On the Aggregate and Distributional Effects of Innovation Policies*

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Abstract

We study the aggregate and distributional impacts of R&D subsidy policies using a heterogeneous-agent model featuring entrepreneurial and incorporation options, endogenous firm-level innovation, and financial market imperfections. We find that a higher R&D subsidy rate increases aggregate output and welfare, but also results in higher wealth concentration at the top level. The presence of financial frictions limits the aggregate gains and amplifies the distributional effects of R&D subsidies. In addition, we quantify how the welfare effects due to the optimal subsidy policy are distributed across households that differ in their occupation, income, and wealth.

Keywords: R&D subsidies, innovation, inequality, and tax policy.
JEL classification: E2, E6, O3

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1 Introduction

Governments in most developed countries subsidize business research and development (R&D) to promote long-term economic growth led by technology improvement, but the subsidies vary in terms of their generosity. A large body of literature has studied the effects of government subsidies on firm-level R&D expenditure, aggregate output and welfare.[1] However, less is known about the distributional impact of R&D subsidies on households that differ in their occupation, income, and wealth.

In the United States, firm ownership is highly concentrated, and firm owners are much wealthier than the rest of the population.[2] If the government provides more generous R&D subsidies, the increase in firms' profits may lead to more wealth to be accumulated in firm owners, worsening the wealth inequality in the US. Therefore, the distributional consequences of the policy cannot be ignored. In this paper, we develop a quantitative model in which firm-level innovation is endogenous and firm ownership is as concentrated as in the US economy. We use this framework to compute the optimal subsidy rate on R&D expenditures and quantify its distributional effects across households.

In our model, the economy consists of three types of households: workers, entrepreneurs, and owners of C-corporations. Households are heterogeneous in their occupations, wealth, labor productivity, and firm productivity. In addition to the occupational choice of becoming a worker vs. an entrepreneur, we also model an option of incorporation, which is endogenously determined by the choice of the entrepreneur. The key differences between an entrepreneur owning a pass-through entity and a corporate owner (of the same firm) are as follows. First, the entrepreneur owns the entire share of the firm, whereas once incorporated, the corporate owner owns a fixed share of the firm, and the rest of shares are owned by all households. Second, for a pass-through entity, business profits are taxed according to the personal income tax code. In contrast, C-corporations are subject to double taxation: first, a business profit tax at the firm level and then a dividends tax at the owner's level. Third, the capital demand of pass-through entities is subject to a collateral constraint so that the production scale is constrained by the wealth of their owners. In comparison, C-corporations have unlimited access to credit markets and are free from financial frictions.

A firm can build up its productivity by expending on R&D, and the government subsidizes a fraction of R&D expenditures. We adopt a process of technology upgrades and downgrades

[1] For theoretical analyses, see Acemoglu et al. (2018), Akcigit, Hanley, and Stantcheva (2016), and Akcigit, Hanley, and Serrano-Velarde (2021). For empirical estimates, see, for examples; Wilson (2009), Brown, Fazzari, and Petersen (2009), Dechezleprêtre et al. (2016), and Howell (2017).

[2] More details about the population share and the wealth and income share of firm owners are provided in Section 2.

that is similar to Buera and Fattal Jaef (2018). The change in idiosyncratic productivity follows a binomial process, with the expected rate of technology improvement determined by the amount a firm spends on R&D.

We estimate the parameters of our model by matching a set of empirical moments in the US economy, including the wealth and population share of entrepreneurs and corporate owners, the relative size of the corporate sector, and the distribution of firm sizes and R&D expenditures. Our model can reproduce many salient features of the US economy, including the wealth distribution of all households as well as that of the firm owners (including entrepreneurs and corporate owners). Under our calibration, the status quo R&D subsidy rate is 8 percent.

We then use our calibrated model to investigate to what extent financial frictions affect a firm's R&D expenditures and the effectiveness of the optimal R&D subsidy policy. To this end, we conduct a counterfactual experiment in which we tighten the collateral constraints for pass-through entities. We find that the financial shock disproportionately affects the R&D investment made by more productive entrepreneurs. Intuitively, this is because more productivity firms demand more capital, and thus their expected returns from R&D expenditures are reduced by a larger amount after the negative financial shock. In addition, productive entrepreneurs also experience a substantial decline in wealth and income, which results in a decline in concentration in top wealth and income.

We then solve for the optimal subsidy rate toward pass-through entities. While the optimal subsidy rate does not vary much with the degree of financial frictions, welfare gains are substantially reduced under tighter borrowing constraints. This is because the effects of subsidies on R&D expenditures are capped when the collateral constraint binds, which is the case for most productive entrepreneurs. In turn, aggregate output, the equilibrium wage, and the TPF growth under optimal R&D subsidies decline with tighter financial constraints.

Finally, we study the optimal subsidy rate when the government subsidizes both pass through entities and C-corporations. We study two cases. First, we study the case in which the subsidy rates are the same between pass-through entities and C-corporations (uniform policy), and the optimal uniform subsidy rate is found to be 34 percent. Second, we study the case when the government sets the subsidy rate depending on the firms' legal form (legal-form dependent policy), and the optimal rate is found to be 46 percent for pass-through entities and 23 percent for C-corporations.

Regarding the aggregate impact, both the uniform and the legal-form-dependent subsidy increase welfare and aggregate output, owing to their effect on encouraging firms to spend on R&D, which results in higher TFP and the equilibrium wage. The increase in welfare is more significant under the optimal legal-form dependent policy (0.57 percent under uniform subsidy vs. 0.77 percent under legal-form dependent subsidy). This is because the uniform policy essentially adds a restriction to the social planner's optimization problem by requiring the subsidy rates to be equal between the two types of firms.

In our model, the presence of financial frictions plays a crucial role in shaping the distribution of income and wealth, and for this reason, a more generous R&D subsidy policy substantially increases both the income and the wealth concentration. The mechanism is as follows. First, due to an increase in R&D incentivized by the policy, entrepreneurs have a higher probability of technology upgrades, and therefore, they tend to save more to finance higher capital demand in the future. Second, with a higher wealth level, productive entrepreneurs are more able to overcome financial constraints and thus make more business profits. Third, higher profits allow most productivity entrepreneurs to allocate more resources to R&D expenses and asset accumulation, which further increases their future income and wealth.

In terms of the distributional effect on welfare, almost all workers (97 percent under the uniform subsidy and 95 percent under the legal-dependent subsidy) benefit from both policies, because the R&D subsidy policies increase the equilibrium wage. However, a substantially smaller fraction of entrepreneurs (64 percent and 50 percent) receive welfare gains, and even fewer corporate owners (21 percent and 4 percent) benefit. The average welfare gains are negative for firm owners, primarily because the higher wage rate reduces business income.

We find that the welfare gains and losses are dramatically different for firm owners across wealth and income groups. For example, under the legal-form-dependent subsidy, entrepreneurs who are in the top 0.1 percent of the income distribution receive a 0.8 percent welfare gain. This is because most entrepreneurs in the top income bracket are also in the highest productivity bracket. This type of entrepreneurs invest more in R&D due to the more generous subsidy rate and expect a higher return on capital in the future. Therefore, they expect to demand a larger amount of capital, for which they need to save more assets. The higher wealth level makes financial constraints further relaxed for this type of entrepreneurs, which results in higher business income. In contrast, the capital demand and R&D decisions in C-corporations are made at the corporate level, unrelated to the wealth of corporate owners. Therefore, for corporate owners, the effect of the increasing wage rate dominates. The corporate owners who are in the top 0.1 percent of the income distribution receive a over 4 percent welfare loss.

In addition, both types of firm owners in the bottom income brackets may have higher welfare gains than those who are in the top brackets. This is because firm owners with lower income levels are more likely to become workers in the future. Since almost all workers receive welfare gains due to the higher equilibrium wage, the welfare gains of this type of firm owners are also higher due to the higher expected future income.

Related Literature

Our paper is related to several strands of literature. First, our paper is related to the quantitative macro public finance literature that studies the effect and the optimal design of innovation policies. Existing literature points out two main reasons for R&D underinvestment in the private sector and thus provides rationales for government subsidies. The first is the public good nature of R&D outcomes that individual firms fail to internalize (Acemoglu et al. (2018), Akcigit, Hanley, and Stantcheva (2016), Akcigit, Hanley, and Serrano-Velarde (2021)). The second is the financial frictions that impede R&D investments, especially for small and young firms (Brown, Fazzari, and Petersen (2009), Howell (2017)). A number of papers have studied the effectiveness of different policy tools that aim to increase innovation (Wilson (2009), Dechezleprêtre et al. (2016), Bloom, Van Reenen, and Williams (2019), Hall (2020), König et al. (2020)).

Our paper focuses on the second reason and makes three key contributions to the existing literature. First, we separate different types of firms by their legal forms. Second, in our model, financial frictions affect the aggregate economy through its impact of R&D expenditures. Third, we investigate both the aggregate and the distributional effects of R&D subsidies on households with different occupations, wealth, and income.

Second, our paper builds on the large literature on the macroeconomic implications of entrepreneurship and its role in shaping wealth and income inequality. Quadrini (2000) and Cagetti and De Nardi (2006) are among the first papers that point out incorporating individual (entrepreneur)- specific technology and financial frictions can generate more plausible wealth inequality than that implied by a precautionary motive. This idea is then further developed to study taxation policies (Meh (2005), Meh (2008) Cagetti and De Nardi (2009) Buera, Kaboski, and Shin (2015) and Scheuer (2014)), economic development (Buera and Shin (2013) and Buera, Kaboski, and Shin (2021)) and business cycle fluctuations after financial crisis (Buera and Moll (2015) and Bassetto, Cagetti, and De Nardi (2015)). See Buera, Kaboski, and Shin (2015) for an excellent survey.

Our contribution to this literature is incorporating the endogenous choice of business legal forms between pass-through entities and C-corporations. To this end, our paper is most related to Dyrda and Pugsley (2018), who build the connection between the rise in income and wealth inequality and the growth of pass-through entities in the share of business receipts in US. In addition, Glover and Short (2010) also model the decision to incorporate in the model of entrepreneurs. The ownership structure of firms in our model is also similar to that in Zetlin-Jones and Shourideh (2017). However, they abstract from the incorporation option for private firms.

Last, our theoretical framework builds on the literature that studies the aggregate and distributional effects of taxation on private business under concentrated ownership. Existing literature has explored various tax polices on the product market (Boar and Midrigan (2019), Bhandari and McGrattan (2021)). We contribute to this strand of literature by adding endogenous innovation and study the optimal form of R&D subsidies.

2 Motivating Evidence

In this section, we outline three empirical facts summarizing R&D subsidy policies in developed countries and the evolution of income and wealth inequality in the US. These stylized facts provide motivation for our model and context for our quantitative analysis.

2.1 Large Variation in R&D Subsidies

Governments in most advanced economies subsidize R&D to promote technology improvement, but such policies largely differ in terms of their overall generosity and in the distribution of support between large and small and medium sized enterprises (SMEs).

Figure 1 compares the implied tax subsidy rates on R&D expenditure between different countries.[3] In 2021, the US R&D tax subsidy rates are 0.06 for large firms and 0.07 for SMEs. Both numbers are below the OECD average. For example, Italy's R&D subsidy rate has significantly increased since 2015, reaching 0.15 in 2021 for both large firms and SMEs. France has always been among the countries with the highest R&D subsidy rate: its subsidy rate is 0.30 for large firms and 0.37 for SMEs. Some countries give more generous R&D subsidies to SMEs than to large firms, for example, Korea.[4]

The large difference in R&D subsidy policies across advanced economies leads us to investigate the optimal design of R&D subsidy policy in the US. Specifically, should the US government increase the generosity of its R&D subsidy? In addition, should the subsidy be more generous for smaller firms or larger ones?

One important consideration for this question is the distributional effects of R&D policy.

[3] The implied tax subsidy rate measures the generosity of tax support, and a higher rate implies more generous support. For more details on the definition, see https://www.oecd.org/sti/rd-tax-incentive-indicators.htm.

