 10, with 10 indicating the *lowest* levels of taxation and regulation. We normalize both to go between 0 and 1 instead, to provide coefficients that are larger and easier to interpret. *Reg* is much more continuous than Tax, probably because the latter depends only on two sub-components, whereas *Reg* is an average of 15 sub-components. This is clear in Figure 1.

Our baseline data is an unbalanced panel. The EFW data is not as complete as the PWT and WDI data, so our analysis is constrained by the availability of Tax and *Reg*. The EFW data goes from 1970 to 2018, but in the years before 2000 it is published only every 5 years. At most, we have 25 years of observations for Tax and *Reg*, but for many countries there are many fewer observations. In all, we have 159 countries in the dataset, but only 128 that have at least 10 years of data. Descriptive statistics for the data that we use in the empirical analysis that follows are shown in Table 1.

Table 1 shows substantial dispersion in our measures for taxation and regulation. It is interesting

[14]The correlation coefficients between all four measures of y are extremely high: the lowest is .949 ($RGDP^{NA}$ and $RGDP^{WB\$}$); the highest is .998 ($RGDP^E$ and $RGDP^{NA}$).

[15]Thus, it appears that the average score weights income taxes more heavily.

[16]There are three components (credit market, labor market, and business regulations) and 15 sub-components.

Table 1: Summary Statistics of the Data

Variable	*Min*	*Mean*	*StdDev*	*Max*	*N*
$\ln y$	5.500	8.780	1.221	12.555	10,416
$g_y \equiv \Delta \ln y$	-1.659	0.022	0.085	0.886	10,229
Reg	0.100	0.664	0.127	0.947	3,432
Tax	0.000	0.589	0.263	1.000	3,005
HC	1.007	2.087	0.728	4.352	8,653
$AbsLatitude$	0.002	0.283	0.188	0.713	14,591

that regulation has a standard deviation that is twice that of taxation, and a slightly greater range. Table 1 also shows substantial dispersion for income. The lowest country (Liberia in 1996) has a per capita output level that is about 1,000 times smaller than that of the highest country (the United Arab Emirates in 1970). Table 1 shows an average income per capita growth of 2.2% with a standard deviation of 8.5%, which is not surprising given the negative growth rates for many observations in our sample.[17] Last, we also report descriptive statistics for the human capital index and the measures of absolute latitude that we use below, to illustrate that our sample also has wide variation in terms of geography and human capital formation.

As is standard in the literature, we measure the level of per capita output using the natural logarithm:[18]

$$\ln y_{it} = \alpha_1 + \beta_1 Tax_{it-1} + \gamma_1 Reg_{it-1} + \delta_1 Z_{it} + \mu_i + \omega_t + \epsilon_{1it} \tag{32}$$

where $\ln y_{it}$ is the natural log of per capita real output for Country i in Year t; and Z_{it} is a vector of controls that we introduce below. We lag the variables of interest, Tax and Reg, by one year to give them a chance to impact the outcome y; and we allow for both country and time fixed-effects, μ_i and ω_t, which we may consider part of a composite error, whose other component ϵ_{1it} is well behaved. We expect that the coefficients $\beta_1 > 0$ and $\gamma_1 > 0$, if our theory is correct. Our model assigns no positive role for regulation or taxation, as we noted in the Introduction, since we believe the benefits of these policies – say, the EPA – are to enhance quality of life, not income. We cannot rule out the case where regulation and taxation *do* raise GDP — the "public interest theory" in the words of Djankov et al. (2002) — in which case our coefficients will be *negative.*

The main estimating equation for the *growth rate* g_y is:

$$g_{y,it} = \alpha_2 + \beta_2 Tax_{it-1} + \gamma_2 Reg_{it-1} + \lambda y_{0,i} + \delta_2 Z_{it} + \mu_i + \omega_t + \epsilon_{2it} \tag{33}$$

where $g_{y,it}$ is the growth rate of y in Country i and Year t and is measured as the year-on-year difference in the natural log of y: $g_y \equiv \Delta \ln y$. This equation has the same form as (32) except we add initial per capita output to capture any transitional dynamics, a standard practice in estimating

[17] In fact, all growth rates below the percentile 25 are negative.

[18] See, for example, Hall and Jones (1999), Djankov et al. (2002), and Acemoglu and Johnson (2005).

growth equations across countries; it is expected that $\lambda < 0$. For estimation with country fixed-effects, however, we will not be able to estimate λ, since the data for initial output vanishes when we take the deviation from the mean over time. In the growth regression, we expect $\beta_2 = 0$ and $\gamma_2 > 0$. Unlike in the level equation, tax policy should not affect the growth rate ($\beta_2 = 0$).

We lag the independent variables in equations (32) and (33) to emphasize the direction of causality implied by our model, although it is clear that reverse causality can bias the parameter estimates (see Section 8.4). Lags are not to be interpreted as a definite solution to this potential problem, but we use them to address how past changes in taxation and regulation can affect current economic performance.

We estimate the regressions in two ways. First, to establish a baseline, we assume away the effects μ_i and ω_t and estimate (32) and (33) with pooled OLS. Second, we use fixed-effects panel methods to allow for country- and time-effects.

