

# Taxation, Innovation and Entrepreneurship\*

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## Abstract

We examine the public provision and financing of basic research. While basic research is a public good benefiting innovating entrepreneurs, the provision and financing also affect the entire economy: occupational choices of potential entrepreneurs, wages of workers, dividends to shareholders, and aggregate output. We show that the general economy impact of basic research rationalizes a pecking order of taxation to finance basic research. In particular, in a society with desirable dense entrepreneurial activity, a large share of funds for basic research should be financed by labor taxation and a minor share is left to profit taxation. Such tax schemes induce a significant share of agents to become entrepreneurs, thereby rationalizing substantial investments in basic research that fosters their innovativeness. These entrepreneurial economies, however, may make a majority of workers worse off. In such circumstances, stagnation may prevail.

**Keywords** Basic research · Economic growth · Entrepreneurship · Income taxation · Political economy

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# 1 Introduction

The role of innovative entrepreneurship for the well-being of societies has been a constant concern for policy-makers and is at the center of policy debates on how to induce growth in the Eurozone (Economist, 2012). With basic research and taxation, we will examine in this paper two key drivers that shape entrepreneurial activities in societies and that are prominent in the academic and policy debates.<sup>1</sup>

Basic research is a sophisticated public good. The main beneficiaries are innovating entrepreneurs as basic research improves their chances to develop new varieties or new, less cost-intensive production technologies.<sup>2</sup> At the same time, these innovating entrepreneurs are needed for basic research investments to become effective: basic research is embryonic in nature and impacts on the economy only indirectly via applied research and commercialization. In this paper we examine how much should be provided and how it should be financed. Finally we study whether the optimal policies can be politically implemented.

Providing and financing basic research is an intricate task as taxation will not only help to fund these investments, but it also impacts on the entire economy through manifold feedback effects. In particular, basic research investments and tax policies jointly impact on:

- the occupational choice of individuals to become entrepreneurs;
- wages earned by workers;
- dividends paid to shareholders of final good producers;
- aggregate output.

We address these interdependencies in a general equilibrium framework. We develop a simple model of creative destruction where a final consumption good is produced using labor and a continuum of indivisible intermediate goods as inputs. Agents can either work in the final goods sector, in the intermediate goods sector, or they can become entrepreneurs or basic researchers. Entrepreneurs can benefit from basic research provided by the government and invest in applied research in order to develop labor saving technologies for

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<sup>1</sup>Cf. European Commission (2008), European Commission (2013), and General Secretariat of the European Council (2010), for example. With the ambition to stimulate innovation and growth, the European Union is aiming towards directing 3% of GDP to R&D by 2020, 1/3 of which is supposed to be publicly funded (basic) research. The Netherlands, for example, have recently strengthened tax incentives for entrepreneurship and innovation (Government of the Netherlands, 2010).

<sup>2</sup>The positive effect of basic research on applied research has been subject to several studies (cf. Gersbach et al. (2013) for a discussion of the literature.). Link and Rees (1990) and Acs et al. (1994) provide evidence suggesting that small firms might benefit particularly strongly from University R&D.

intermediates. Successful entrepreneurs will earn monopoly profits by producing their intermediate good. In addition, entrepreneurship has immaterial cost (such as entrepreneurial effort cost) and benefits (such as the desire to take the initiative and social status). Potential entrepreneurs weigh these costs and benefits against the labor income lost when deciding on whether or not to become entrepreneurs. The government finances its basic research investments using a combination of labor income and profit taxes. Among others, this financing decision affects the occupational choice by potential entrepreneurs and hence impacts on the effectiveness of basic research investments.

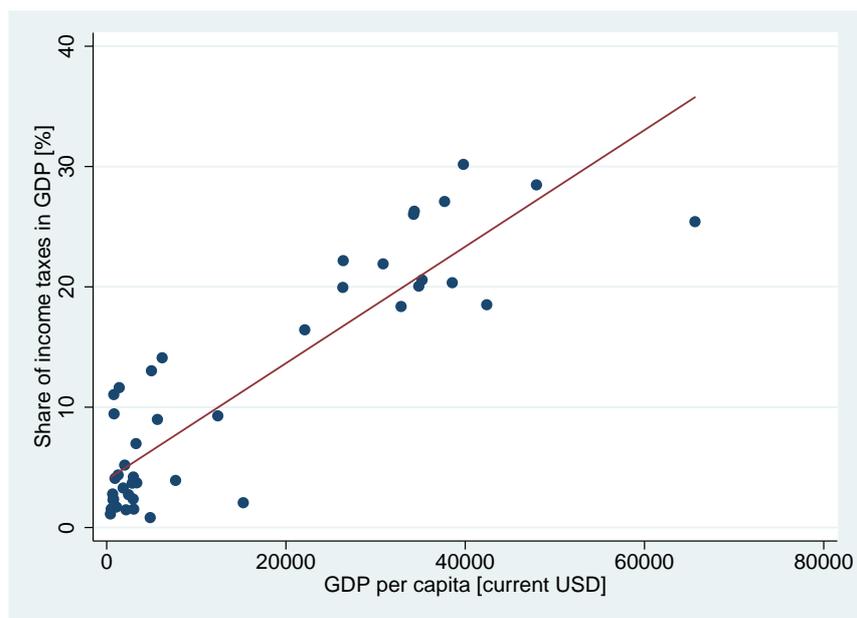
Our first main insight is that financing basic research – a public good that impacts the economy indirectly through various channels – rationalizes a pecking order of taxation. In particular, when innovations can potentially lead to labor saving that exceeds labor used for entrepreneurial activities and basic research, an innovative economy with dense entrepreneurial activities and basic research is desirable (called entrepreneurial economy). In an entrepreneurial economy, a large share of funds for basic research should be primarily financed by labor taxation, while a minor share is left to profit taxation. The property that tax rates on one source of income (here labor) is higher than tax rates on another source (here profits) is called a pecking order of taxation. The pecking order – with primary reliance on labor income taxes – ultimately arises from the complementarity of basic research investments and tax policies: the pecking order of taxation induces a significant share of agents to become entrepreneurs thereby increasing the benefits from investments in basic research.