[4] All of the subsidy rates mentioned above are for profitable firms. More information on the loss-making situation can be found at https://www.oecd.org/sti/rd-tax-incentive-indicators.htm.

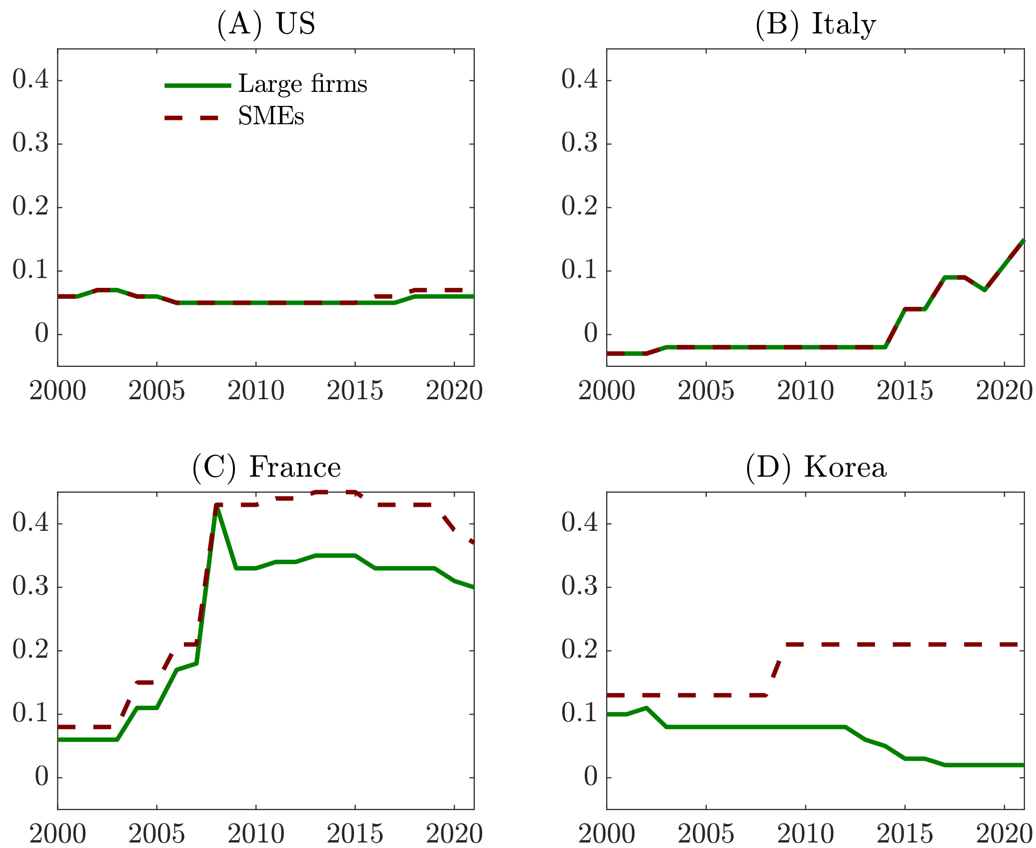

Figure 1: Implied R&D Subsidy Rates

Because the R&D subsidy reduces the cost of innovation, leading to higher firm profits and productivity, firm owners directly benefit from more generous subsidies. When firm ownership is highly concentrated, as is the case in the US, more generous R&D subsidies may lead to welfare gains unequally distributed between firm owners and workers. Therefore, the form of business organizations is a key factor to take into consideration when designing the optimal R&D policy.

2.2 Rising Shares of Pass-Through Entities

The effects of R&D subsidies depend on the forms that business organizations take. As a result of a series of tax reforms since 1980, the share of firms organized as pass-through entities (for example, LLCs and S-corporations) instead of C-corporations more than doubled from 1980 to 2012 (Dyrda and Pugsley (2018)).

Pass-through entities differ from C-corporations in three important aspects. First, the profits of pass-through entities are taxed once as the personal income tax of the firm's owner. In comparison, the profits of C-corporations are subject to double taxation, first at the entity level as a corporate profit tax and then at the owner's level as a dividend income tax. Unlike corporate income tax and dividends income tax, which are both linear, the personal income tax is progressive. This implies that the R&D investment decisions for pass-through entities may be distorted by the entrepreneurs' personal income tax code.

Second, most entrepreneurs of pass-through entities are subject to financial frictions, whereas C-corporations have much better access to credit markets. Due to financial frictions, the demand for capital in pass-through entities may depend on their entrepreneur's own wealth levels. and at the same time entrepreneurs have incentives to save more when expecting a higher return on capital investments. In this paper, we show that financial frictions may distort the R&D investment decisions and limit the effects of R&D subsidy policies for pass-through entities.

Third, the ownership of pass-through entities is very concentrated, whereas ownership of C-corporations is diversified. If R&D subsidies become more generous, more profits will be passed through to entrepreneurs, which may increase wealth and income concentration at the same time. Due to these key differences between pass-through entities and C-corporations, it is important to account for firms' legal types when studying the optimal R&D subsidy policy.

2.3 Increasing Inequality in Wealth and Income

The increasing number of pass-through entities leads to more income and wealth being concentrated in entrepreneurs. On average, entrepreneurs hold more wealth and earn more income than the rest of the population in the US. Table 1 shows that in 2016, entrepreneurs represent only 6.8 percent of the US population, but hold 30.8 percent of the wealth in the US economy. Table 1 further shows that from 1992 to 2016, the US experienced a significant increase in income and wealth inequality. The share of wealth (income) of the top 1 percent of household increased from 30.0 (11.5) percent to 39.5 (23.5) percent. Dyrda and Pugsley (2018) argue that the rise of pass-through entities explains approximately 40 percent of the increase in the top 1 percent pre-tax income share in the US.

The combination of the increase in the share of pass-through entities and the rise in wealth inequality suggests that the welfare gains of R&D subsidies may largely vary across households that differ in occupation, income, and wealth. Therefore, it is important to take different legal forms of business and household heterogeneity into consideration when studying the effects of R&D subsidies.

Table 1: Shares of Wealth and Income Composition

	1992	1998	2004	2010	2013	2016
Population share of entrepreneurs (%)	7.4	6.9	7.0	7.9	6.6	6.8
Population share of corporate owners (%)	1.2	1.2	0.9	0.7	0.6	0.5
Wealth share of entrepreneurs (%)	24.5	23.8	28.1	33.1	32.4	30.8
Wealth share of corporate owners (%)	7.9	8.5	5.0	4.6	5.3	4.2
Wealth share of top 1% of households (%)	30.0	34.0	33.5	34.2	35.4	39.5
Wealth share of top 0.1% of households (%)	11.1	12.6	11.6	12.4	12.9	15.1
Income share of top 1% of households (%)	11.5	16.5	16.9	17.0	19.5	23.5
Income share of top 0.1% of households (%)	3.7	6.1	6.3	5.7	8.0	9.0

Source: Authors' computation based on Survey of Consumer Finance. Entrepreneurs are defined as self-employed, pass-through entities owners who are actively engaged in management. Corporate owners are defined as self-employed owners of non pass-through entities who are actively engaged in management.

3 Model

We study an economy populated by a continuum of households that choose between being a worker or a firm owner. There are two types of firms: pass-through entities and C-corporations. All firms are born as pass-through entities. The sole proprietor of a pass-through entity (entrepreneur) has the option to incorporate the firm and then becomes the major owner of a public C-corporation. There is a government that raises revenues through taxes and designs the policy on subsidizing the R&D expenditure of firms.

In this section, we first describe the model environment in Section 3.1 and then describe the optimization problems for C-corporations and households in Section 3.2 and 3.3. Last, we define the stationary equilibrium of our model in Section 3.4.

3.1 Environment

Before we characterize the optimization problems in the private sector, we first present the essential elements and assumptions in our model.

Demographics. We consider an economy with a continuum of individual households of measure one. Time in the model is discrete. In each period, individuals choose between three occupations: worker, entrepreneur (owner of a pass-through entity), and owner of a

C-corporation. The fractions of each type of household are endogenous and their life span is infinite. Each entrepreneur runs a pass-through entity and earns business income from the firm's profit. The C-corporation owner earns a fixed share of dividends from the corporate firm. The rest of the share of corporate profits is equally distributed to all households. We assume that entrepreneurs and C-corporation owners are only engaged in management activities in their firms, and only workers provide labor supply in a competitive labor market.[5]

Legal forms. Our model features an endogenous choice of the legal form of business organization with the following restrictions. First, all firms must start as a pass-through entity. In other words, every new C-corporation was a pass-through firm in the previous period. Second, only C-corporations, not pass-through entities, pay a fixed operation cost in every period. Third, there is no privatization option for C-corporations. The corporate owner receives a fixed share of dividends until the C-corporation decides to exit the market.

In line with Dyrda and Pugsley (2018), our model also captures the trade-off between two legal forms. The benefit of being a pass-through entity is the preferential tax treatment: the profit of a pass-through entity is only taxed once according to the personal income tax code. In comparison, the profit of the C-corporation is subject to double taxation: the corporate income tax is levied on profits at the entity level and the dividend income tax is levied on the dividend at the owner level.

The cost of being a pass-through entity is the financial frictions. Entrepreneurs of pass-through entities have to finance internally using their own equity, and the financial market frictions impose an intra-period borrowing constraint on their capital demand. In contrast, C-corporations have unlimited access to external finance, which makes their demand for capital unconstrained.

Preference. Households are endowed with one unit of time in each period to choose between work and leisure. Each household maximizes its discounted stream of utilities by choosing consumption c_t and working hours h_t in each period. The household's objective function is given by:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma_1}}{1-\sigma_1} - \xi \frac{h_t^{1+\sigma_2}}{1+\sigma_2} \right) \right\}, \tag{1}$$

where $\beta \in (0,1)$ is the discount rate, σ_1 measures relative risk aversion, σ_2 is the inverse Frisch elasticity, and ξ is the weight of the disutility of labor. The expectation operator

[5] This assumption is consistent with the definition of business owner in our empirical analysis. Specifically, we require that both entrepreneurs and corporate owners be self-employed business owners and active in the management role.

is with respect to all future idiosyncratic shocks. We assume that there is no aggregate uncertainty in the model.

Labor productivity. Households differ in their labor productivity due to realizations of idiosyncratic shocks. We assume that the logarithm of labor productivity e of households follows a standard AR(1) process, given by

$$log(e') = \rho_e log(e) + \epsilon_e, \tag{2}$$

where ρ_e is the annual persistence of the autoregressive process and $\epsilon_e \sim \text{N}(0, \sigma_e)$ is i.i.d. across all households.

Firm productivity We follow Buera and Fattal Jaef (2018) to model the process of technology upgrades and downgrades. Specifically, we assume that the growth rate of idiosyncratic productivity follows a simple binomial process, with an expected rate of growth determined by the firm's R&D expenditures, and an exogenous standard deviation.

We use z to represent firm productivity.[6] We assume that productivity grid points are evenly distributed over a fixed interval, $[z_{min}, z_{max}]$. j indexes the j^{th} grid point of productivity. We then have

$$z_j = z_{min} + \Delta_z \times (j-1), \tag{3}$$

where Δ_z is the step size of innovation. The upper bound of firm productivity equals $z_{max} = z_{min} + \Delta_z \times (N_z - 1)$, where N_z is the total number of productivity grid points.

R&D technology. Firms choose the probability of productivity upgrades by making R&D investments. Regarding the technology of R&D, firms in each period invest in $\chi(p, z)$ units of consumption good, which yields a probability p of a technology upgrade[7]. If the current firm productivity equals z_{max}, then we assume that with probability p, the productivity remains at the same level in the next period[8].

The cost of innovation is assumed to take the following form:

$$\chi(p.z) = z\mu(e^{\phi p} - 1), \tag{4}$$

where μ is a scale parameter and ϕ is a the elasticity parameter. Under this assumption,

[6] z can represent either the firm productivity of a pass-through entity or the firm productivity of a C-corporation, depending on the current occupation of the household that owns the firm.