One might worry that Tax and Reg are too closely related to produce precise estimates of their separate effects. While they are positively correlated, if we ignore country heterogeneity and pool all our observations, the correlation coefficient is only about $\rho = 0.22$. Moreover, the R^2 in the regression of Tax on Reg is only about .05, so the effect of multicollinearity on the variance of the estimated coefficients will not be large. If we take means of Tax and Reg by country, then the correlation of those means is even smaller, only $\rho = 0.085$ (and R^2 is a mere .01). Finally, there are 138 countries (out of 159 in the pooled regression) that have at least some variation in Tax over time (all 159 have variation in Reg over time). If we correlate Tax and Reg separately for each country, we find that 21 have $\rho < 0$ and 117 have $\rho > 0$. The 138 ρ values are fairly widely dispersed in the interval $\rho = (-0.79, 0.97)$.

In Figure 1b we plot the basic scatter between Tax_{t-1} and the log of y_t, using the entire sample. We also show the regression line from pooled OLS; the slope coefficient is $\beta_1 = 0.101$ and is insignificant ($p = .249$). In Figure 1a we show the scatter plot between Reg_{t-1} and the log of y_t. The result is very different. The slope of the pooled regression line is positive with $\beta_2 = 5.63$ and is highly significant ($p = 0.000$). A better regulation score is associated with higher GDP per capita. As noted earlier, Reg is a much more continuous measure than is Tax.

7.2 Baseline Estimation: No Controls

Table 2 shows the results for pooled OLS for both levels y and growth rates g_y, without any controls, using Tax_{it-1} and Reg_{it-1}.[19]

The results in the table show that Reg_{t-1} works as predicted. A higher regulation score is associated with higher levels of y_{it} and a higher growth rate $g_{y,it}$: all of the coefficients on Reg_{t-1} are positive, significant, and large: the coefficient γ_1 on $Reg_{t-1} = 5.98$ in Column (3). The sample standard deviation of Reg_{t-1} is .116 (where the mean is .682 and the maximum is .947). This means that a country with a Reg score that is one standard deviation above that of another country would

[19] We do not include time dummies in the OLS regressions in Table 2. The results with time dummies (not reported) are very similar to those in Table 2 and do not change the basic message. Below we use country- and time-fixed-effects.

Table 2: Pooled OLS. Dependent Vars: $\ln y$ and g_y

	ln y			Growth of y		
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	0.101		-0.478***	0.004		0.000
	(0.087)		(0.066)	(0.003)		(0.003)
Reg_{t-1}		5.630***	5.979***		0.043***	0.042***
		(0.143)	(0.159)		(0.010)	(0.010)
y_0				-0.006***	-0.008***	-0.007***
				(0.001)	(0.001)	(0.001)
Constant	9.274***	5.420***	5.540***	0.066***	0.056***	0.054***
	(0.057)	(0.099)	(0.116)	(0.008)	(0.008)	(0.009)
Year FE	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	NO	NO
Obs.	2965	3383	2961	2965	3383	2961
Adjusted R^2	0.00	0.33	0.34	0.02	0.03	0.03

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

tend to have an $\ln y$ that is $5.98 * .116 = .691$ points higher. In levels, then, y would tend to be about twice as high (a factor of $e^{.691} = 1.9961$). The coefficient in the growth equation is .043, so growth would be associated with an extra .005 points for those countries whose Reg_{t-1} score was one standard deviation higher (.043*.116 = .00497). This might be about a 28% difference in the growth rate (say, .018 to .023).

Our theory also predicts that a higher tax score should be associated with higher levels of y_t but there is no evidence of that in Table 2 or in Figure 1a. In fact, the one significant coefficient on Tax_{t-1} — in Column (3) — is *negative*. The prediction concerning Tax_{t-1} and g_y – that is, that $\beta_2 = 0$ – is supported by these results.[20]

To exploit the panel nature of our data, to control for the possibility of heterogeneity across countries or time, we now use the fixed-effects estimator. The fixed-effects technique is appropriate when either unobserved effect is correlated with our main regressors Tax_{t-1} and Reg_{t-1}. The regressions in Table 3 reflect (32) and (33) but omitting any controls Z_{it}. These results are entirely consistent with the theoretical model: (1) the level coefficient γ_1 on Reg_{t-1} is highly significant and positive (although smaller than in the pooled regressions); and, (2) Tax_{t-1} *is* significant and positive in equations for $\ln y$ – Cols (1) through (3) — although much smaller in magnitude compared to Reg_{t-1}. For the growth rate group, Tax_{t-1} continues to show no association with growth, while Reg_{t-1} significantly and positively associated with growth.

It is noteworthy that the $\ln y$ panel results and pooled OLS results can be explained if Tax_{t-1}

[20] We only report the results for the PWT data for output per capita. The qualitative nature of our results do not depend, however, on which measure of y we use. The World Bank data yields very similar results.

Table 3: Country and Time Fixed Effects. Dependent Vars: $\ln y$ and g_y

		$\ln y$			Growth of y	
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	0.218**		0.157*	-0.000		-0.003
	(0.099)		(0.093)	(0.011)		(0.010)
Reg_{t-1}		1.297***	1.253**		0.065**	0.069*
		(0.371)	(0.510)		(0.029)	(0.038)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Obs.	2965	3383	2961	2965	3383	2961
Adjusted R^2	0.52	0.56	0.55	0.11	0.10	0.12

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

were *negatively* correlated with the fixed effect, while Reg_{t-1} were *positively* associated with the fixed effect.[21] This is important because it can help us identify variables that might be associated with the fixed effect. For example, in Section 8.2 we find that the absolute value of a country's latitude would be a good candidate based on this criteria. And, perhaps more importantly, the correlation it might tell us something about the bias of β_1 and γ_1 in the presence of endogeneity. We expand on this below in Section 8.4.