However, optimal policies in an entrepreneurial economy harm workers with little shareholdings as labor saving innovations lead to declining real wages. These distributional effects can give rise to a conflict between efficiency and equality that undermines political support for growth policies. To examine this conflict, we assume a political economy perspective and analyze growth policies in a median voter framework. We show that the median voter may reject any growth stimulating entrepreneurial policies if shareholdings are skewed to the right. Then, the society is “trapped” in a stagnant economy. Furthermore, even if the median voter supports a growth stimulating entrepreneurial economy, his preferred policy choice is still inefficient vis-à-vis the social optimum. This inefficiency concerns both, tax policies and basic research investments. Basic research investments tend to be too low, thus providing a rationale for the surprisingly high rates of return to public investments in (basic) research typically found in empirical studies. Interestingly, these inefficiencies are mitigated as upper bounds on taxation increase. Then, tax incentives to entrepreneurs (efficiency) and redistribution of gains from innovation (equality) can be better aligned.

Larger upper bounds on taxation allow more redistribution to the median voter and thus equity concerns can be satisfied which may make growth policies politically feasible. At the same time, larger upper bounds on tax rates allow more flexibility in the relationship between tax rates on labor and profits which is decisive for entrepreneurship and innovation and thus for efficiency concerns.

The preceding insights may have implications for two determinants of the boundaries of tax rates: constitutional bounds and fiscal capacity. Constitutional bounds to taxation are sometimes proposed as a means of protecting investors from excessive indirect expropriation via tax policies. We show that low upper tax bounds may actually harm firm owners if growth policies are subject to the political process. Then, low upper bounds on taxation may undermine the political support for growth policies and the society may be “trapped” in a stagnant economy, with little entrepreneurship and low profits. Indeed, we will argue that bounds on taxation are likely to be rejected in a constitutional design phase behind the veil of ignorance.

Figure 1: Fiscal capacity and GDP per capita



Alternatively, tax bounds may implicitly arise from fiscal capacity, which stands for the ability of the government to collect taxes. Figure 1 plots fiscal capacity against GDP per capita for a cross-section of countries. Following Besley and Persson (2009) we have used income taxes over GDP as a proxy for fiscal capacity. The plot indicates a strong positive relationship between past fiscal capacity and GDP per capita. We provide a political

economy rationale for why weak fiscal institutions might harm growth prospects. In a nutshell, weak fiscal capacities do not allow for sufficient redistribution to let a critical mass of the population participate in gains from growth stimulating policies. Hence they might undermine the political support needed for their implementation.

The paper is organized as follows: Section 2 embeds our paper in the literature. Sections 3 and 4 outline the model and derive the equilibrium for given tax policies and basic research investments. In section 5, we analyze aggregate consumption optimal policies. Section 6 presents an analysis of the political economy of financing basic research. Section 7 concludes. We provide several robustness checks to our pecking order result as well as all the proofs in the Appendix.

## 2 Literature

Our paper is related to several important strands of the literature.

### *Rationale for public funding of basic research*

The case for public funding of basic research is well established in the literature, in particular at least since the seminal paper of Nelson (1959). He identifies fundamental conflicts between providing basic research and the interests of profit making firms in a competitive economy: First, the provision of basic research has significant positive external effects that cannot be internalized by private firms. Second, the long lag between basic research and the reflection thereof in marketable products might prevent short-sighted firms from investing. And third, the high uncertainty involved in the research process might induce a private provision of basic research that is below the socially optimal level. These three problems are the more severe, the more basic the research is and they therefore motivate public provision of basic research in particular.

The rationale for the public provision of basic research is matched by empirical evidence. Gersbach et al. (2013) report data showing that for a selection of 15 countries the average share of basic research that was performed in the government and higher education sector was approximately 75% in 2009. From the OECD main science and technology indicators we find that across OECD member countries around 80% of total research performed in the government or higher education sector is also funded by the government.<sup>3</sup>

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<sup>3</sup>Data have been downloaded from OECD (2012a) in May 2012. As far as available, 2008 data has been used. For each country, the share of public funding in the government and higher education sector has been computed as follows:

### *Financing of basic research*

Our main question in this paper is how optimally chosen basic research expenditures should be financed. Our paper is thus related to the literature on financing productive government expenditures. In the seminal paper, Barro (1990) examines the case of productive government expenditures as a flow variable. Futagami et al. (1993) develop the case of productive government expenditures representing investments in a stock. These authors develop investment-based endogenous growth models where the individual firm faces constant returns to scale with respect to both, private capital and the public services provided by the government. A detailed discussion of this literature can be found in the comprehensive survey by Irmen and Kuehnel (2009). By contrast, our model is rooted in the tradition of R&D based endogenous growth models, and particularly those that explicitly take into account the hierarchical order of basic and applied research (see, for example, Arnold (1997), Morales (2004), or Gersbach et al. (2010)). In this kind of models, basic research has no productive use in itself, but rather fuels into the productivity of the applied research sector, where knowledge is transformed into blueprints for new or improved products. Moreover, a second important role of financing basic research will be addressed in this paper. Basic research may be financed via a combination of labor income, profit, and lump-sum taxes. The relative size of labor to profit taxes affects the trade-off faced by potential entrepreneurs between being employed in the labor market and becoming an entrepreneur and hence influences the number of innovating entrepreneurs in our economy.