[7] Similarly, the probability of a technology downgrade by one step is $1-p$.

[8] Similarly, if the current firm productivity equals z_{min}, then we assume that with probability $1-p$, productivity remains at the same level in the next period.

the innovation cost is linear in a firm's current productivity and convex in the upgrade probability.

Production. There are two sectors of firms in the product market: pass-through entities (denoted by E) and C-corporations (denoted by F). All firms have access to a decreasing-returns-to-scale production technology that combines two factors of inputs, labor l and capital k, into output. The production function takes a standard Cobb-Douglas form given by

$$y^s(z,k,l) = z(k^\alpha l^{1-\alpha})^{\gamma^s}, \tag{5}$$

where $s \in \{E,F\}$ indexes the legal form of firms, γ^s is the sector-specific span-of-control parameter. A share, γ^s, of output goes to factors of inputs. Out of this share, a fraction of α goes to capital and $1-\alpha$ goes to labor. The output of production is a homogeneous final good, whose competitive price is the numéraire of the economy.

Financial market. In our model, households cannot borrow inter-period debt to finance consumption or make capital investments. Firms can borrow an intra-period loan from financial intermediaries at a risk-free rate of r to finance their capital demand. For entrepreneurs, a collateral constraint arises because capital must be paid out before revenue is realized. Since borrowing and lending decisions take place after the firm's productivity shock is realized, there is no uncertainty about whether an entrepreneur can repay the loan at the end of the period.

The collateral constraint for entrepreneurs is given by

$$k \leq \lambda a, \tag{6}$$

where λ captures the tightness of credit. As we mentioned above, C-corporations are assumed to have unlimited access to financial markets and thus are not subject to collateral constraints.

Fiscal policies. Table 2 summarizes all tax and subsidy policies in our model. The government finances its expenditure on R&D subsidies and other public spending, G, through four tax instruments. First, all households are subject to a non-linear personal income tax levied on either business (for entrepreneurs) or wage income (for workers), i, according to the tax schedule $T_p(\cdot)$. The income tax function takes the following form

$$T_p(i) = i - (1-\tau_y)i^{1-\lambda_y}, \tag{7}$$

Table 2: Summary of Tax and Subsidy Policies

Tax code	Notation	Shape	Payers or receivers
Personal income tax	$T_p(y)$	non-linear	workers and entrepreneurs
Dividends tax	τ_d	linear	all households
Consumption tax	τ_c	linear	all households
Corporate income tax	τ_b	linear	C-corporations
R&D subsidy	$R^s_\chi(y)$	non-linear	all firms

which is proposed by Benabou (2002) and also used in Heathcote, Storesletten, and Violante (2017). The first parameter τ_y determines the average level of taxation in the economy, and the second parameter λ_y determines the degree of progressiveness of the tax system. In addition to the income tax, households are subject to a linear consumption tax τ_c and a linear dividend tax τ_d.

C-corporations are subject to double taxation. Specifically, the government also imposes a flat-rate corporate income tax, τ_b, on the profits of C-corporations, which is collected before C-corporation owners receive dividend payments. C-corporation owners also pay a dividend tax, τ_d, when receiving dividends.

Regarding R&D subsidy, we allow for the subsidy to be potentially size dependent and sector specific. Specifically, we assume that the government subsidizes a fraction of R&D expenditure, with the subsidy rate given by

$$R^s_\chi(y) = 1 - (1 - \tau^s_\chi) y^{-\lambda^s_\chi}, \tag{8}$$

where y is the current-period output of the firm, τ^s_χ determines the average rate of the R&D subsidy, and λ^s_χ governs the progressivity of the R&D subsidy.[9] In our benchmark calibration, we approximate the US R&D subsidy policy with a linear R&D subsidy policy, which means we set $\lambda^s_\chi = 0$.

3.2 C-corporation's Problem

In this section, we first specify the timing in the C-corporation sector, and then describe the optimization problem for C-corporations.

[9] We follow Akcigit, Hanley, and Serrano-Velarde (2021), where the authors also use this HSV-type function to approximate the non-linear shape of the R&D subsidy rate.

Timing. At the beginning of each period, a C-corporation is born when an entrepreneur decides to incorporate her pass-through entity. The transition is immediate. Once the process of incorporation is complete, the entrepreneur becomes the major owner of the C-corporation. However, all future decisions will be made at the firm level, independent of the corporate owner's personal characteristics. In other words, capital input, labor input, R&D expenditure, dividend payouts, and decision to exit are not affected by the corporate owner's asset level or labor productivity.[10]

For incumbent C-corporations, at the beginning of each period, the firm observes its new productivity draw. Then, it chooses whether to continue the business or to exit the market. Once the exit choice is made, the corporate owner becomes a worker.

Exit decision. Let $v^F(z)$ denote the value of a C-corporation with productivity z. The exit decision is characterized by

$$V(z) = max\left\{v^F(z), 0\right\}, \tag{9}$$

where 0 is the cut-off value below which firms will choose to exit the market.

Firm problem. We assume that to continue their businesses, C-corporations have to pay a fixed operation cost κ_F in every period. Then, conditional on choosing to continue, a risk-neutral C-corporation solves a two-stage optimization problem. In the first stage, conditional on firm productivity z, the C-corporation makes intra-period decisions on capital and labor. In the second stage, the C-corporation chooses the probability of a technology upgrade in the next period by investing in R&D. Specifically, the C-corporation solves the following recursive problem:

$$v^F(z) = \max_P \left\{ d(z) + \frac{1}{1+(1-\tau_d)r}\left[PV(z^+) + (1-P)V(z^-)\right]\right\} \tag{10}$$

subject to

$$d(z) = (1-\tau_b)\left(\max_{k,l}\left\{y^F(z,k,l) - wl - (r+\delta)k\right\} - [1-R^F_\chi(y)]\chi(P,z) - \kappa_F\right) \tag{11}$$

$$d(z) \geq 0, k \geq 0, l \geq 0, \tag{12}$$

[10]The exit decision is one of the key difference between a pass-through entity and a C-corporation. Unlike the C-corporation whose exit decision depends only on z, a pass-through entity may choose to exit when the entrepreneur has a very high labor productivity draw and chooses to become a worker. The exit decision of pass-through entities is explained in detail in Section 3.3.

where $d(z)$ is the total dividends paid to shareholders, and $V(z^+)$ ($V(z^-)$) is the firm value if technology is upgraded (downgraded) by one step in the next period.

Notice that the choice of the probability of a technology upgrade, P, does not change profits in the current period. The C-corporation chooses P to maximize its discounted streams of future dividends. A greater P brings a higher probability of a technology upgrade, but it is also associated with a greater cost, as specified in Equation (3). All after-subsidy R&D investment is deductible from corporate-income-tax.

Mutual funds. We assume there is a mutual fund equally owned by all households. The fund owns the remaining share of all the C-corporations and distributes the remaining dividends of all C-corporations to all households. The sum of all dividends paid to all households is given by

$$D = (1-\theta)\int d(z)\mu^C \tag{13}$$

where θ is the share retained by C-corporation owners after incorporation, and μ^C is the distribution of incumbent firms in the corporate sector.

3.3 Household's Problem

In this section, we first describe the timing of households' decisions, and then specify the occupation choice and the incorporation choice, as well as the optimization problems for each occupation.

Timing. At the beginning of every period, households observe their asset, a, labor productivity, e, firm productivity, z, and their occupation in the previous period, η_-. Then, conditional on these state variables, they choose their current-period occupations. If an individual was a worker ($\eta_- = 1$) in the previous period, then she can choose between continuing to be a worker or becoming an entrepreneur to start a pass-through entity. If an individual was a entrepreneur ($\eta_- = 2$) in the previous period, she can choose to become a worker, continue to be an entrepreneur and run the same firm, or become a C-corporation owner by incorporating her firm. If an individual was a corporate owner ($\eta_- = 3$) in the previous period, she can keep this occupation status if the firm chooses to continue its operation in this period. Otherwise, if the C-corporation decides to exit, its owner becomes a worker. The possible switch between occupations and firm legal forms is summarized in Figure 2.

If the individual is a worker in the current period, she receives labor income, return from savings, and dividends from the mutual fund. Then, she makes consumption and labor supply decisions. With probability ψ, her next-period entrepreneurial productivity will downgrade

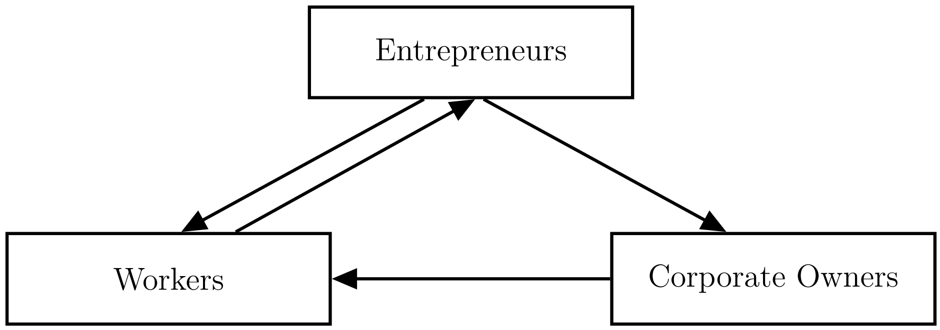

Figure 2: Possible Switch between Occupations and Firm Legal Forms

by one step. With probability $1-\psi$, her next-period entrepreneurial productivity will redraw from a Pareto distribution. The worker's labor productivity evolves according to the AR(1) process.

If the individual is an entrepreneur in the current period, she gains entrepreneurial income, return from savings, and dividends from the mutual fund. In addition to the consumption vs. saving decision, an entrepreneur also chooses capital and labor for production and R&D investment. The entrepreneur's labor productivity evolves according to an AR(1) process, and the probability of technological upgrades depends on her R&D expenditures.

If the individual is a corporate owner in the current period, she receives return from savings, dividends from the firm that she owns, and dividends from the mutual fund. The corporate owner only makes inter-temporal consumption decisions. The corporate owner's labor productivity evolves according to an AR(1) process, and the probability of technological upgrades depends on the R&D expenditure decision made by the C-corporation.

Occupation and incorporation choice. If an individual was a worker in the previous period, her value function, as a result of her occupational choice, is given by

$$v(a,e,z,1) = max\left\{v^W(a,e,z,1), v^E(a,e,z,1)\right\} \tag{14}$$

where the first term in the curly bracket is the value of continuing to be a worker, and the second term is the value of becoming an entrepreneur.

Next, if an individual was an entrepreneur in the previous period, her value function, as a result of both the occupation choice and the incorporation decision, is given by

$$v(a,e,z,2) = max\left\{v^W(a,e,z,2), v^E(a,e,z,2), v^C(a,e,z,2)\right\} \tag{15}$$

where the first term in the curly bracket is the value of becoming a worker, the second term is the value of continuing to be an entrepreneur, and the third term is the value of becoming a corporate owner after incorporation.

Last, if an individual was the owner of a C-corporation in the previous period, her value function, as a result of the exit or continuation decision, is given by

$$v(a,e,z,3) = \mathbb{I}(z < \underline{z})v^W(a,e,z,3) + \mathbb{I}(z \geq \underline{z})v^C(a,e,z,3) \tag{16}$$

where the first term (on the right hand side) is the value of becoming a worker, and the second term is the value of continuing to be a corporate owner. The indicator function shows whether the C-corporation with productivity z chooses to operate or exit, and $\underline{z}$ is the cut-off productivity, above which the firm chooses to continue.

Worker's problem. A worker chooses consumption, c, savings, a', and working hours, h, to solve the following recursive problem:

$$v^W(a,e,z,\eta_-) = \max_{c,a',h} \left\{ u(c,h) + \beta \left[(1-\psi)\mathbb{E}_{e'}v(a',e',z^-,1) + \psi \int_{z'} \mathbb{E}_{e'}v(a',e',z',1)G(z') \right] \right\} \tag{17}$$

subject to

$$(1+\tau_c)c + a' = a + weh + (1-\tau_d)(ra + D) - T_p(we) \tag{18}$$

$$c \geq 0, a' \geq 0 \tag{19}$$

where $\eta_- \in \{1,2,3\}$, $G(z)$ is the Pareto distribution (with a shape parameter ζ) from which the worker can re-draw their entrepreneurial productivity, and ψ is the probability of redraw. Note that the dividends tax is applied to the return from savings, ra, as well as the dividends from owning the public mutual fund, D.