The results in Table 3 conform broadly to the model's predictions. However, we have not added any controls, considered other types of data, or addressed the issue of potential simultaneity. We turn to these next, beginning with human capital.

8 Robustness

8.1 Human Capital

Better regulation – a rise in the *Reg* score — works in our model by reducing the fixed cost of producing intermediates v_0, which expands the number of intermediate good firms M (see Eq. (14)) and raises the degree of specialization in final-good production. This has both a direct effect on y via the increasing-returns production function (2), but also an indirect effect by raising the productivity of effort in accumulating human capital (see Eq. (5)). Countries with lower regulatory barriers should have more human capital as well as higher levels of per capita output. Lower taxes, according to the model, do *not* increase specialization or the accumulation of human capital.

Our measure of human capital HC comes from the Penn World Table. This data combines the series constructed over the years by Robert Barro and Jong-Wha Lee (see Barro and Lee (2013))

[21] This statement applies to the $\ln y$ regressions and assumes that $\beta_1 > 0$ and $\gamma_1 > 0$. In the case noted in the text, for the pooled regressions β_1 would be biased toward 0 and γ_1 would be biased away from 0. This is consistent with our results, since β_1 rises and γ_1 falls as we move from Table 2 to Table 3. The same applies, though less strikingly, between Tables 5 and 6 in the next section.

Table 4: Dependent Variable: HC

	Pooled OLS			Country Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	-0.075		-0.361***	0.767***		0.419***
	(0.050)		(0.038)	(0.064)		(0.062)
Reg_{t-1}		3.275***	3.418***		2.114***	1.636***
		(0.091)	(0.100)		(0.128)	(0.164)
Constant	2.599***	0.290***	0.447***	2.114***	1.059***	1.206***
	(0.034)	(0.063)	(0.072)	(0.037)	(0.085)	(0.102)
Year FE	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	YES	YES	YES
Obs.	2779	3149	2775	2779	3149	2775
Adjusted R^2	0.00	0.34	0.34	0.27	0.44	0.46

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

with a similar series by Daniel Cohen, Manuel Soto, and Laura Leker (see Cohen and Leker (2014); Cohen and Soto (2007)). These datasets measure years of schooling at five- or ten-year intervals, but the Penn World Table creates an index of human capital that goes from 1 to 5 (intervening years are imputed using linear interpolation).[22] In Table 4 we show both pooled OLS and panel country fixed-effects regressions in which HC is the dependent variable and Tax_{t-1} and Reg_{t-1} are the independent variables.

These regressions show that there is a strong positive association between a minimal regulatory environment and the stock of human capital. Not only are the coefficients large and very significant, the R^2 values are quite high at about .35 to .40, depending on the method.[23] The association between Tax_{t-1} and HC is, on the other hand, less clear cut. In the pooled regressions, the association in nil or even negative. In the country fixed-effects regressions the association is positive but small compared to the magnitude of the Reg_{t-1} coefficients.[24]

These results provide some support for the mechanism of our model that links regulation, via human capital, to high levels of output per capita. They also suggest that human capital HC be added as a control Z_t in Equations (32) and (33), since it is quite possible that HC has a direct effect on y and g_y, apart from it's association with Reg. Accordingly, in Table 5, we add HC to the pooled OLS regressions that appear in Table 2.

The results in Table 5 show that Reg remains positive and very significant in the equations for

[22] More specifically, the PWT uses the Barro-Lee data for 95 countries and the Cohen-Soto-Leker data for 55 countries. To see the list of countries, and a rationale for using either the BL or CSL data, see "Human Capital in PWT 9.0" available online at the Groningen Growth and Development Centre: https://www.rug.nl/ggdc/docs/human_capital_in_pwt_90.pdf.

[23] The regressions in columns (4) - (6) use only *country* fixed effects. Time fixed-effects produced even larger coefficients for $\ln y$, but when we use both country and time fixed effects together, there is no significant association of either policy with HC.

[24] Again, using both time and country fixed-effects reveal no significant associations.

Table 5: Pooled OLS. Adding Human Capital

	ln y			Growth of y		
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	0.073		-0.096	0.005*		0.002
	(0.063)		(0.061)	(0.003)		(0.003)
Reg_{t-1}		1.349***	1.819***		0.036***	0.033**
		(0.150)	(0.182)		(0.012)	(0.014)
HC_{t-1}	1.393***	1.280***	1.210***	0.007***	0.004*	0.004
	(0.019)	(0.023)	(0.027)	(0.002)	(0.002)	(0.002)
y_0				-0.008***	-0.009***	-0.008***
				(0.001)	(0.001)	(0.001)
Constant	5.752***	5.147***	5.078***	0.066***	0.061***	0.056***
	(0.062)	(0.075)	(0.092)	(0.008)	(0.010)	(0.011)
Year FE	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	NO	NO
Obs.	2779	3149	2775	2779	3149	2775
Adjusted R^2	0.62	0.66	0.64	0.03	0.04	0.03

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

y and g_y, although for $\ln y$ the magnitude of the coefficient falls to a quarter of what we observed in Table 2. Still, an increase in Reg of .116 units (one standard deviation) would be associated with an increase in $\ln y$ of .211 — see column (3) – or an increase in y by the factor 1.24. If Reg were the causal force, then we could say that a society that managed to raise its regulatory index by one standard deviation (or 1.16 points in the original index) would eventually achieve an increase in per capita output of 24%. The coefficient on human capital itself is of similar magnitude and significance in the equations for $\ln y$ but shows less effect on g_y. The effect of Tax, however, remains without much influence on y or g_y.