### *Tax structures and entrepreneurial activity*

Empirical evidence in the literature suggests that the tax structure indeed influences the level of entrepreneurial activities in an economy. Using cross-sectional data of US personal income tax returns, Cullen and Gordon (2007) estimate the impact of various tax measures on entrepreneurial risk-taking. They find that a cut in corporate tax rates either raises or does not significantly affect entrepreneurial risk taking, depending on the model specification. Cullen and Gordon interpret their results to be in line with their theory, as risk-sharing of non-diversifiable entrepreneurial risks with the government is positively related to the corporate income tax rate. Djankov et al. (2010) analyze cross-country data for 85 countries. They find that higher effective tax rates paid by a hypothetical new company have a significant adverse effect on aggregate investment and entrepreneurship. Da Rin et al. (2011) report that corporate income taxes significantly reduce firm entry in a panel

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$\frac{\text{sub-total government funding in higher education sector} + \text{sub-total government funding in government sector}}{\text{total funding higher education sector} + \text{total funding government sector}}$ . The average of these shares across all OECD member countries was found to be slightly below 80%.

of 17 European countries. Gentry and Hubbard (2000) analyze 1979 to 1992 data from the Panel Study on Income Dynamics to argue that less progressive tax rates significantly increase entrepreneurship.

### *Optimal taxation in an economy with entrepreneurship*

At the heart of our model is the occupational choice by (potential) entrepreneurs. Boadway et al. (1991) present a model with heterogeneous agents who can choose between becoming entrepreneurs or workers. They analyze optimal tax rates, where tax rates are the same for both types of labor or income. By contrast, in our model the government can discriminate between taxes on profits and on labor income. Kanbur (1981) considers a model with endogenous occupational choice of homogeneous agents between becoming a worker earning a safe wage or an entrepreneur earning risky profits. Among others, he considers entrepreneurial risk-taking given occupation dependent taxation, but he does not derive optimal tax policies.<sup>4</sup>

Moresi (1998) and Scheuer (2011) analyze optimal tax policies in models of asymmetric information with occupational choice, where the government faces a trade-off between efficiency and equality.<sup>5</sup> The distinctive feature of our model is that we analyze optimal tax policies and investment of tax revenues in basic research where the government simultaneously affects the share of entrepreneurs and their innovativeness.

### *Political economics of tax policies*

In our model, productive government investments in basic research foster labor saving technological innovation. In general equilibrium, innovation has a positive effect on profits but a negative effect on wages. These distributional effects are further accentuated by the pecking order of taxation, giving rise to trade-offs between efficiency and equality similar to the ones considered in the literature on optimal taxation. We address these distributional effects from a political economy perspective when analyzing growth stimulating policies in a median voter framework. Hence, our work is also related to the literature on the political

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<sup>4</sup>In this regard his work is close in nature to recent work on calibrated dynamic general equilibrium models that are used to assess the effects of stylized tax reforms (see Meh (2005) or Cagetti and De Nardi (2009), for example).

<sup>5</sup>Hauffer et al. (2012), for example, take a different viewpoint on optimal tax policies with entrepreneurship: They consider a model where entrepreneurs engage in risky innovation and endogenously choose the quality (riskiness) of their project. Gains from innovation are subject to different tax treatments, depending on whether the entrepreneur entered the market or sold his project to an incumbent. Optimal tax policies then trade-off the gains from increased competition via market-entry against the losses of reduced entrepreneurial risk-taking due to lost tax deductions in case of failure.

economics of tax policies.

Romer (1975), Roberts (1977), and Meltzer and Richard (1981) represent a classical benchmark suggesting that majority voting over linear income taxes will result in inefficiently high tax rates if the income distribution is skewed to the right. Persson and Tabellini (1994) and Alesina and Rodrik (1994) were among the first to assess the role of redistributive taxation for long-run economic growth by incorporating politico-economic equilibria into endogenous growth models. According to their models, increased inequality compromises long-run growth perspectives via stronger redistributive taxation. Both papers present empirical evidence supporting this main finding. In our model higher inequality also hinders growth stimulating policies. However, this conflict of interest between growth policies and redistribution can be resolved if (constitutional) tax bounds are sufficiently flexible as described previously.

With (constitutional) tax bounds being at center stage in our political economy section, our work also relates to the literature on constitutional design for tax policies. In a pioneering work in this area, Brennan and Buchanan (1977) assume that constitutional design takes place behind the veil of ignorance regarding own future income. The constitutional limits on taxation should optimally be designed as an obstacle for a Leviathan-type government that maximizes revenues within these limits. The implications of our model point to the opposite: constitutional tax bounds that are too small can prevent growth stimulating policies from being supported by the median voter. Hence, households tend to object any tax bound when voting behind the veil of ignorance in a constitutional design phase.

An alternative view on the bounds of taxation at play in our model is to interpret them as a reduced form for state capacity in the spirit of Acemoglu (2005) and Besley and Persson (2009). While in the latter fiscal capacity affects growth indirectly via its complementarity with other state capacities, in the former fiscal capacity directly influences growth as a determinant of the extent of distortionary taxation and productive investments by self-interested governments. We provide an alternative political economy rationale for why fiscal capacities might fundamentally affect growth: Weak fiscal capacities do not allow for sufficient redistribution of gains from innovation and hence undermine its political support.

### 3 The Model

The economy is populated by a continuum of measure  $\bar{L} > 1$  of households who derive utility  $u(c) = c$  from a final consumption good. Agents are indexed by  $k$  ( $k \in [0, \bar{L}]$ ).