Entrepreneur's problem. We assume that there is no entry cost for pass-through entities, and therefore, all entrepreneurs solve the same problem, despite their occupations in the previous period. Entrepreneurs solve a two-stage optimization problem in each period. In the first stage, given firm productivity z and asset a, an entrepreneur chooses capital, k and labor, l, to maximize profits in the current period. The intra-period optimization problem is given by

$$\pi(a,z) = \max_{k,l} \left\{ y^E(z,k,l) - wl - (r+\delta)k \right\} - [1 - R^E_\chi(y)]\chi(p,z) \tag{20}$$

subject to

$$0 \leq k \leq \lambda a, l \geq 0, \tag{21}$$

where the upper bound of capital arises due to the presence of the collateral constraint.

In the second stage, the entrepreneur makes inter-temporal consumption vs. saving decisions, as well as decisions about R&D expenditures, which determines the probability of a technology upgrade in the next period. The dynamic optimization of the entrepreneur is given by

$$v^E(a,e,z,\eta_-) = \max_{c,a',p} \left\{ u(c,0) + \beta \left[p\mathbb{E}_{e'} v(a',e',z^+,2) + (1-p)\mathbb{E}_{e'} v(a',e',z^-,2) \right] \right\} \tag{22}$$

subject to

$$(1+\tau_c)c + a' = a + \pi(a,z) + (1-\tau_d)(ra+D) - T_p[\pi(a,z)] \tag{23}$$

$$c \geq 0, a' \geq 0 \tag{24}$$

where $\eta_- \in \{1,2\}$. Notice that the continuation value of the recursive problem captures how the choice of p affects future expected value. With probability p $(1-p)$, the pass-through entity will experience a technology upgrade (downgrade). The profit of the pass-through firm is taxed according to personal income schedule. All after-subsidy R&D investment is deductible from personal-income tax.

Corporate owner's problem. We assume that there is no incorporation cost, and therefore, all corporate owners solve the same optimization problem, despite whether their firms were pass-through or corporate firms in the previous period. Conditional on being a corporate owner, the individual chooses consumption c and savings, a', to solve the following recursive problem

$$v^C(a,e,z,\eta_-) = \max_{c,a'} \left\{ u(c,0) + \beta \left[P(z)\mathbb{E}_{e'} v(a',e',z^+,3) + [1-P(z)]\mathbb{E}_{e'} v(a',e',z^-,3) \right] \right\} \tag{25}$$

subject to

$$(1+\tau_c)c + a' = a + (1-\tau_d)[ra + D + \theta d(z)] \tag{26}$$

$$c \geq 0, a' \geq 0 \tag{27}$$

where $\eta_- \in \{2,3\}$. The probability of technological upgrade, $P(z)$, is chosen by the C-corporation and depends only on the current technology level. Since the corporate owner retains a share θ of the C-corporation, she receives a share θ of the after-corporate-income-tax dividends of the corporate firm, $\theta d(z)$. Notice that the corporate owner receives both dividends from the mutual fund, D, and dividends from the firm she partially owns, $\theta d(z)$, both of which are taxed according to the dividends tax schedule.

3.4 Stationary Equilibrium

Households are indexed by individual states $\mathbf{s} = \{a, e, z\}$ and C-corporations are indexed by z. Given government tax and subsidy policies $X^G = \{\tau_c, \tau_d, \tau_b, R^s_\chi, T_p, G\}$, a stationary recursive competitive equilibrium is a set of value functions $\{v^F, v^W, v^E, v^C\}$, allocation of C-corporations $X^F = \{d(z), P(z), k(z), l(z), y(z)\}$, allocation of workers $X^W = \{c(\mathbf{s}), a'(\mathbf{s}), h(\mathbf{s})\}$, allocation of entrepreneurs $X^E = \{c(\mathbf{s}), a'(\mathbf{s}), p(\mathbf{s}), k(\mathbf{s}), l(\mathbf{s}), y(\mathbf{s})\}$, allocation of corporate owners $X^C = \{c(\mathbf{s}), a'(\mathbf{s})\}$, optimal occupation and incorporation decisions X^D, prices $\{r, w\}$, dividends from the mutual fund D, and the distribution of C-corporation, workers, entrepreneurs, and corporate owners $\mu = \{\mu^F(z), \mu^W(\mathbf{s}), \mu^E(\mathbf{s}), \mu^C(\mathbf{s})\}$ such that

1. Given prices $\{r, w\}$ and government policies X^G, allocations X^F, X^W, X^E , X^C, X^D and value functions $\{v^F, v^W, v^E, v^C\}$ solve the maximization problem described in Sections 3.2 and 3.3.

2. Capital market clears:

$$\sum_{\eta=W,E,C} \int a'(\mathbf{s}) d\mu^\eta(\mathbf{s}) = \int k(\mathbf{s}) d\mu^E(\mathbf{s}) + \int k(z) d\mu^F(z)$$

3. Labor market clears:

$$\int eh(\mathbf{s}) d\mu^W(\mathbf{s}) = \int l(\mathbf{s}) d\mu^E(\mathbf{s}) + \int l(z) d\mu^F(z)$$

4. The government budget is balanced:

$$G + \int R_\chi[y^F(z)]\chi(P(z), z)\mu^F(z) + \int R_\chi[y^E(\mathbf{s})]\chi(p(\mathbf{s}), z)\mu^E(\mathbf{s}) =$$

$$\sum_{\eta=W,E,C} \int \tau_d ra((\mathbf{s})) d\mu^\eta(\mathbf{s}) + \int T_p(weh(\mathbf{s})) d\mu^W(\mathbf{s}) + \int T_p[\pi(a,z)] d\mu^E(\mathbf{s})$$

$$+ \sum_{\eta=W,E,C} \int \tau_c c(\mathbf{s})\mu^j(\mathbf{s}) + \int \frac{\tau_b}{1-\tau_b} d(z)\mu^F(z) + \int \tau_d \theta d(z)\mu^F(z) + \tau_d D$$

5. The distribution μ is a fixed point where its transition is consistent with the policy functions and the law of motion for μ:

$$\mu = \Phi(\mu)$$

where Φ is a one-period-ahead transition operator such that $\mu' = \Phi(\mu)$.

Table 3: Externally Calibrated Parameters

Parameter		Value	Source
Relative risk aversion	σ_1	1.50	Attanasio et al. (1999)
Inverse Frisch elasticity	σ_2	1.00	Chetty et al. (2011)
Capital share	α	0.35	Standard
Depreciation rate	δ	0.06	Stokey and Rebelo (1995)
Corporate income tax	τ_b	0.36	Bhandari and McGrattan (2021)
Dividend tax	τ_d	0.20	Bhandari and McGrattan (2021)
Consumption tax	τ_c	0.07	Bhandari and McGrattan (2021)
Average income tax	τ_y	0.26	Boar and Midrigan (2019)
Progressivity of income tax	λ_y	0.07	Boar and Midrigan (2019)
Persistence of labor productivity	ρ_e	0.96	Storesletten, Telmer, and Yaron (2004)
Boundary of z grid points	$[z_{min}, z_{max}]$	$[1, 5]$	Buera and Fattal Jaef (2018)

4 Calibration

In this section, we discuss our calibration strategy. First, Section 4.1 shows the subset of parameters that are calibrated externally. The values we assign to these parameters are either standard ones in the literature or can be directly measured from the data. The rest of the parameters, which represent the unique features of the U.S. economy displayed in the Survey of Consumer Finances (SCF) and Compustat, are calibrated internally in Section 4.2. Section 4.3 evaluates the model's fit to the data by comparing the non-targeted moments of model predictions with their empirical counterparts.

4.1 Externally Calibrated Parameters

We calibrate the model at an annual frequency. We set the relative risk aversion $\sigma_1 = 1.50$ and the depreciation rate of capital $\delta = 0.06$. These values are commonly used in the literature (for instance, Attanasio et al. (1999) and Stokey and Rebelo (1995), respectively). The share of capital in production, α, is set to 0.35. The inverse of the Frisch elasticity of labor supply, σ_2, is set to 1.00, in line with the estimates provided by Chetty et al. (2011).

We set the corporate income tax rate $\tau_b = 0.36$, the dividends tax rate $\tau_d = 0.20$, and the consumption tax $\tau_c = 0.07$, consistent with the corporate profit tax on C-corporations, the capital gains tax, and the consumption tax used in Bhandari and McGrattan (2021). We choose the parameter controlling the average income tax, $\tau_y = 0.26$, and the progressivity of income tax, $\lambda_y = 0.07$, following Boar and Midrigan (2019). We set the persistence of labor productivity $\rho_e = 0.96$, consistent with the estimates by Storesletten, Telmer, and Yaron (2004) and Guvenen (2009). We set the lower and upper bound of the z grid point equal to 1 and 5, which is similar to Buera and Fattal Jaef (2018). Table 3 summarizes the values of all externally calibrated parameters with their sources.

4.2 Internally Calibrated Parameters

The remaining 13 parameters that are internally calibrated are listed in Table 4, where we also present the associated moments generated by our model and their empirical counterparts. The internally calibrated parameters are aimed at capturing the key aggregate and distributional features of US households and firms. We choose the set of parameters by minimizing the distance between the model statistics and their empirical counterparts.[11] Even though every targeted moment is determined simultaneously by all parameters, in what follows, we discuss each of the moments in relation to the parameter for which, intuitively, the moment yields the most identification power.

We set the discount factor $\beta = 0.94$ to match a 4 percent real interest rate. We discipline the parameter governing disutility of labor, ξ, by targeting 38 hours of market work per week on average for the working-age population ($h = 0.38$, assuming 100 hours of discretionary time per week).[12] Following Boar and Midrigan (2019), we set the borrowing constraint $\lambda = 1.97$ to match the average debt to capital ratio for entrepreneurs of 0.35, as reported by Crouzet and Mehrotra (2020) for US firms. We choose the R&D subsidy rate at $\tau^s_\chi = 0.08$ for both sectors to match the R&D subsidy to GDP ratio of 0.25 percent, consistent with the number reported in the OECD R&D Tax Incentives database.[13]

We choose the scale of R&D cost $\mu = 0.31$ and the elasticity of R&D $\phi = 12.8$ to match the R&D to output ratio (4 percent in both the data and the model) and the total R&D expenditures share of the largest 10 percent of firms (0.78 in the data and 0.76 in the model). The intuition is that with a higher elasticity, ϕ, the increase in R&D cost is greater for larger firms than smaller firms, which makes the reduction in R&D expenditure greater for larger

[11] Specifically, a vector of parameter Θ is chosen to minimize the minimum-distance-estimator criterion function

$$f(\Theta) = [\mathbf{m}_{data} - \mathbf{m}_{model}(\Theta)]'\mathbf{W}[\mathbf{m}_{data} - \mathbf{m}_{model}(\Theta)],$$

where $\mathbf{m}_{data}$ and $\mathbf{m}_{model}(\Theta)$ are the vectors of moments in the data and the model, and $\mathbf{W}_{ii} = \text{diag}(\omega_i/\mathbf{m}^2_{i,data})$ is a diagonal weighting matrix, where i indexes the i_{th} moment. We place additional weight, ω_i, on the data we view as more important to match. We normalize $\sum_{t=1}^{13}\omega_i = 1$.

[12] Since we assume that only workers supply labor hours in our model, we set $h = 0$ for both entrepreneurs and corporate owners in the utility function.

[13] As discussed above, we set the progressivity parameter for the R&D subsidy rate $\lambda^s_\chi = 0$ in our benchmark economy. We calculate the optimal shape of the R&D subsidy in our quantitative experiments in Section 5.