In Table 6 we present the results of fixed-effects regressions for y and g_y that include HC as a control. In this table, we account for both country and time fixed-effects. The estimates of γ_1, the effect of Reg_{t-1} on $\ln y_t$, are very similar to those in Tables 3 and 5 in both magnitude and precision. The estimates of γ_2, the effect on the growth rate, are also very similar with and without HC included. Tax_{t-1}, on the other hand, is less strongly associated with $\ln y$ compared to Table 3, which left out HC. In neither case is Tax_{t-1} associated with $g_y = \Delta \ln y$.

Human capital is often a very powerful determinant of $\ln y$, and highly collinear with other independent variables, so much so that some researchers are reluctant to include it as a regressor since it renders other variables insignificant.[25]

We have shown that Reg is strongly associated with economic outcomes, both the level of

[25]See, for example, Acemoglu and Johnson (2005), footnote 17.

Table 6: Country and Time Fixed Effects: Adding Human Capital

	ln y			Growth of y		
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	0.208*		0.144	0.002		-0.001
	(0.106)		(0.095)	(0.011)		(0.011)
Reg_{t-1}		1.263***	1.315**		0.079***	0.076**
		(0.422)	(0.545)		(0.029)	(0.037)
HC_{t-1}	0.337*	0.535***	0.371**	-0.027**	-0.035***	-0.025**
	(0.183)	(0.154)	(0.162)	(0.011)	(0.010)	(0.010)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Obs.	2779	3149	2775	2779	3149	2775
Adjusted R^2	0.53	0.58	0.56	0.11	0.11	0.12

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$\ln y$ and the growth rate $g_y = \Delta \ln y$. There is more limited support for establishing a positive association with Tax with $\ln y$. We do find such an association when we impose fixed effects – especially in the absence of HC — but not in the pooled data: if such an association exists, it occurs within countries, not across countries. That in itself is an interesting finding. Tax does not appear to have much association at all with the growth of y, which is consistent with our theory and past empirical results.

8.2 Latitude

There is some evidence of the existence of a fixed country effect, since the panel results work well (especially to explain $\ln y$) but differ from the pooled OLS results. In this section, we add *Latitude* to the pooled OLS specifications in Table 5. Our thinking is that *Latitude* might be a proxy for the elements of climate, technology, institutions, and possibly culture, that constitute the principal sources of country heterogeneity.[26] As noted above, in our sample, *Latitude* is *negatively* correlated with Tax ($\rho = -.214$) and *positively* correlated with *Reg* ($\rho = .246$) – which is just the set of conditions that we noted were necessary to reconcile the pooled and panel regressions in Section 7.2.[27]

The results with *Latitude* appear in Table 7. The addition of *Latitude* does slightly increase the coefficient size and significance of *Reg*, compared to the results in Table 5. It remains highly significant and of relatively great magnitude for both ln y and g_y, as our theory predicts. Adding *Latitude* also makes Tax positive and significant in almost all cases, (the exception is Column (3)). Although we do not expect a significant effect of Tax on g_y — but do find one — we note that the

[26]The measure of *Latitude* is the absolute value of latitude, divided by 90 to normalize so that it runs from 0 to 1. The data on latitude come from the World Bank.

[27]See footnote 21 and associated text.

Table 7: Pooled OLS: Adding Latitude

	ln$y$			Growth of y		
	(1)	(2)	(3)	(4)	(5)	(6)
Tax_{t-1}	0.239***		0.069	0.011***		0.008**
	(0.066)		(0.063)	(0.003)		(0.003)
Reg_{t-1}		1.682***	1.961***		0.046***	0.038***
		(0.146)	(0.173)		(0.013)	(0.014)
HC_{t-1}	1.196***	1.043***	0.987***	0.003	-0.001	-0.001
	(0.028)	(0.031)	(0.034)	(0.002)	(0.003)	(0.003)
Latitude	1.042***	1.146***	1.106***	0.031***	0.033***	0.033***
	(0.101)	(0.088)	(0.097)	(0.005)	(0.005)	(0.006)
y_0				-0.009***	-0.010***	-0.010***
				(0.001)	(0.001)	(0.001)
Constant	5.825***	5.151***	5.102***	0.075***	0.068***	0.064***
	(0.061)	(0.071)	(0.088)	(0.008)	(0.010)	(0.010)
Year FE	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	NO	NO
Obs.	2755	3124	2751	2755	3124	2751
Adjusted R^2	0.63	0.68	0.66	0.04	0.05	0.05

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

magnitude of the coefficient is quite small compared to that of Reg.

We find it interesting that, on average, countries far from the equator – for example, Sweden and Denmark — have chosen a policy strategy that pairs low regulation with high taxation. The results shown in Table 7 suggest that this is a good mix to encourage high levels of per capita output and strong economic growth.

8.3 Other Data

There are other sources of data for measuring the burden of taxation and regulation. For taxation, one such measure is the *International Tax Competitiveness Index* ("$ITCI$") from the Tax Foundation.[28] This index is constructed as a weighted average of tax rates on corporate income, individual income, consumption, property, and a measure of international tax rules. It is, in this sense, more comprehensive than the EFW data. Unfortunately, it does not have great coverage: it only goes from 2014 to 2019 and is available only for 36 OECD countries, for a total of 212 observations. As with our other policy variables, we normalize it to run between 0 and 1, with 1 corresponding to the most competitive tax environment.