### 3.1 Production

The final good, denoted by  $y$ , is produced with a continuum of intermediate goods  $x(i)$  ( $i \in [0, 1]$ ). The production technology is given by

$$y = L_y^{1-\alpha} \int_0^1 x(i)^\alpha di, \quad (1)$$

where  $L_y$  denotes labor employed in final good production and where  $0 < \alpha < 1$ . The final good is only used for consumption, hence in equilibrium output of the final good equals aggregate consumption ( $C = y$ ).

We assume that intermediate goods  $x$  are indivisible, i.e.  $x(i)$  is either 1 or 0.<sup>6</sup> The final consumption good is chosen as the numéraire whose price is normalized to 1. Firms in the final good sector operate under perfect competition. They take the price  $p(i)$  of intermediate goods as given. In the following we work with a representative final good firm maximizing

$$\pi_y = y - \int_0^1 p(i)x(i) di - wL_y \quad (2)$$

by choosing the quantities  $x(i) \in \{0, 1\}$  and the amount of labor  $L_y$ . If the final good producer chooses  $x(i) = 1$  for all  $i$ , the demand for labor in final good production will be

$$L_y = \left( \frac{1 - \alpha}{w} \right)^{\frac{1}{\alpha}}. \quad (3)$$

### 3.2 Behavior of intermediate good producers

Each intermediate good can be produced by a given technology using  $m > 0$  units of labor. Hence the marginal production costs are  $mw$  and we assume that the standard technology is freely available. This implies perfect competition and a price equal to the marginal costs. If an entrepreneur engages in research and development and successfully innovates,

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<sup>6</sup>As we will explain in more detail later on, we consider the case of labor saving technological progress in the intermediate sector. With indivisible intermediate goods, labor saved in intermediates production is not taken up elsewhere in the economy at constant wages. This can give rise to a stark conflict of interest between equality and efficiency in our economy and hence to interesting political economy effects. We discuss these in detail in section 6. Three remarks are in order: First, our main finding of the optimality of a pecking order of taxation does neither rely on labor saving technological innovation nor on the indivisibility of intermediates. It rather follows from the complementarity of basic research and the occupational choice of potential entrepreneurs. Second, we believe the conflict between equality and efficiency in our economy to be broadly in line with the decreasing shares of labor income, in particular for low skilled labor, in aggregate income that can be observed in the recent past in the EU and the US (cf. footnote 27). And third, while the indivisibility of intermediates can accentuate the equality-efficiency trade-off in our economy, it is not necessary for such effects to arise (cf. footnote 28).

the production costs decline by a factor  $\gamma$  ( $\gamma < 1$ ) leading to marginal production costs of  $\gamma mw$ . The innovating entrepreneur obtains a monopoly and it will turn out that he still offers his product at the price equal to the marginal cost of potential competitors,  $mw$ , thereby gaining profit  $\pi_{xm} = (1 - \gamma)mw$ .

### 3.3 Innovation

There is a measure 1 of individuals  $[0, 1] \subset [0, \bar{L}]$  who are potential entrepreneurs. Individuals face different costs and benefits when deciding to become an entrepreneur. Specifically, we assume that agents are ordered in  $[0, 1]$  according to their immaterial utilities from entrepreneurial activities: In particular, individual  $k$  faces the utility factor  $\lambda_k = (1 - k)b$  ( $k \in [0, 1]$ ,  $b$  being a positive parameter). This factor rescales the profit earned from entrepreneurial activities in order to take into account immaterial cost (such as cost from exerting efforts as an entrepreneur or utility cost from entrepreneurial risk taking that are not reflected in the utility from consumption) and immaterial benefits (such as excitement, initiative taking, or social status) associated with entrepreneurial activity.<sup>7</sup> Agents with a higher index  $k$  have lower utility factors. A utility factor  $\lambda_k < 1$  represents net utility cost from being an entrepreneur while a factor  $\lambda_k > 1$  represents net immaterial benefits.<sup>8</sup> For individuals  $k$  with  $\lambda_k = 1$ , and thus  $k^{crit} = 1 - \frac{1}{b}$ , immaterial cost and benefits associated with entrepreneurial activities cancel out. If  $b$  is small and thus  $k^{crit}$  is small or even zero, the society is characterized by a population of potential entrepreneurs for whom effort cost matter most. If  $b$  is large and thus  $k^{crit}$  is large, the potential entrepreneurs enjoy being one compared to a worker. We assume that  $\lambda_k$  is private information and thus only observed by agent  $k$ .<sup>9</sup>

The chances of entrepreneurs to successfully innovate can be fostered by basic research. Basic research generates knowledge that is taken up by entrepreneurs and transformed into innovations applied in the production process. Suppose that the government employs  $L_B$  ( $0 \leq L_B \leq \bar{L}$ ) researchers in basic research. Then the probability that an entrepreneur

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<sup>7</sup>Cf. footnote 17 for a discussion on how differences in risk-attitudes might give rise to occupational choice effects similar to the ones arising from our immaterial benefit factor  $\lambda_k$ . In our model, there is no aggregate risk and entrepreneurship is not prone to moral hazard. Hence, with complete markets entrepreneurs can perfectly insure against entrepreneurial risk. In this case,  $\lambda_k$  does not capture utility cost from entrepreneurial risk taking.

<sup>8</sup>Our concept of immaterial utilities associated with being an entrepreneur is in line with recent empirical evidence (cf. Hamilton (2000); Benz and Frey (2008); Benz (2009); Douglas and Shepherd (2000); Praag and Versloot (2007)). Most studies find that entrepreneurship involves positive non-monetary benefits.