Table 4: Internally Calibrated Parameters

Parameter		Value	Target	Model	Data
Discount factor	β	0.94	Real interest rate, %	4.00	4.00
Disutility of labor	ξ	7.50	Average labor hours	0.38	0.38
Borrowing constraint	λ	1.97	Average debt to capital ratio	0.35	0.35
R&D subsidy rate	τ_χ^s	0.08	R&D subsidy to GDP, %	0.26	0.25
Scale of R&D cost	μ	0.31	R&D to output ratio, C-corp	0.04	0.04
Elasticity of R&D cost	ϕ	12.8	Top 10% R&D share, C-corp	0.76	0.78
Pareto shape of $G(z)$	ζ	5.12	Top 11% employment share	0.81	0.79
Probability of re-draw	ψ	0.08	Wealth share of entrepreneurs	0.32	0.33
DRS, pass-through	γ^E	0.85	Share of entrepreneurs, %	6.82	6.58
DRS, C-corp	γ^C	0.81	Output share of C-corp	0.62	0.63
Fixed operation cost	κ_F	0.50	Share of corporate owners, %	0.59	0.58
Step size of z	Δ_z	0.22	SD of employment growth rate	0.24	0.25
Std. dev. of e shocks	σ_e	0.21	Std. dev. of log labor earnings	0.76	0.80

firms. In addition, an increase in either the scale parameter or the elasticity parameter implies a lower R&D to output ratio. Therefore, we first vary the elasticity parameter to match the concentration of R&D spending, and then adjust μ to match the total R&D to output ratio. Note that these two empirical moments are computed from Compustat, which only includes publicly listed companies, so we also compute the model counterparts using a subset of firms that contains only C-corporations.

We choose the Pareto shape parameter $\zeta = 5.12$ to match the fact that the largest 11 percent of firms in the US hire 79 percent of labor, which is computed from the Business Dynamics Statistics (BDS) database.[14] We choose the probability of productivity re-draw $\psi = 0.08$, which implies that a worker can learn a new entrepreneurial blueprint every 12.5 years on average.[15] We choose the value for this parameter to target the wealth share of entrepreneurs (32 percent in the model and 33 percent in the data). The intuition is that with a higher probability of re-draw, workers have more incentives to accumulate assets because assets serve as collateral for renting capital when workers start businesses. In turn, the wealth share of entrepreneurs would be lower.

[14] Source: U.S. Census Bureau - Center for Economic Studies - Business Dynamics Statistics.

[15] We assume that households can only invest in R&D when they choose to become entrepreneurs. As a result, workers' firm productivity downgrade by one step in every period, meaning that their entrepreneurial blueprints become gradually outdated. With probability of ψ, workers can re-draw a higher productivity and lost the previous one.

We set the span-of-control parameters $\gamma^E = 0.85$ (for pass-through entities) and $\gamma^C = 0.81$ (for C-corporations), and the fixed operation cost in C-corporations $\kappa_F = 0.50$ to jointly match the share of entrepreneurs (6.6 percent in the data and 6.8 percent in the model), the share of corporate owners (0.6 percent in both the data and the model), and their output share (0.63 in the data and 0.62 the model). Here, we use the relative average output of pass-through and corporate firms to discipline the two span-of-control parameters and use the relative number of pass-through and corporate firms to pin down the fixed operation cost parameter. The population share of entrepreneurs and corporate owners are computed using the 2013 SCF, and the output share of C-corporations is reported by Dyrda and Pugsley (2018).

We use the standard deviation of the employment growth rate (reported in Atkeson and Burstein (2010)) to inform the choice of the step size of firm productivity, Δ_z, which we set as $\Delta_z = 0.22$. Given the the externally calibrated persistence of labor productivity, ρ_e, the standard deviation of the labor productivity shock, σ_e, is set to match the cross-sectional standard deviation of log labor earnings, which equals 0.76 in the model and 0.80 in the data (reported in Guvenen et al. (2015).

4.3 Model Performance

We next evaluate the model's ability to account for a number of additional features of the data that are not directly targeted in our calibration.

Wealth distribution. We first discuss how the model-simulated wealth distribution of all households fits with the 2013 SCF data. Panel (A) of Table 5 shows that, given our exogenous labor income process and endogenous firm productivity process, the model can reproduce an empirically realistic cross-sectional wealth distribution, at both the top and the bottom of the distribution. For example, the wealthiest 1 percent of households hold 35.4 percent of wealth in the data and 34.7 percent of wealth in the model, the 5th quantile (wealthiest 20 percent) of households hold 87.3 percent of wealth in the data and 88.0 percent of wealth in the model, and the 1st and 2nd quantiles of households combined hold nearly no wealth both in the data and in the model.

Firm owners in wealth and income distribution. Panels (B) and (C) of Table 5 show that our model can reproduce the fractions of wealth held by entrepreneurs and corporate owners very similar to what is reported in the data. In both the model and the data, firm owners account for a large share of wealth at the top, and corporate owners are even more wealthy than entrepreneurs. For example, out of the total wealth held by the top 1 percent

Table 5: Non-Targeted Moments: Wealth Distribution

	Share of total sample (in %)							
	Quintiles					Top (%)		
	1st	2nd	3rd	4th	5th	90-95	95-99	99-100
(A) All households								
Model	0.0	0.0	1.9	10.1	88.0	13.7	25.1	34.7
US Data	-0.7	0.6	3.1	9.7	87.3	12.2	27.7	35.4
(B) Entrepreneurs								
Model	0.0	0.0	0.1	1.0	30.6	2.3	9.0	17.4
US Data	0.0	0.0	0.1	0.7	31.6	2.1	9.3	18.8
(C) Corporate owners								
Model	0.0	0.0	0.0	0.0	5.1	0.2	1.4	3.4
US Data	0.0	0.0	0.0	0.1	5.2	0.1	1.5	3.5

Note: All the data statistics are computed from the 2013 SCF.

wealthiest households, entrepreneurs hold 50.1 percent (17.4/34.7) in the model and 53.1 (18.8/35.4) percent in the data, and corporate owners hold 9.8 percent (3.4/34.7) in the model and 9.9 percent (3.5/35.4) in the data. Moreover, both the model and the data show that firm owners hold a very small share of wealth at the first to fourth quantiles.

Notice that although we only target the share of entrepreneurs, the share of corporate owners, and the share of wealth held by entrepreneurs in our calibration, our model can generate more wealth and income distributional features that are displayed in the data than what are targeted in the calibration. Panel (A) of Table 6 displays that, in the model, 36 percent of households in the top 5 percent of wealth distribution are entrepreneurs, and 6 percent of which are corporate owners. Furthermore, Panel (B) of Table 6 shows that, in our model, entrepreneurs earn 17 percent of all income and corporate owners earn 4 percent of total income and 5 percent of total wealth. Both of these numbers are very close to the data.

Other non-targeted statistics. Panel (C) of Table 6 reports the three additional non-targeted moments of interest. First, in the data, the share of aggregate tax revenues in US

Table 6: Other Non-Targeted Moments

	Model	Data
Panel (A)		
Top 5% wealth, fraction of entrepreneur	0.36	0.35
Top 5% wealth, fraction of corporate owners	0.06	0.05
Panel (B)		
Income share of entrepreneurs	0.17	0.19
Income share of corporate owners	0.04	0.03
Wealth share of corporate owners	0.05	0.05
Panel (C)		
Total tax revenue to GDP ratio	0.27	0.25
R&D investment to GDP ratio, %	3.25	2.71
Entrants relative employment to incumbent	0.20	0.19

GDP was 0.25 in 2013.[16] The model statistic is 0.27, which is reasonably close to the data. Second, our model produces a 3.25 percent total R&D investment to GDP ratio in the US, which is slightly higher than the 2.71 percent reported in 2013.[17] Last, in our model the ratio between the average employment of entrants relative to the average employment of incumbents is 0.20, which is close to the data counterpart reported in Buera and Fattal Jaef (2018).

5 Quantitative Analysis

This section provides quantitative analysis of our model. First, in Section 5.1, we demonstrate how financial frictions affect firms' incorporation and R&D expenditure decisions, as well as the welfare gains of R&D subsidies. Next, in Section 5.2, we study the optimal R&D subsidies, with an emphasis on their distributional effects.

[16]Source: OECD (2021), Revenue Statistics 2021: The Initial Impact of COVID-19 on OECD Tax Revenues, OECD Publishing, Paris, https://doi.org/10.1787/6e87f932-en

[17]Source: OECD (2022), Gross domestic spending on R&D (indicator). doi: 10.1787/d8b068b4-en (Accessed on 17 March 2022)

5.1 Financial Frictions and the Effects of R&D Subsidies

In this subsection, we first quantify the extent to which financial frictions affect R&D expenditures in pass-through entities, as well as the aggregate and distributional effects. We then study the implications of financial frictions on the effectiveness of R&D subsidies on the aggregate economy.

5.1.1 Quantifying the Impact of Financial Frictions.

We use our calibrated model to quantify the impact of financial frictions on macroeconomic and distributional variables. To this end, we conduct a counterfactual analysis in which we tighten the borrowing capacity of entrepreneurs. Specifically, we lower the collateral constraint parameter λ from 2.0 to 1.5 and study the steady-state outcomes of the model.[18]

We focus on general equilibrium effects of this credit shock, meaning that we adjust the wage rate and the interest rate to clear the labor and capital markets. We also change the average personal income tax parameter, τ_y, to ensure that the government budget is balanced in the new steady state.

Incorporation choices. Panel (A) of Figure 3 displays the occupation and incorporation choice of the households whose previous-period occupation is an entrepreneur ($\eta_- = 2$) in the benchmark economy.[19] As expected, households with low firm productivity z switch to the worker sector due to low entrepreneurial income. Households with high firm productivity and low asset choose to become a corporate owner. Although the decision to incorporate reduces entrepreneurs' share of the company, firm profits will increase due to better access to the financial market. In contrast, wealthy entrepreneurs tend not to incorporate their firms because they are more able to self finance their capital demand.

Panel (B) of Figure 3 shows that in the counterfactual economy with tighter collateral constraints, incorporation becomes a better option for a larger set of entrepreneurs, especially for those with high firm productivity. In other words, the asset cutoff above which households choose to remain as an entrepreneur becomes higher than in the benchmark economy.

R&D investment. We first discuss the mechanism through which financial frictions affect entrepreneurs' R&D expenses. Following a successful technological upgrade, the optimal capital demanded by firms increases. For entrepreneurs with low assets, their usage of capital

[18] A decrease in λ from 2.0 to 1.5 implies that the average debt to capital ratio declines from 0.35 in the benchmark economy to 0.24 in the counterfactual economy.

[19] To focus on the most important two state variables, asset and firm productivity, we only present the discrete occupation choice for households whose labor productivity e equals the average, i.e., $log(e) = 0$.

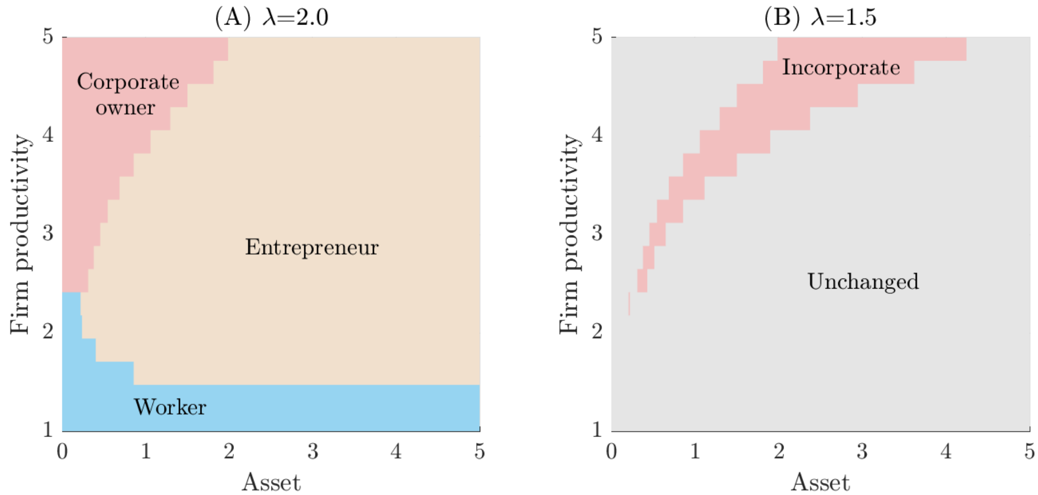

Figure 3: Impact of Financial Frictions on Entrepreneur's Incorporation Choice

is lower than the optimal level due to the financial constraint, which in turn reduces the profit gain after a technology upgrade. As a result, financial frictions distort the innovation decision made by credit constrained entrepreneurs because they lower the expected return from R&D expenditure.