The World Bank's *Doing Business in the World Index* provides an alternative measure of the extent of the regulatory burden. Specifically, it reports on the cost — in terms of time, money, and number of separate steps — of accomplishing certain tasks that are crucial for the conduct of business. As this index ("$Ease$") rises – again from 0 to 1 – it becomes less burdensome to run a business. The coverage for $Ease$ is longer and broader than for $ITCI$ and we have almost 2,000 observations. This means that the sample sizes for regressions that do *not* involve $ITCI$ will be much larger.

We show results using this data in Appendix D. The results are quite similar to those we have found using the EFW data. The results using fixed effects, especially, conform closely to the predictions of the model. When we use pooled OLS, the tax measure $ITCI$ fails to show a significant effect on $\ln y$, as it has in other regressions using Tax. Even with pooled OLS, however, the regulation measure $Ease$ has a significant and positive association with $\ln y$ and g_y. We elaborate and show the results in Appendix D.

We conclude from these results that there is support for our theory, especially when it comes to the regulatory environment, that extends beyond the EFW data.

8.4 Simultaneity

We have shown that the policy variable Reg is almost always positively associated with the outcomes $\ln y$ and $g_y \equiv \Delta \ln y$, as predicted by the theory. To a lesser extent, Tax is associated positively with $\ln y$, as predicted, but in some cases we find little or no association.

We have reason to believe that these associations are at least partly caused by exogenous changes in Reg and Tax, as we explain in this section by considering the possibility that causation

[28] See Bunn and Asen (2020). The data, method, and results are available at GitHub/TaxFoundation/international-competitiveness-index.

is simultaneous. Our measure of Tax is a score based on the top marginal tax rate and the minimum income level at which it applies (both for income and payroll). It is not difficult to imagine that Tax itself depends on $\ln y$, so that $\ln y$ and Tax might be determined simultaneously. Prosperous countries might, like those in Scandinavia, impose high tax rates, which reduces the tax score Tax. In fact, Sweden's average tax score is a very low .09 out of 1.00, putting it in the first decile of our sample.[29]

This possibility of simultaneity can be addressed by adding two equations to our model:

$$Tax_t = \alpha_3 + \pi_3 \ln y_t + \kappa_3 Z_{Xt} + \epsilon_{3t} \tag{34}$$

$$Reg_t = \alpha_4 + \pi_4 \ln y_t + \kappa_4 Z_{Rt} + \epsilon_{4t} \tag{35}$$

where Z_X and Z_R are strictly exogenous variables that help determine, respectively, Tax and Reg. Importantly, we assume that $\pi_3 < 0$ and $\pi_4 < 0$, reflecting the idea above that, other things equal, countries that experience high or rising economic outcomes are those that impose *higher* tax and regulatory burdens on their citizens. (Recall that our tax and regulation measures are scores such that higher values reflect *lower* taxes and fewer regulations.) Another way to say this is that countries rarely cut taxes or reduce the regulatory burden *because* economic outcomes improve. The reverse appears to be more plausible: tax-cutting and deregulation appear mainly as a response to disappointing economic results.

Under these conditions, and ignoring the fixed effects in (32) and (33), the coefficients on Tax_{t-1} and Reg_{t-1} in Tables 5 and 7 are likely *biased toward zero*. That is, at least in the simplest case of one variable, Tax and Reg would covary inversely with the errors ϵ_1 and ϵ_2 in (32) and (33).[30] If, as our theory predicts, the true coefficients $\beta_i > 0$ and $\gamma_i > 0$ (for $i = 1, 2$), this negative covariance would establish a negative bias in our estimates. If simultaneity is present, the true coefficients are probably greater than the estimates we have found.

The logic of this section leads us to conclude that, while simultaneity means we have not uncovered the structural parameters, the true exogenous effects of changes in regulation and taxation are more important than we have estimated.

9 Conclusion

Taxes are necessary for funding the basic services required of a modern society. Keeping order, organizing defense, enforcing laws and contracts, fighting communicable disease, and many other functions, require a steady stream of revenue. Regulations are necessary to operationalize laws and formalize official procedures. Taxes and regulations, however, are also designed to influence or constrain individual behavior. For example, a gasoline tax discourages driving in order to reduce CO_2 in the atmosphere. Regulations have been used to prevent discriminatory actions.

[29] Not all rich countries have low tax scores (high tax rates): Switzerland's score is .78.

[30] To see this, plug (32) into (34) and note that the coefficient on ϵ_1 in this reduced-form equation is $\frac{\pi_3}{1-\pi_3\beta_1} < 0$ since we assume $\pi_3 < 0$ and $\beta_1 > 0$.

Regulations can, at times, substitute for taxes that are meant to change behavior. In the clean air example, the government could instead mandate cars with low emissions or high mileage; or it could cap individual driving miles. Regulations of this type may be favored by governments since, although the regulation might raise cost by more than the tax, it is often not clear who bears the cost. Regulations, however, are often not as efficient as taxes in operating on the margin to influence behavior. Gasoline taxes raise cost per mile driven; catalytic converters increase the fixed cost of the trucking fleet regardless of the number of miles driven. So, while regulations may be favored by governments, they may be sub-optimal because they impose fixed costs instead of variable costs. This difference – the preponderance of fixed costs from regulations — appears to be much more general than just the case of clean air. The relative importance of fixed cost in regulations provided the motivation to see if this could lead to differences in the effects of regulations and taxes on economic activity.