<sup>9</sup>This does preclude to condition taxation on  $\lambda_k$ . We note that our results remain unaffected if  $\lambda_k$  is common knowledge but tax policies do not condition thereon.

successfully innovates is given by  $\eta(L_B)$  where  $\eta(L_B)$  fulfills  $\eta(0) \geq 0$ ,  $\eta'(\cdot) > 0$ ,  $\eta''(\cdot) < 0$  and  $\eta(\bar{L}) \leq 1$ .<sup>10</sup> Depending on whether  $\eta(0) = 0$  or  $\eta(0) > 0$ , basic research is a necessary condition for innovation or not.

Accordingly, if a measure  $L_E$  of the population decided to become entrepreneurs and each has the success probability  $\eta(L_B)$ , the share of intermediate sectors with successful innovation is equal to  $\eta(L_B)L_E$ .<sup>11</sup> We note that the property  $L_E \leq 1$  allows that entrepreneurs perform research on a variety different from others.<sup>12</sup>

### 3.4 Financing scheme

Expenditures for basic research have to be financed by taxes. The government can levy taxes on labor income or profits. Additionally, we assume that the government can levy lump sum taxes or make lump sum transfers.<sup>13</sup> Later we examine the case when this is not possible. A tax scheme is a vector  $(t_L, t_P, t_H)$  where  $t_L$  and  $t_P$  are the tax rates on labor income and on profits, respectively, and  $t_H$  denotes a lump sum tax or transfer. We assume that there are upper bounds (and potentially lower bounds) of labor income and profit taxes. Upper bounds on taxation may either be specified explicitly in the constitution or they may arise implicitly from fiscal capacities in the spirit of Besley and Persson (2009), for example.<sup>14</sup> We denote the upper and lower bounds by  $\bar{t}_j$  and  $\underline{t}_j$ ,  $j \in \{L, P\}$ , respectively. For our theoretical analysis we assume the upper bounds are strictly smaller than 1, i.e.  $\bar{t}_j \leq 1 - \varepsilon$  for some arbitrarily small  $\varepsilon > 0$ .

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<sup>10</sup> $\eta'(\cdot)$  and  $\eta''(\cdot)$  denote the first and second derivative, respectively, of  $\eta(\cdot)$  with respect to  $L_B$ .

<sup>11</sup>We use a suitable version of the law of large numbers for a continuum of random variables.

<sup>12</sup>Strictly speaking we assume that there is no duplication of research efforts. It is straightforward to incorporate formulations in which several researchers compete for innovation on one variety. This would decrease the benefits from basic research for entrepreneurs and for the society.

<sup>13</sup>Our model allows for unsuccessful entrepreneurs which earn zero profits. Consequently, in case that their share of the profits of the final good firm are not too high, they may not be able to pay the lump sum tax. For a broad range of parameter values, lump-sum taxes are negative in optimum, implying that this is not an issue. If not, we assume that all individuals have a certain endowment, which could be drawn upon by the government in this case.

<sup>14</sup>Alternatively, upper bounds on tax rates may implicitly arise from harmful supply-side effects of taxation: Supply effects of profit taxes are at the very heart of the analysis pursued here. Yet, in an open economy the government might also be confronted with additional harmful supply effects associated with high profit taxes that are not considered here and that may give rise to effective upper bounds on profit taxes. Similarly, supply effects of labor income taxes are only considered to the extent to which they affect the occupational choice by potential entrepreneurs. In addition, labor income taxes might affect the labor/leisure choice of workers and might hence be effectively bound from above. Lower bounds on profit taxes, in particular, might be demanded by the international community. The European Council of Economics and Finance Ministers, for example, has agreed upon a code of conduct for business taxation which is intended to tackle harmful competition in the field of business taxation (European Union, 1998). Although this code of conduct does not define explicit lower bounds on taxation and is not legally binding, it still represents a considerable political commitment not to have extremely low tax rates on profits.

Throughout our paper, we assume that the government needs to run a balanced budget, i.e. the government budget constraint is given by

$$wL_B = t_L(\bar{L} - L_E)w + t_P(\pi_y + \eta(L_B)L_E\pi_{xm}) + t_H\bar{L}, \quad (4)$$

where  $t_H = 0$  in the scenario without lump-sum taxes.

### 3.5 Sequence of events

We summarize the sequence of events as follows.

- (1) The government hires a number  $L_B$  of researchers to provide public basic research and chooses a financing scheme.
- (2) A share  $L_E$  of the population decide to become entrepreneurs. With probability  $\eta(L_B)$  they successfully innovate, which enables them to capture monopoly rents. A share  $(1 - \eta(L_B))L_E$  will not be successful and will earn zero profits.
- (3) Each intermediate good firm  $i$  hires a number  $L_x(i)$  of workers in order to produce the intermediate good  $x(i)$ .
- (4) The representative final good firm buys the intermediate goods  $x(i)$  at a price  $p(i)$  and produces the homogeneous final good  $y$ .

## 4 Equilibrium

In this section we derive the equilibrium for a given amount of basic research and a given financing scheme.

### 4.1 Occupational choice by potential entrepreneurs

We first address the choice of occupation. Potential entrepreneurs, i.e. agents in the interval  $[0, 1]$ , can choose between being employed as workers and trying to develop an innovation to be used in the production of intermediate goods. We are left with two cases: all agents choose to be workers or both occupations are chosen in equilibrium.<sup>15</sup> If both occupations are chosen in equilibrium, the marginal entrepreneur has to be indifferent

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<sup>15</sup>More precisely, in the first case only a set of individuals of measure 0 decides to become an entrepreneur.