We next quantify how entrepreneurs change their expenditures on R&D following a tightening financial condition and discuss its impact on technology growth. We also compare the responses of entrepreneurs to the financial shock with C-corporations.

The green solid line in Panel (A) of Figure 4 displays the percentage change of R&D investment made by entrepreneurs (pass-through entities) with respect to varying firm technology, z. As it shown in the figure, the financial shock disproportionally affects the R&D investment made by more productive entrepreneurs, and the drop in R&D expenditures can be up to 60 percent. As a result of the decrease in R&D investment. Panel (B) of Figure 4 shows that the technology upgrade probability decreases by 0.5 to 2 percent for the productive entrepreneurs.

For C-corporations, although they are free from financial frictions, they are also negatively affected due to the general equilibrium effect of the increase in the interest rate (0.35 percent). The drop in R&D investment and the associated technology upgrade probability for C-corporations after the credit shock is much less than that for pass-through entities (dashed line in Panel (A) and (B)).

Aggregate and distributional implications. Columns (A) and (B) of Table 7 compare the aggregate variables for the benchmark and the counterfactual economy. The welfare

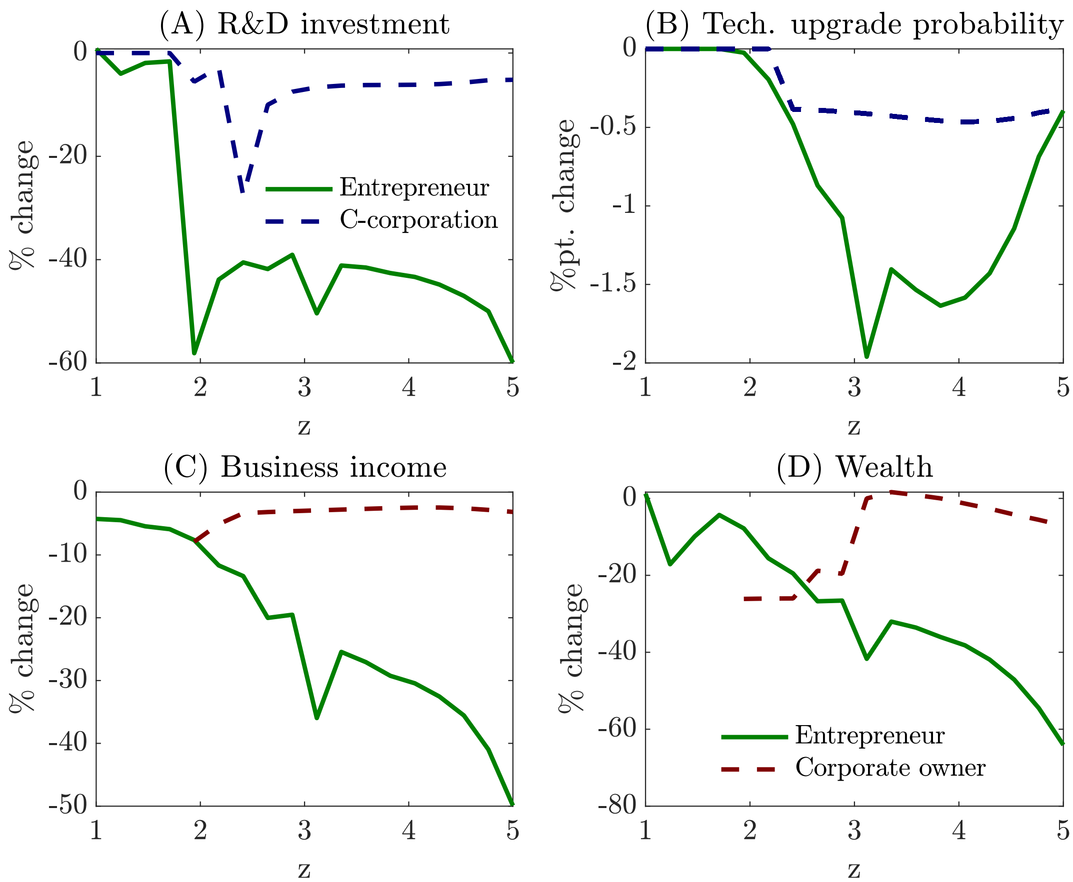

Figure 4: Impact of Financial Frictions on Firm Owners

change[20] due to the tightening of the collateral constraint is very small. Although it leads to a 0.63 percent decline in the equilibrium wage, which primarily affects the income of workers, the effect can be partially offset by the increase in interest rate as well as the decline in personal income tax rate.

The output slightly reduces by 0.80 percent, despite that both sectors experience a sizable (approximately 2.5 percent) decrease in the measured TFP. What causes this result is the reallocation of production away from the financially constrained and less productive pass-through entities to C-corporations. In our experiment, the share of output produced by C-corporation increases by nearly 10 percentage points.

The 0.35 percentage point increase in the equilibrium interest rate is primarily due to the substantial decline of wealth held by productive entrepreneurs, as shown in Panel (D) of

[20]We define the consumption-equivalent welfare change as the permanent increment in consumption that leaves the household indifferent between the calibrated and the counterfactual economy. We can calculate the welfare changes for each individual state, **s**, and integrate over the stationary distribution in the calibrated economy. More details are provided in Appendix A.

Table 7: Macroeconomic and Distributional Effects of Financial Frictions

	(A)	(B)	(C)	(D)
	Status quo subsidy		Optimal subsidy	
	$\lambda = 2.0$	$\lambda = 1.5$	$\lambda = 2.0$	$\lambda = 1.5$
average subsidy, pass-through, τ_χ^E	0.08	0.08	0.45	0.44
change in welfare, %	-	0.03	0.68	0.29
change in output, %	-	-0.80	3.10	1.79
change in wage, %	-	-0.63	2.29	1.16
interest rate, %	4.00	4.35	3.88	4.24
change in average income tax, %	-	-0.15	0.62	0.31
change in TFP, pass-through, %	-	-2.56	4.81	3.34
change in TFP, C-corporation, %	-	-2.40	-0.24	-0.34
TFP loss, pass-through, %	22.7	24.5	21.1	23.3
fraction of entrepreneur, %	6.82	6.78	6.00	6.29
fraction of corporate owner, %	0.59	0.80	0.59	0.81
corporate output share, %	61.7	71.6	56.7	68.7
top 1% wealth share, %	34.7	28.8	40.0	32.7
top 1% income share, %	13.8	11.5	15.5	12.7
wealth share of entrepreneurs, %	31.8	27.5	33.0	28.8

Figure 4. For the same reason, we observe a 5.9 percentage point drop in the wealth share of the top 1 percent wealthiest households and a 4.3 percentage point decline in the wealth share of entrepreneurs. The dis-saving of the productive entrepreneurs is also associated with a significant decrease in their business income (see Panel (C) of Figure 4) because they are more financially constrained and thus make fewer profits. As expected, the income share of the top 1 percent households declines by 2.3 percentage points.

The fraction of entrepreneurs is nearly unchanged. This is because the financial shock disproportionally affects the income of the most productive entrepreneurs, which only account for a very small share of entrepreneurs. Another reason is that the decline in the equilibrium wage rate reduces the value of being an worker. The fraction of corporate owners substantially increases by 0.21 percentage point, which is consistent with the changes in incorporation decisions shown in Figure 3.

5.1.2 Effectiveness of R&D subsidies

In this section, we study how the effects of the optimal R&D subsidy policy depend on the degree of financial frictions. To this end, we compute the optimal linear subsidy rate on entrepreneurs' R&D investment for the calibrated economy and the counterfactual economy and compare the policy effects on the aggregate economy. We focus on the general equilibrium effect of the R&D subsidy policy, and adjust the wage and interest rate to clear the labor and capital markets. We change the average personal income tax parameter, τ_y, to keep the government budget balanced.

Columns (C) and (D) of Table 7 compare the impact of the optimal R&D subsidy rates under different financial conditions. Although the optimal subsidy rates are close (45 vs. 44 percent), the aggregate impact on welfare is substantially different. The welfare gains in the counterfactual economy ($\lambda = 1.5$) are cut by nearly 60 percent compared to the benchmark economy ($\lambda = 2.0$). Moreover, the output, wage rate, and TFP effects of the R&D subsidy are all much smaller under tighter collateral constraints.

Panel (A) of Figure 5 provides intuition for why the welfare gain under optimal R&D subsidy is limited due to financial frictions. It shows that R&D investments increase by a much larger amount when financial constraint is more relaxed, and the difference is more significant for more productivity pass-through entities.

Providing more generous R&D subsidies to pass-through entities increases wealth concentration. For example, the wealth share of the top 1 percent wealthiest households increases by 5.3 percentage points in the benchmark case. This is because the more generous R&D subsidy encourages more R&D expenditures and thus increases expected future productivity. Entrepreneurs are then more willing to accumulate assets to finance their future capital demand. As illustrated in panel (D) of Figure 5, this effect is more pronounced for the entrepreneurs at the top of the productivity distribution. Since entrepreneurs with top productivity are mostly in the top of wealth distribution, wealth concentration increases as a result.

5.2 Optimal R&D Subsidy and its Distributional Effects

In this section, we study the optimal subsidy rate for both pass-through entities and C-corporations. First, we study optimal uniform subsidy, where we restrict that the policy is equally generous between the two types of firms. Second, we study legal-form dependent subsidy policy, where we allow the government to vary the subsidy rate depending on the

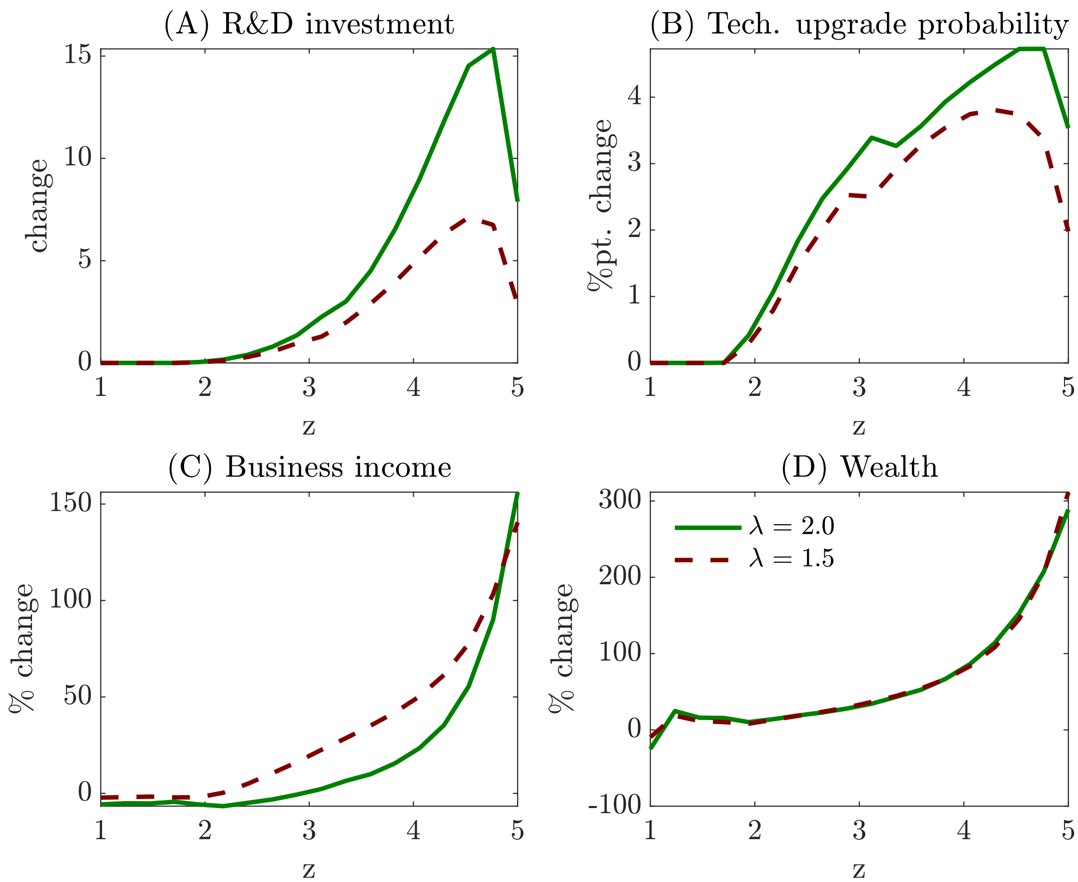

Figure 5: Impact of Optimal R&D Subsidy with Different Financial Constraints

legal forms of firms.