We use a model of increasing returns to scale to show that the fixed cost associated with regulations can have a more harmful effect on output compared to taxation. The reason is that an increase in fixed-cost reduces specialization, the variety of intermediate input firms in operation. This reduces output directly and, as in the work of Lucas, reduces the efficiency of human capital accumulation. Both current output and growth fall. Taxation reduces output, but does not change the rate of growth.

We estimated the effect of tax and regulation on per capita GDP and its growth rate. We found that regulation was strongly related to per capita output and growth in the way suggested by the theory. Taxation was weakly associated with output and hardly associated with growth at all. We considered several controls, different data sets, and simultaneity. Countries like Sweden, who have high taxes but light regulations (in our data), may have hit upon the right combination of policies to simultaneously raise revenue and influence behavior.

Our results show that the main panel effects are within effects, not between effects. We find this encouraging because if the results were true mainly across countries, they could be due to many more unobservable characteristics, like culture, geography, and history. Our results suggest that nations that can reduce onerous regulations may be able to increase their growth and levels of per capital output.

Appendices

A Zero-Profit Equilibrium in the Conventional Sector

Here we provide more details of the production equilibrium in Section 4. The first step is to find the value $\tilde{x}$ that each intermediate firm produces for sale to final-good firms, when M is given (along with e_w, h, and N). To do so, solve (10) for e_x:

$$e_x = \frac{M\left(v_0 + v_1 x\right)}{\bar{h}N} \tag{36}$$

To find $\tilde{x}$, first use (6) and (7) to substitute for p and w_b in the markup condition (9); then substitute $e_w - e_x = e_y$ in the result. Finally, use (36) to substitute for e_x, and solve for x:

$$\tilde{x} = \frac{\alpha^2\left(e_w\bar{h}N - v_0 M\right)}{\left(1-\alpha+\alpha^2\right)v_1 M} \equiv X\left(e_w\bar{h}N, M\right) \tag{37}$$

We call the function that represents intermediate output $\tilde{x} = X\left(e_w\bar{h}N, M\right)$. The $X(\ldots)$ function allows us to find e_x/e_w (using (36)) and $e_y/e_w = 1 - e_x/e_w$ as functions of $e_w\bar{h}N$ and M. Because e_w is given at this point, we can then find e_y and e_x separately, which allows us to find w_b, p, and Y using the structural equations. The value of $\tilde{x}$ as a function of M is represented by the EQ locus in Figure 2.

Our base case assumes that intermediate firms earn no profit in equilibrium. That is, when profit is positive new firms will enter the intermediate-good market and increase the number of specialized inputs, which drives profit to zero. M is endogenous.

Given e_w, h, and N, the ZP locus in Figure 2 shows the momentary zero-profit combinations of x and M in the intermediate-good sector. To derive the ZP locus set profit (8) to zero, and substitute for p, w_b, e_y, and e_x as above to yield:

$$x = \frac{\alpha e_w h N - v_0 M}{v_1 M} \tag{38}$$

The ZP locus is also downward sloping.

The ZP locus crosses the EQ locus once from above. Intermediate firm's profits are positive *below* the ZP locus, and negative above. Hence, the free-entry, zero-profit monopolistically competitive equilibrium in the conventional sector is unique and stable at point A in Figure 2. Equate (37) and (38) to see that the equilibrium number of firms (range of specialization) is given by $M^* = \frac{\alpha(1-\alpha)}{v_0}e_w\bar{h}N$, which appears as Equation (14) in the text. Substitute M^* back into either (37) or (38) to get $x^* = \frac{\alpha v_0}{(1-\alpha)v_1}$, which is (11) in the text. Another way to find x^* is to substitute (3) and (9) into the profit expression (8) and set the result to zero.

In the text, we found the equilibrium allocations of effort (13) and (12). As a check, we can also use (36) after substituting the expressions for M^* and x^*. This yields $e_x = \alpha e_w$ from which it follows that $e_y = (1-\alpha)e_w$. Finally, to obtain the equilibrium, reduced-form base wage w_b in (15) in the text, we use (7) and then substitute in the equilibrium values for e_y, x, and M that we have found in this appendix.

B Intertemporal Optimization

The representative household maximizes (18) in the text subject to two constraints, a time constraint, $1 = e_w + e_l$, and a resource budget constraint, $c = w_b h e_w$, where $e_w = e_y + e_i$. Individuals consider the base wage w_b to be given, even though it depends on aggregate effort. Accumulating h allows them to increase their actual wage $w_s = w_b h$ in a manner that they perceive to be proportional.

The Hamiltonian for the problem is:

$$\begin{aligned}\mathcal{H} &= u(c) + \lambda\left(L^{\gamma} h^{1-\gamma} e_l - \eta h\right) + \\ &+ \theta_1 (w_b h e_w - c) + \\ &+ \theta_2 (1 - e_w - e_l)\end{aligned}$$

where λ is the co-state, shadow price of h, we attach the constraints with Lagrangian multipliers θ_1 and θ_2, and utility is assumed to be logarithmic: $u(c) = \ln c$.