between being employed as a worker and becoming an entrepreneur. The expected net profit of an entrepreneur is

$$\pi^E = (1 - t_P)\eta(L_B)\pi_{xm} = (1 - t_P)w\eta(L_B)m(1 - \gamma) .$$

The last expression indicates that the expected profit of the entrepreneur consists of the expected amount of labor saved in intermediate good production,  $\chi(L_B) \equiv \eta(L_B)m(1 - \gamma)$ , scaled by the wage rate net of profit taxes. Hence, the expected utility for an individual  $k$  with (dis-)utility factor  $\lambda_k = (1 - k)b$  from being an entrepreneur is<sup>16</sup>

$$EU^E(k) = (1 - t_P)w\chi(L_B)(1 - k)b .$$

The individual is indifferent between being employed as a worker and becoming an entrepreneur if  $EU^E(k) = (1 - t_L)w$ . Solving for the equilibrium amount of entrepreneurs yields<sup>17</sup>

$$L_E^e = \max \left\{ 0; 1 - \frac{1 - t_L}{1 - t_P} \frac{1}{\chi(L_B)b} \right\} . \quad (5)$$

In the following, we use  $\tau$  as an abbreviation for  $\frac{1-t_P}{1-t_L}$ , with the upper and lower bounds of  $\tau$  denoted by  $\bar{\tau}$  and  $\underline{\tau}$  being defined by the respective bounds of  $t_L$  and  $t_P$ .  $\tau$  is a measure of tax incentives given to (potential) entrepreneurs. Moreover, let  $\bar{\tau} \geq 1 \geq \underline{\tau}$  implying that a neutral tax policy  $t_L = t_P$  is always possible.

<sup>16</sup>We note that we have chosen a multiplicative functional form. An alternative approach is to use an additive functional form by deducting the cost (see e.g. Boadway et al. (1991) or Scheuer (2011)). The multiplicative approach is more convenient and analytically much easier. In addition, it implies that the net immaterial benefit is scaled by entrepreneurial profits. The multiplicative approach may therefore be more appropriate to reflect effort costs and social status benefits, in particular, as these would typically be related to profits. For  $\lambda_k < 1$  the effort cost dominate, while for  $\lambda_k > 1$  the social status benefits dominate. Qualitatively, however, the additive and the multiplicative approach involve the same trade-offs and pecking order considerations.

<sup>17</sup>In our model, potential entrepreneurs differ in their immaterial cost and benefits from being an entrepreneur. Agents whose expected utility from being an entrepreneur exceeds the utility from working in the labor market opt to become an entrepreneur, thus giving rise to continuous occupational choice effects. We note that a similar result for the occupational choice would arise if agents differed in the risk attitude rather than in an extra (dis-)utility term. Suppose for example that potential entrepreneurs differ only in their degree of constant relative risk-aversion with  $u_k(c) = \frac{c^{1-r_k}}{1-r_k}$ , where  $r_k$  is distributed according to some continuous and differentiable distribution function  $F_{r_k}(r_k)$  on  $[0, 1]$ , satisfying  $\frac{dF_{r_k}(\cdot)}{dr_k} > 0$ ,  $\forall r_k \in [0, 1]$ . Suppose further that insurance against entrepreneurial risks is not possible. Then, individual  $k$  opts to become an entrepreneur if his certainty equivalent from being an entrepreneur is at least as large as his after-tax wage:  $[\eta(L_B)]^{\frac{1}{1-r_k}} (1 - t_P)m(1 - \gamma)w \geq (1 - t_L)w$  for the case of no other income. It follows that all potential entrepreneurs with  $r_k \leq \bar{r} = \max \left\{ 0; 1 - \frac{\ln(\eta(L_B))}{\ln(1-t_L) - \ln((1-t_P)m(1-\gamma))} \right\}$  will become entrepreneurs. The equilibrium number of entrepreneurs is then given by  $L_E = F_{r_k}(\bar{r})$ . As for the case with heterogeneous immaterial cost and benefits from being entrepreneur, entrepreneurship is increasing in  $m$ ,  $t_L$ , and  $L_B$ , decreasing in  $t_P$  and  $\gamma$  and it is independent of  $w$ . However, basic research has an additional effect here: next to increasing the expected profit from being an entrepreneur, it affects associated entrepreneurial risks.

Knowing  $L_E$  from (5), we obtain the amount of labor employed in the production of intermediates as

$$L_x^e = \int_0^1 L_x(i) di = m - \chi(L_B)L_E^e \quad (6)$$

if  $x(i) = 1 \forall i$ . This corresponds to the amount of labor necessary to produce the intermediate goods with the old technology less the (expected) amount of labor saved by the new technologies invented by the entrepreneurs.

## 4.2 Equilibrium for given basic research and financing scheme

We will now derive the equilibrium for given basic research and tax policy. Due to the indivisibility of the different varieties of the intermediate goods, we have to consider the case that despite diminishing returns to intermediate goods in final good production, the final good firm will not use all of the different varieties or will even go out of business and not produce at all. We start by considering the equilibrium in the market for intermediate goods with positive production in the final good sector:

### Lemma 1

- (i) *In any equilibrium with positive production in the final good sector, intermediate good producers supplying their product will charge  $p_i = mw$ .<sup>18</sup>*
- (ii) *In any equilibrium with positive production in the final good sector, the final good producer uses all varieties of intermediate goods.*

The proof of Lemma 1 can be found in Appendix C.1. As a consequence of point (ii) of Lemma 1, we can use the equilibrium number of entrepreneurs in (5) and labor in intermediate good production in (6) together with the market clearing condition in the labor market

$$\bar{L} = L_E + L_B + L_y + L_x, \quad (7)$$

to derive the number of workers employed in the final good sector in an equilibrium with positive final good production

$$L_y^e = \bar{L} - L_B - L_E^e - L_x^e. \quad (8)$$

Equation (3) yields the corresponding equilibrium wage rate as

$$w^e = (1 - \alpha)(\bar{L} - L_B - L_E^e - L_x^e)^{-\alpha}. \quad (9)$$

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<sup>18</sup>To avoid the need to discretize the strategy-space in order to obtain existence of equilibria in the price-setting game in the intermediate good industry  $i$ , we assume as a tie-breaking rule that the final good producer demands the product from the innovating entrepreneur if he offers the same price as non-innovating competitors.