For both policies, we search for the optimal uniform subsidy rate that maximizes ex-ante welfare of all households. We study the general equilibrium effect for both policies, meaning that the equilibrium wage and interest rate will adjust to clear labor and capital markets. In addition, for both policies, we vary the average labor income tax to ensure that the government has balanced budget.[21]

5.2.1 Macroeconomic and Distributional Effects

Table 8 summarizes how the equilibrium variables are changed under these two policies and from the benchmark economy.

[21] Specifically, we adjust τ_y such that G does not change from the benchmark economy.

Table 8: Macroeconomic and Distributional Effects of Optimal R&D Subsidies

	(A) Benchmark Economy	(B) Optimal Uniform	(C) Legal-Form Dependent
average subsidy, pass-through, τ_χ^E	0.08	0.34	0.46
average subsidy, C-corporation, τ_χ^C	0.08	0.34	0.23
I. Macroeconomic variables			
change in welfare, %	-	0.57	0.77
change in output, %	-	3.34	3.87
change in wage, %	-	2.86	3.05
interest rate, %	4.00	4.07	3.95
change in average income tax, %	-	1.28	1.07
change in TFP, pass-through, %	-	3.54	5.20
change in TFP, C-corporation, %	-	1.36	0.50
TFP loss, pass-through, %	22.7	21.3	20.8
R&D to output ratio, %	3.25	5.26	5.33
subsidy to output ratio, %	0.26	1.79	1.80
fraction of entrepreneur, %	6.82	6.15	5.92
corporate owner share, %	0.59	0.62	0.61
II. Distributional variables			
top 1% wealth share, %	34.7	36.0	39.2
top 20% wealth share, %	88.0	88.2	89.3
top 1% income share, %	13.8	14.1	15.2
top 20% income share, %	51.1	51.3	51.7
wealth share of entrepreneurs, %	31.8	29.6	31.7
wealth share of corporate owners, %	5.15	5.34	4.90
income share of entrepreneurs, %	17.0	16.4	17.3
income share of corporate owners, %	3.70	3.65	3.43
top 11% firm employment share, %	80.6	81.8	80.7
top 10% firm R&D share, %	91.7	84.3	80.5
R&D subsidy share, pass-through, %	27.2	30.4	64.9

First, for both the uniform and the legal-form dependent policy, the optimal subsidy rate substantially increases from the benchmark rate. The optimal uniform subsidy rate is found to be 34 percent, which is financed through an increase in the average personal income tax by 1.28 percent. The optimal legal-form dependent subsidy rate is found to be 46 percent for pass-through entities and 23 percent for C-corporations, which is financed by an increase in the average personal income tax by 1.28 percent.

The increases in both aggregate output and welfare are higher under the legal-form dependent policy than under the uniform policy (3.87 percent vs. 3.34 percent, and 0.77 percent vs. 0.57 percent, respectively.) This result is not a surprise, because the uniform policy essentially adds a restriction to the social planner's optimization problem by requiring the subsidy rates to be equal between the two types of firms.

What is more interesting is the changes in the equilibrium wage and the equilibrium interest rate. The equilibrium wage increases in both cases, because the more generous R&D subsidy motivates firms to increase R&D expenditure, and thus labor demand increases, leading to a higher equilibrium wage.

The equilibrium interest rate increases under uniform policy but decreases under legal-form dependent policy. The reason is as follows. For both policies, capital demand increases due to higher firm productivity as a result of more R&D investment. At the same time, entrepreneurs increase their savings, especially for the most productive ones. This is because due to the increase in R&D incentivized by the policy, entrepreneurs have a higher probability of technology upgrades, and therefore, they tend to save more to finance higher capital demand in the future. As shown in panel (C) of Figure 5, under the legal-form dependent policy, entrepreneurs at the top of the productivity distribution increase in their wealth more dramatically than in the case of the unform subsidy. As a result, the effect of rising asset supply dominates the effect of increasing capital demand, driving down the equilibrium interest rate.

Regarding distributional variables, both policies increase concentration in wealth and income and the presence of financial frictions plays a crucial role. This is bcause, first, as explained above, under the subsidy policy, productive entrepreneurs substantially increase their savings. Second, with a higher wealth level, productive entrepreneurs are more able to overcome the financial constraints and thus make more business profits. Third, higher profits allow entrepreneurs to allocate more resources to R&D expenditures and asset accumulation, which further increases their future income and wealth. The legal-form dependent R&D subsidy entrepreneurs more favorable supports than the uniform subsidy, which strenghens the above-mentioned mechansim. We find that the top 1 percent wealth share increases from 34.7 percent in the benchmark economy to 36.0 percent under the optimal uniform subsidy and 39.2 percent under the optimal legal-form dependent policy.

5.2.2 Welfare Changes across Households

Now, we look into how these two policies change welfare of different households.

Table 9: Welfare Changes from Optimal R&D Subsidies

	All HHs	Worker	Entrep.	C owner
I. Optimal Uniform R&D Subsidy				
welfare gains, %	0.57	0.63	-0.18	-1.42
percent better off	97.0	99.7	64.1	20.5
top 0.1% income	-0.82	0.99	-0.67	-1.80
top 1% income	-1.12	0.91	-1.24	-1.90
top 10% income	0.29	0.71	-0.69	-1.73
bottom 50% income	0.59	0.61	0.14	-0.28
bottom 25% income	0.59	0.61	0.04	-0.13
top 0.1% wealth	0.69	0.96	0.55	0.40
top 1% wealth	0.53	0.83	0.38	-0.09
top 10% wealth	0.44	0.65	-0.06	-0.79
bottom 50% wealth	0.62	0.63	-1.53	-4.17
bottom 25% wealth	0.60	0.62	-3.88	-4.20
II. Optimal Legal-Form-Dependent R&D Subsidy				
welfare gains, %	0.77	0.85	-0.24	-2.16
percent better off	94.8	98.3	49.5	3.86
top 0.1% income	0.11	-0.72	0.81	-4.26
top 1% income	-1.54	-0.68	-1.04	-3.45
top 10% income	0.08	0.54	-0.89	-2.73
bottom 50% income	0.87	0.90	0.24	-0.21
bottom 25% income	0.89	0.92	0.14	0.05
top 0.1% wealth	-0.31	-0.71	0.03	-1.46
top 1% wealth	-0.66	-0.58	-0.48	-1.78
top 10% wealth	0.03	0.29	-0.49	-1.92
bottom 50% wealth	0.94	0.96	-2.11	-4.65
bottom 25% wealth	0.92	0.94	-4.23	-4.71

Table 9 shows that under the optimal uniform R&D subsidy, almost all workers gain, whereas entrepreneurs and C-corporation owners lose on average. This is mainly due to the increase in equilibrium wage, which benefits workers but lowers business profits for firm owners (including both entrepreneurs and corporate workers). On the other hand, the welfare gain largely differ with respect to households' income and wealth levels.

To understand the intuition for this large difference, we first analyze how these two policies change business income and wealth for entrepreneurs and corporate owners at different productivity levels. In Section 5.2.1, we have already explained what contributes to the increase in the income and wealth of entrepreneurs (especially the most productive ones) under the optimal R&D subsidy policies. The factor that reduces business income for all firm owners after the implementation of R&D subsidies is the increase in equilibrium wage. As shown in panel (A) of Figure 6, the general equilibrium effect is negligible for productive entrepreneurs, but not for the unproductive ones. Since the productivity distribution of pass-through entities is heavily skewed to the left, majority of entrepreneurs actually experience an income loss as a result of the optimal R&D subsidies.

Panel (B) of Figure 6 shows that the business income of corporate owners across the productivity distribution declines due to the rise of the equilibrium wage rate. Because of that, as shown in panel (D), the wealth of corporate owners reduces by a nonnegligible amount, especially under the case of the legel-form dependent subsidy policy.

Now we discuss the distributional effects of the optimal uniform R&D subsidy, which is summarized in Table 9 (I). First, regarding the differences in welfare gains across income groups, Table 9 (I) shows that top income workers gain the most, which is mainly due to the fact that they have higher labor productivity and thus receive higher gain from wage income. However, bottom income firm owners have higher welfare gains than top income firm owners. This is because bottom income firm owners are more likely to choose to be workers in the future, in which case the higher equilibrium wage will become a benefit rather than a cost to them.

Regarding the difference in welfare gains across wealth groups, for all occupations, top wealth households have a larger welfare gain. This is mainly due to the increase in the equilibrium interest rate, which benefits savers and makes borrowers lose.

We then discuss the distributional effect of the optimal legal-form dependent subsidy, which is summarized in Table 9 (II). Regarding the differences across income groups, similar to the optimal uniform policy, the welfare gain is larger for bottom income firm owners than top income firm owners. What is different from the optimal uniform subsidy is for the workers. For workers, bottom income has higher welfare gain, and the reason is that the equilibrium interest rate decreases under the legal-form dependent policy, making borrowers rather than savers benefit. A large fraction of bottom income workers are borrowers, and thus they gain more than top income workers.

What might seem counterintuitive is the difference in the welfare changes of entrepreneurs across wealth groups. Top wealth entrepreneurs receive a positive welfare gain. This is