There are three static FOC's:

$$\frac{\partial \mathcal{H}}{\partial c} = 0 \Rightarrow \frac{1}{c} = \theta_1 \tag{39}$$

$$\frac{\partial \mathcal{H}}{\partial e_w} = 0 \Rightarrow \theta_1 w_b h = \theta_2 \tag{40}$$

$$\frac{\partial \mathcal{H}}{\partial e_l} = 0 \Rightarrow \lambda L^{\gamma} h^{1-\gamma} = \theta_2 \tag{41}$$

In addition, the shadow utility price λ of human capital must change constantly to equate the cost and benefit of accumulating human capital:

$$\begin{aligned}\dot{\lambda} &= (\rho - \eta)\lambda - \frac{\partial \mathcal{H}}{\partial h} \\ &= (\rho - \eta)\lambda - \lambda\left((1-\gamma) L^{\gamma} h^{-\gamma} e_l - \eta\right) - \theta_1 w_b e_w\end{aligned} \tag{42}$$

Finally, we require the transversality condition (19) in the text.

The second differential equation is given by the learning technology (4), which we repeat here for convenience:

$$\dot{h} = L^{\gamma} h^{1-\gamma} e_l - \eta h \tag{43}$$

where, from (5):

$$L \equiv \frac{M}{\overline{e_w}\, N} \tag{44}$$

The representative household takes L and the economy-wide averages $\bar{h}$ and $\bar{e}_w$ as given when undertaking the maximization. After that, we impose aggregate consistency so that the representative household's choices match economy-wide averages: $\bar{h} = h$ and $\bar{e}_w = e_w$.

We now show how to simplify (42) and (43) to obtain the system in the text, (23) and (24).

First, divide (43) by h to see that $\frac{\dot{h}}{h} = \left(\frac{L}{h}\right)^{\gamma} e_l - \eta$. As noted in the text, substitute (14) into (44) to see that $\left(\frac{L}{h}\right)^{\gamma}$ is a *constant*, which we call A. That is,

$$A \equiv \left(\frac{L}{h}\right)^{\gamma} = \left(\frac{\alpha(1-\alpha)}{v_0}\right)^{\gamma} \tag{45}$$

This means we can write the accumulation equation as:

$$\dot{h} = h(Ae_l - \eta) \tag{46}$$

The first-order conditions (39) - (41), with the constraint $c = w_b e_w h$. and the definitions of A and z, yield:

$$e_w = \frac{1}{zA} \tag{47}$$

It follows that:

$$e_l = 1 - \frac{1}{zA} \tag{48}$$

so that the accumulation equation is:

$$\dot{h} = h\left(A - \frac{1}{z} - \eta\right) \tag{49}$$

This is (23) in the text.

To derive (24), use (42), along with (39), (45) and the definition $z \equiv \lambda h$ to get:

$$\frac{\dot{\lambda}}{\lambda} = \rho - (1-\gamma) Ae_l - \frac{1}{z} \tag{50}$$

To get the motion equation for z, recall that $\frac{\dot{z}}{z} = \frac{\dot{\lambda}}{\lambda} + \frac{\dot{h}}{h}$. Use (48) in (50), then add to (49) to get:

$$\dot{z} = z[\rho - \eta + \gamma A] - (1+\gamma) \tag{51}$$

The dynamic system comprises (49) and (51) which appear as (23) and (24) in the text.

C Calibration and Fixed Cost

In this appendix we show that the level of y falls when the fixed cost $(1+\beta)v_0$ rises.

There are no transitional dynamics so we can fully characterize the path of per capita output with values for initial y and the growth rate: $y(t) = y(0)e^{g_y t}$. We first calibrate the model to an arbitrary index of $y(0) = 100$ and a growth rate of $g_y = .018$, which corresponds roughly to US experience in the last century, and then show that for any feasible set of parameters, the effect of raising β on $y(0)$ is negative.

The growth rate is determined by four elementary parameters: ρ, η, α, and γ. We set the rate of time discount to $\rho = .04$, which is in the range of estimates that appear in the literature, and the rate of population growth at $\eta = .013$, which is close to the US average over the last century. Our qualitative results are not sensitive to ρ, but it is necessary for an optimal policy that $\rho - \eta > 0$.

We assume for our baseline that $\alpha = .4$, which is approximately equal to capital's share in the US economy. However, below we consider a wide range of values for α. To calibrate γ, we note that population growth over US history does not appear to have had much influence on the growth rate of per capita output.[31] Therefore, we set γ to ensure that $\partial g_y / \partial \eta = 0$ using (28). This yields $\gamma = 1 - \alpha = .6$. It follows that when we vary α in the sensitivity analysis, we also vary γ.

The above four parameters are sufficient to find the value of A by using (27) and (28) along with our empirical observation that US growth was about $g_y = .018$ over the last century. In fact, if $\gamma = 1 - \alpha$, as we assume, then the expression for A reduces to $A = g_y + \rho$.[32] Using the value $g_y + \rho = .058$, we find $v_0 = 27.6162$ from (45).

To find the path of $y(t)$, we also require values for v_1, and the stocks $h(0)$ and $N(0)$. Use the expression for y in (17), our assumption that $y(0) = 100$, and arbitrary values $h(0) = 10$ and $N(0) = 10,000$.[33] These values gives us $v_1 = 1.185$.