Finally we determine when an equilibrium with positive production will occur, that is, under which condition the final good firm will make positive profits. Using the profit function (2) and Lemma 1, we obtain in equilibrium

$$\pi_y^e = (L_y^e)^{1-\alpha} - w^e L_y^e - w^e m .$$

Inserting the equilibrium wage rate (9) yields

$$\pi_y^e = \alpha(L_y^e)^{1-\alpha} - (1 - \alpha)m(L_y^e)^{-\alpha} .$$

We observe that the final good firm's profit strictly increases in the amount of labor it employs in equilibrium. This is very intuitive as higher employment in final good production yields higher output and this is associated with lower wages in equilibrium, implying that the prices of both inputs labor and intermediate goods are lower. Consequently, the final good firm's profits will be positive, if the amount of labor employed in final good production exceeds the critical level,  $L_y^c \equiv m \frac{1-\alpha}{\alpha}$ . By (8), this will always be the case in equilibrium, if governmental policy  $(L_B, \tau)$  satisfies the following condition

$$\frac{m}{\alpha} \leq \begin{cases} \bar{L} - L_B & \text{if } \frac{1}{\tau\chi(L_B)b} \geq 1 \\ \bar{L} - L_B + \left[1 - \frac{1}{\tau\chi(L_B)b}\right] [\chi(L_B) - 1] & \text{if } \frac{1}{\tau\chi(L_B)b} < 1 \end{cases} . \quad (\text{PPC})$$

Otherwise the wage rate is too high such that the indivisible intermediate goods are too expensive to realize positive profits.<sup>19</sup>

We are now in a position to characterize the allocation and prices in the equilibrium of the economy for given basic research investments  $L_B$  and a given financing scheme  $\tau$ .

**Proposition 1**

(i) *If  $L_B$  and  $\tau$  satisfy condition (PPC), there is a unique equilibrium with  $x^e(i) = 1$  for all  $i$  and*

- (1)  $L_E^e = \max \left\{ 0; 1 - \frac{1-t_L}{1-t_P} \frac{1}{\chi(L_B)b} \right\}$
- (2)  $L_x^e = m - \chi(L_B)L_E^e$
- (3)  $L_y^e = \bar{L} - L_B - m + L_E^e [\chi(L_B) - 1]$
- (4)  $w^e = (1 - \alpha) (L_y^e)^{-\alpha}$
- (5)  $p^e(i) = m(1 - \alpha) (L_y^e)^{-\alpha} \forall i$

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<sup>19</sup>Lemma 1 implies that the cost of intermediates essentially are a fixed cost which is increasing in  $w^e$ . If wages are too high ( $L_y^e$  is too low), then the variable profits from operation are not large enough to compensate for these fixed cost.

$$(6) \quad y^e = (L_y^e)^{1-\alpha}$$

$$(7) \quad \pi_y^e = (L_y^e)^{-\alpha} (\alpha L_y^e - m(1 - \alpha))$$

$$(8) \quad \pi_{xm}^e = (1 - \gamma)m(1 - \alpha)(L_y^e)^{-\alpha} \quad .$$

(ii) If  $L_B$  and  $\tau$  do not satisfy condition (PPC), there is a unique equilibrium with  $x^e(i) = 0$  for all  $i$ ,  $L_E^e = L_x^e = L_y^e = 0$ , and zero profits.

The proof of Proposition 1 can be found in appendix C.2.

## 5 Optimal Policies

The government can manipulate the previously established equilibrium outcomes by investing in basic research and via the tax scheme. The government's objective is to maximize welfare in the economy, which comprises a material component, consumption, and an immaterial component, the entrepreneurs' (dis-)utility of being an entrepreneur. The utility of being an entrepreneur cannot be observed directly by the government. In our simple model framework, the government can determine the immaterial welfare component from the revealed occupational choices of the individuals together with the precise distribution of disutilities from being entrepreneur. As this distribution may be impossible to observe in reality, we first consider a government that concentrates on the material welfare component, that is, on aggregate consumption. We will show in Appendix A that our main insight regarding the pecking order of taxation prevails and may be reinforced with a broader welfare measure that additionally accounts for the utility costs and benefits from becoming an entrepreneur. We will now start our discussion of optimal policies with some preliminary considerations before we turn to the solution of the government's maximization problem.

### 5.1 Preliminary considerations

#### *Efficient vs. inefficient entrepreneurship*

Note that before taxes, the expected profit of an entrepreneur is higher than the wage rate in goods production if  $\chi(L_B) \geq 1$ . That is, by the entrepreneurial activity the individual saves in expectation more labor in intermediate good production than the unit of labor he could provide himself to the labor market. However, even if entrepreneurship would have a negative impact on labor supply in final good production, i.e. if  $\chi(L_B) < 1$ , individuals

may find it worthwhile to become an entrepreneur due to immaterial benefits and the tax policy  $\tau$ . In this respect, we make the following assumption:

**Assumption 1**

(i)  $\chi(0) < 1$  ,    (ii)  $1/\bar{\tau} < b \leq 1/\chi(0)$  .

Assumption 1(i) states that, in expectation, entrepreneurship will reduce the labor supply for final good production, and thus final output, when no basic research is provided. The last inequality in the second condition allows the government to preclude output reducing entrepreneurship by implementing a neutral tax policy and not investing in basic research. By contrast, the first inequality ensures that in the situation with labor-saving entrepreneurship, the government will be able to induce a positive measure of individuals to become entrepreneurs via its tax policy.