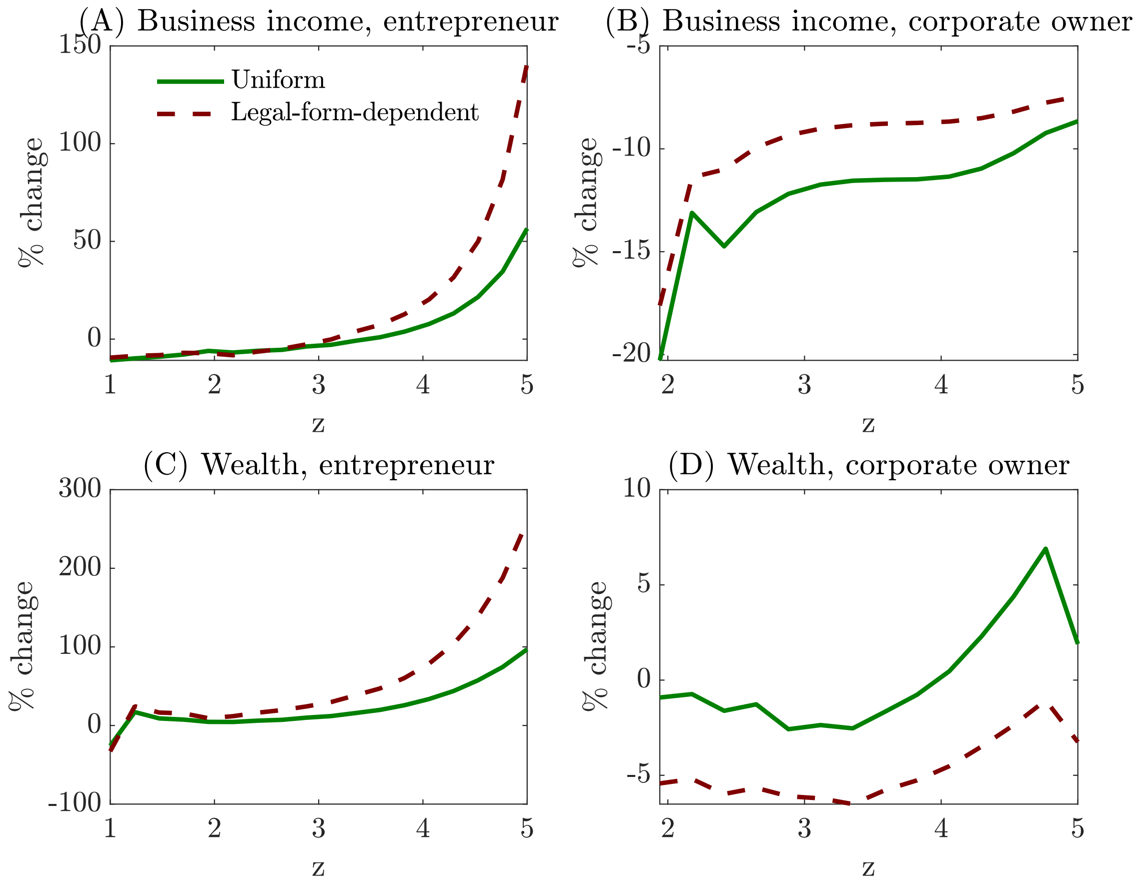

Figure 6: Effects of Optimal R&D Policy to All Firms

because although they lose from the decrease in interest rate, a large fraction of top wealth entrepreneurs are also at the top productivity level, and the increases in income and wealth for this type of entreprenuers are very high following the higher R&D subsidy rate (see Figure 6 ((A) and (C)). The rest of entrepreneurs, especially those at the bottom of the distribution, receive a large welfare loss because their business income declines due to the higher wage rate.

6 Conclusion

In this paper, we build a quantitative macro model to study the aggregate and distributional effects of the optimal R&D subsidy policy. Our model framework features endogenous occupational choices, the option of incorporation, endogenous innovation, and financial frictions. The calibrated version of our model matches well both the distribution of household wealth and the distribution of firm sizes in the US economy.

In our calibrated model, financial frictions reduce R&D expenditures in pass-through entities and limit the gains in welfare and aggregate output for the optimal R&D subsidy policy. We show that to maximize the aggregate welfare gain, the government should subsidize both pass-through entities and C-corporations, and the optimal subsidy rate is higher for pass-through entities.

Regarding the distribution effect of the optimal R&D subsidy policy, almost all workers are winners but the average welfare gain is negative for firm owners. This is because the optimal subsidy policy encourages R&D, which increases firm productivity and thus leads to higher labor demand. Higher productivity firms benefit more from more generous R&D subsidies, and therefore, the optimal subsidy policy increases wealth concentration. However, whether households at the top of the wealth distribution gain or lose also depends on their occupations and changes in the equilibrium interest rate, which may increase or decrease depending on different policies.

References

Acemoglu, Daron, Ufuk Akcigit, Harun Alp, Nicholas Bloom, and William Kerr. 2018. "Innovation, reallocation, and growth." *American Economic Review* 108 (11):3450–91.

Akcigit, Ufuk, Douglas Hanley, and Nicolas Serrano-Velarde. 2021. "Back to basics: Basic research spillovers, innovation policy, and growth." *The Review of Economic Studies* 88 (1):1–43.

Akcigit, Ufuk, Douglas Hanley, and Stefanie Stantcheva. 2016. "Optimal taxation and R&D policies." Tech. rep., National Bureau of Economic Research.

Atkeson, Andrew and Ariel Tomas Burstein. 2010. "Innovation, firm dynamics, and international trade." *Journal of political economy* 118 (3):433–484.

Attanasio, Orazio P, James Banks, Costas Meghir, and Guglielmo Weber. 1999. "Humps and bumps in lifetime consumption." *Journal of Business & Economic Statistics* 17 (1):22–35.

Bassetto, Marco, Marco Cagetti, and Mariacristina De Nardi. 2015. "Credit crunches and credit allocation in a model of entrepreneurship." *Review of Economic Dynamics* 18 (1):53–76.

Benabou, Roland. 2002. "Tax and education policy in a heterogeneous-agent economy: What levels of redistribution maximize growth and efficiency?" *Econometrica* 70 (2):481–517.

Bhandari, Anmol and Ellen R McGrattan. 2021. "Sweat equity in US private business." *The Quarterly Journal of Economics* 136 (2):727–781.

Bloom, Nicholas, John Van Reenen, and Heidi Williams. 2019. "A toolkit of policies to promote innovation." *Journal of economic perspectives* 33 (3):163–84.

Boar, Corina and Virgiliu Midrigan. 2019. "Markups and inequality." Tech. rep., National Bureau of Economic Research.

Brown, James R, Steven M Fazzari, and Bruce C Petersen. 2009. "Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom." *The Journal of Finance* 64 (1):151–185.

Buera, Francisco J and Roberto N Fattal Jaef. 2018. "The dynamics of development: innovation and reallocation." *World Bank Policy Research Working Paper* (8505).

Buera, Francisco J, Joseph P Kaboski, and Yongseok Shin. 2015. "Entrepreneurship and financial frictions: A macrodevelopment perspective." *economics* 7 (1):409–436.

———. 2021. "The macroeconomics of microfinance." *The Review of Economic Studies* 88 (1):126–161.

Buera, Francisco J and Benjamin Moll. 2015. "Aggregate implications of a credit crunch: The importance of heterogeneity." *American Economic Journal: Macroeconomics* 7 (3):1–42.

Buera, Francisco J and Yongseok Shin. 2013. "Financial frictions and the persistence of history: A quantitative exploration." *Journal of Political Economy* 121 (2):221–272.

Cagetti, Marco and Mariacristina De Nardi. 2006. "Entrepreneurship, frictions, and wealth." *Journal of political Economy* 114 (5):835–870.

———. 2009. "Estate taxation, entrepreneurship, and wealth." *American Economic Review* 99 (1):85–111.

Chetty, Raj, John N Friedman, Nathaniel Hilger, Emmanuel Saez, Diane Whitmore Schanzenbach, and Danny Yagan. 2011. "How does your kindergarten classroom affect your earnings? Evidence from Project STAR." *The Quarterly journal of economics* 126 (4):1593–1660.

Crouzet, Nicolas and Neil R Mehrotra. 2020. "Small and large firms over the business cycle." *American Economic Review* 110 (11):3549–3601.

Dechezleprêtre, Antoine, Elias Einiö, Ralf Martin, Kieu-Trang Nguyen, and John Van Reenen. 2016. "Do tax incentives for research increase firm innovation? An RD design for R&D." Tech. rep., National Bureau of Economic Research.

Dyrda, Sebastian and Benjamin Pugsley. 2018. "Taxes, private equity, and evolution of income inequality in the us." Tech. rep., Working paper.

Glover, Andy and Jacob Short. 2010. "Bankruptcy, incorporation, and the nature of entrepreneurial risk." In *2010 Meeting Papers*, 1010. Society for Economic Dynamics.

Guvenen, Fatih. 2009. "An empirical investigation of labor income processes." *Review of Economic dynamics* 12 (1):58–79.

Guvenen, Fatih, Fatih Karahan, Serdar Ozkan, and Jae Song. 2015. "What do data on millions of US workers reveal about life-cycle earnings risk?" Tech. rep., National Bureau of Economic Research.

Hall, Bronwyn H. 2020. "Tax policy for innovation." In *Innovation and public policy*. University of Chicago Press.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L Violante. 2017. "Optimal tax progressivity: An analytical framework." *The Quarterly Journal of Economics* 132 (4):1693–1754.

Howell, Sabrina T. 2017. "Financing innovation: Evidence from R&D grants." *American Economic Review* 107 (4):1136–64.

König, Michael, Zheng Michael Song, Kjetil Storesletten, and Fabrizio Zilibotti. 2020. "From imitation to innovation: Where is all that Chinese R&D going?" Tech. rep., National Bureau of Economic Research.

Meh, Césaire A. 2005. "Entrepreneurship, wealth inequality, and taxation." *Review of Economic Dynamics* 8 (3):688–719.

———. 2008. "Business risk, credit constraints, and corporate taxation." *Journal of Economic Dynamics and control* 32 (9):2971–3008.

Quadrini, Vincenzo. 2000. "Entrepreneurship, saving, and social mobility." *Review of economic dynamics* 3 (1):1–40.

Scheuer, Florian. 2014. "Entrepreneurial taxation with endogenous entry." *American Economic Journal: Economic Policy* 6 (2):126–63.

Stokey, Nancy L and Sergio Rebelo. 1995. "Growth effects of flat-rate taxes." *Journal of political Economy* 103 (3):519–550.

Storesletten, Kjetil, Chris I Telmer, and Amir Yaron. 2004. "Cyclical dynamics in idiosyncratic labor market risk." *Journal of political Economy* 112 (3):695–717.

Wilson, Daniel J. 2009. "Beggar thy neighbor? The in-state, out-of-state, and aggregate effects of R&D tax credits." *The Review of Economics and Statistics* 91 (2):431–436.

Zetlin-Jones, Ariel and Ali Shourideh. 2017. "External financing and the role of financial frictions over the business cycle: Measurement and theory." *Journal of Monetary Economics* 92:1–15.

Appendices

A Computation Details

In this appendix, we present how to calculate two important measurements of economic well being: ex-ante welfare change of households and total factor productivity (TFP) of firms.

Welfare. We first describe how we calculate the welfare changes from various parameter changes or policies counterfactuals. Households are indexed by individual states $\mathbf{s} = \{a, e, z\}$. We define the consumption-equivalent welfare change as the permanent increase in consumption $\Delta(\mathbf{s})$ that leaves the household indifferent between the stationary equilibria of the two economies. That is,

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u \left([1 + \Delta(\mathbf{s})] \times c, h \right) \right\} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u \left(\tilde{c}, \tilde{h} \right) \right\},$$

where a tilde denotes allocations following the counterfactual. At the aggregate level, the welfare change due to a policy or parameter change k is obtained by integrating over the stationary distribution:

$$CE_k = \sum_{\eta = W,E,C} \int \Delta^{\eta}(\mathbf{s}) \mu^{\eta}(\mathbf{s})$$

where $\mu^{\eta}(\mathbf{s})$ is the distribution of households with occupation $\eta \in \{W, E, C\}$ over the three state variables at the initial steady state.

TFP. We apply Karabarbounis and Macnamara (2021) framework to compute sectoral measured TFP, efficient TFP, and TFP loss. We have the following aggregate relationship in sector $s \in \{E, F\}$:

$$Y^s = A^s_m (M^s)^{1-\gamma} [(K^s)^{\alpha} (L^s)^{1-\alpha}]^{\gamma},$$

where Y^s is aggregate output, A^s_m is (measured) TFP, M^s is the mass of firms, K^s is aggregate capital, and L^s is aggregate labor. Then, the measured TFP in sector j can be computed as follows:

$$A^s_m = \frac{Y^s / M^s}{[(K^s/M^s)^{\alpha} (L^s/M^s)^{1-\alpha}]^{\gamma}}.$$

The efficient level of TFP of sector s, A^s_e, can be derived by reallocating capital and labor across firms to maximize total output subject to the constraints that aggregate capital K and aggregate labor L. At the efficient level, the marginal product of capital (MPK) is equated across all firms. Efficient TFP of sector s can be computed as follows:

$$A_e^s = [\frac{1}{M^s} \int z^{\frac{1}{1-\gamma}} \mu^s(z)]^{1-\gamma},$$

where $\mu^s(z)$ is the productivity distribution of firms in sector s.

The TFP loss of sector s is defined as the percentage difference between the efficient and measured level of TFP:

$$(\text{TFP Loss})^s = \frac{A_e^s}{A_m^s} - 1$$