Now we demonstrate that $\frac{\partial y}{\partial v_0} < 0$ for a wide range of parameter values. The level of y at any instant is given by (17), which we can express as:

$$y = b h^{2-\alpha} N^{1-\alpha} \left(\frac{1}{v_0^{1-\alpha}} \right) e_w^{2-\alpha} \tag{52}$$

where $b \equiv \frac{\alpha^{1+\alpha}(1-\alpha)^{2(1-\alpha)}}{v_1^{\alpha}}$. Now use (26) for e_w and (20) for A to show how e_w depends on v_0:

$$y(v_0) = b\, h^{2-\alpha} N^{1-\alpha} \left(\frac{1}{v_0^{1-\alpha}} \right) \left(\frac{(\rho - \eta)\, v_0^{\gamma}}{(1+\gamma)\left[\alpha(1-\alpha)\right]^{\gamma}} + \frac{\gamma}{1+\gamma} \right)^{2-\alpha} \tag{53}$$

The object b and the stocks h and N do not change with a rise in v_0. The sign of the derivative, then, only concerns the last term, and is independent of the values of v_1, h, and N.

From our calibration strategy, set $\gamma = 1 - \alpha$. Then take the derivative of (53) with respect to v_0. The derivative, which is quite complicated, depends only on α, v_0, and $\rho - \eta$. Keeping $\rho - \eta$ unchanged, call the derivative:

$$\frac{\partial y}{\partial v_0} = b\, h^{2-\alpha} N^{1-\alpha} f(\alpha, v_0) \tag{54}$$

Recall that v_0 depends on α in our calibration. That is, $v_0 = \frac{\alpha(1-\alpha)}{(g_y+\rho)^{\frac{1}{1-\alpha}}}$, which uses the results from our calibration that $\gamma = 1 - \alpha$ and that $A = g_y + \rho$. Make this substitution in (54) to eliminate v_0

[31] For evidence of this, see Goodfriend and McDermott (2021).

[32] That is, substitute (27) into (28); then set $\gamma = 1 - \alpha$ and solve for A.

[33] These values are not quite arbitrary; they deliver values for variable cost v_1 that are much smaller than the fixed cost v_0, which fits our intuition.

from the derivative, leaving:[34]

$$\frac{\partial y}{\partial v_0} = b\, h^{2-\alpha} N^{1-\alpha} g\left(\alpha\right) \tag{55}$$

We evaluate $g\left(\alpha\right)$ numerically for values of α between .1 and .9, in steps of .05. In all cases $g\left(\alpha\right) < 0$.

This demonstrates that an increase in the fixed cost v_0 reduces the level of y in the short run for a wide range of feasible parameters, since as we vary α, we are also varying γ and v_0 to ensure compliance with our basic calibration. As noted in the text, the rate of growth g_y falls according to (31).

D Results from Other Data

In Table 8, we show pooled OLS results for y and g_y using lagged values of $ITCI$ and $Ease$ as well the lagged value of HC. We include *Latitude* as well, but it drops out in the panel fixed-effects regressions in Table 9. These tables demonstrate the same pattern as those in the text: the regulation measure $Ease$ works well in almost all cases; the taxation measure $ITCI$ performs best in the panel regressions.

$Ease$ is always significant in the specifications in both tables with large samples, those that do *not* include $ITCI$. The sample that includes $ITCI$ is both dramatically smaller and exclusively from OECD countries, both of which tend to reduce the sample variation in $Ease$, increasing the standard error.[35] Overall, $Ease$ performs slightly better in the pooled OLS regressions compared to the panel regressions.

In the fixed-effects regressions, $ITCI$ performs just as our theory predicts: significant for y but not for g_y. In the pooled OLS regressions, $ITCI$ seems to have no effect on $\ln y$ or g_y. Only the latter is consistent with our model.

[34] The expression $g\left(\alpha\right)$ is long and complicated. It is available upon request.

[35] The sample variance of $Ease$ is 8 times greater in Column (2) compared to Column (3): .016 vs .002.

Table 8: Pooled OLS: $ITCI$ and $Ease$

	ln y			g_y		
	(1)	(2)	(3)	(4)	(5)	(6)
$ITCI_{t-1}$	-0.127		-0.144	0.017*		0.015
	(0.243)		(0.264)	(0.011)		(0.011)
$Ease_{t-1}$		4.084***	0.433		0.091***	0.037
		(0.255)	(0.822)		(0.023)	(0.031)
HC_{t-1}	0.359***	0.782***	0.340***	-0.013***	-0.007*	-0.015***
	(0.052)	(0.049)	(0.066)	(0.005)	(0.004)	(0.005)
$Latitude$	1.184***	0.252**	1.142***	0.057***	0.000	0.052***
	(0.178)	(0.115)	(0.173)	(0.016)	(0.006)	(0.015)
y_0				-0.001	-0.009***	-0.000
				(0.002)	(0.001)	(0.002)
Constant	8.913***	4.717***	8.674***	0.035*	0.054***	0.012
	(0.177)	(0.085)	(0.418)	(0.019)	(0.013)	(0.022)
Year FE	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	NO	NO
Obs.	180	1540	180	180	1540	180
Adjusted R^2	0.28	0.70	0.28	0.08	0.06	0.08

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Panel Fixed Effects: $ITCI$ and $Ease$

	ln y			g_y		
	(1)	(2)	(3)	(4)	(5)	(6)
$ITCI_{t-1}$	0.381***		0.374***	0.032		0.030
	(0.116)		(0.120)	(0.070)		(0.073)
$Ease_{t-1}$		1.605**	-0.157		0.135**	-0.031
		(0.728)	(0.371)		(0.060)	(0.232)
HC_{t-1}	0.070	-0.089	0.091	-0.039	-0.009	-0.035
	(0.166)	(0.142)	(0.188)	(0.058)	(0.025)	(0.052)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Obs.	180	1551	180	180	1551	180
Adjusted R^2	0.70	0.16	0.70	0.06	0.09	0.06

Robust tandard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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