*Positive production in final good sector*

When setting its policy  $(L_B, \tau)$ , the government has to consider the positive profit condition in the final good sector (PPC) which determines the resulting equilibrium type. The following assumption ensures that any aggregate consumption optimal policy will yield an equilibrium with positive final good production and that we can neglect (PPC) in the government's optimization problem.

**Assumption 2**

$\bar{L} \geq \frac{m}{\alpha}$ .

As we will show at the beginning of the next section, the aim of the government's basic research and tax policies boils down to maximizing the amount of labor available for final good production. As a consequence, if some feasible policy choice satisfies condition (PPC), then so does the optimal policy choice.<sup>20</sup> By Assumption 1(ii), the government can fully suppress entrepreneurship by choosing  $L_B = 0$  and  $\tau = 1$ . Assumption 2 ensures that final good producers' profits are non-negative under this policy regime and hence so they are under the aggregate consumption optimal policy regime.

We now derive optimal basic research policy when lump-sum taxes and transfers are available to the government. As the number of entrepreneurs only depends on the relation between profit and labor income taxes as captured by  $\tau$ , the assumption of lump-sum transfers allows us to separate the choice of  $L_B$  from the choice of the government's tax

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<sup>20</sup>The condition (PPC) can also be interpreted as a defining an upper bound on the wage rate. If the wage rate is too high the inputs in final good production become too expensive to break even with a positive amount of output.

incentives to (potential) entrepreneurs. This scenario will yield the major insights.<sup>21</sup> If no lump sum taxes and transfers are available, the choices of  $\tau$  and  $L_B$  cannot in all cases be separated. However, we will obtain the same qualitative results.<sup>22</sup>

## 5.2 Optimal policy

The government's problem of maximizing material welfare boils down to maximizing aggregate consumption,  $C$ , by choosing the amount of basic research,  $L_B$ , and the optimal ratio between profit and labor taxes,  $\tau$ , while either levying an additional lump sum tax if labor and profit taxes satisfying the optimal  $\tau$  do not suffice to finance the desired amount of  $L_B$  or making a lump sum transfer in case that the revenue generated by  $\tau$  is larger than needed for the basic research expenditures.

$$\begin{aligned} \max_{\{t_L, t_P, t_H, L_B\}} \quad & C = \pi_y + \eta(L_B)L_E\pi_{xm} + wL_y + wL_x + wL_B - (\bar{L} - L_E)wt_L \\ & - t_P [\pi_y + \eta(L_B)L_E\pi_{xm}] - t_H\bar{L} \\ \text{s.t.} \quad & wL_B = (\bar{L} - L_E)wt_L + t_P [\pi_y + \eta(L_B)L_E\pi_{xm}] + t_H\bar{L} \end{aligned}$$

where  $t_H\bar{L}$  denotes the lump-sum taxes or transfers. Inserting the constraint into the objective function and using the aggregate income identity  $y = \pi_y + \eta(L_B)L_E\pi_{xm} + wL_y + wL_x$  reduces the problem to

$$\begin{aligned} \max_{\{L_B, \tau\}} \quad & C(L_B, \tau) = y(L_B, \tau) = (L_y(L_B, \tau))^{1-\alpha} \\ & = [\bar{L} - L_E(L_B, \tau) - L_B - L_x(L_B, \tau)]^{1-\alpha} . \end{aligned}$$

Hence, the objective of the government is to maximize the amount of productive labor in final good production. By inserting  $L_x$ , the objective function can be written as

$$y(L_B, \tau) = [\bar{L} - L_B - m + L_E[\chi(L_B) - 1]]^{1-\alpha} . \quad (10)$$

Maximizing (10) is equivalent to maximizing  $\bar{L} - L_B - m + L_E[\chi(L_B) - 1]$  which we will use in the following.

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<sup>21</sup>Given that basic research investments account for a share of government expenditures only, the scenario with lump-sum taxes might also be interpreted as one where any excess funds are used to finance other government expenditures that benefit all members of the population equally. For a broad range of parameter values, lump-sum taxes are negative in optimum, i.e. we have lump-sum transfers. Then, our analysis is equivalent to an analysis with no lump-sum taxes but investments in an additional public good  $g$  which directly impacts on households' utilities and where  $u(c, g) = c + \frac{g}{L}$ .

<sup>22</sup>A formal analysis of the case without lump-sum taxes will be provided upon request.<sup>3</sup>

It will be informative to solve the government's problem in two steps. First, we determine the optimal tax policy to finance a given amount of basic research. In the second step, we use the optimal tax policy to derive the optimal basic research investments. In the optimization at the first step, the Kuhn-Tucker conditions with respect to the optimal tax policy are

$$\frac{\partial L_E}{\partial \tau} [\chi(L_B) - 1] \geq 0, \quad (11a)$$

$$\frac{\partial L_y}{\partial \tau} (\tau - \underline{\tau})(\tau - \bar{\tau}) = 0. \quad (11b)$$

The term in brackets on the left-hand side of (11a) expresses how much labor in intermediate-good production will be saved in expectation by an additional entrepreneur. We also observe in (11a) that the expected benefit of another entrepreneur depends on the level of basic research expenditures. For example, if  $\eta(0) \approx 0$  implying  $\chi(0) \approx 0$ , an entrepreneur is not as productive in innovating than when working in final good production. Only if the amount of basic research is larger than  $L_{B,min} \equiv \max \{0, \eta^{-1}(1/[m(1-\gamma)])\}$ , where  $\eta^{-1}(\cdot)$  denotes the inverse of  $\eta(\cdot)$ , will an increase in entrepreneurship be favorable for aggregate consumption.<sup>23</sup> Note that  $\frac{\partial L_E}{\partial \tau}$  is clearly non-negative and with  $L_B \geq L_{B,min}$  strictly positive for  $\tau$  in the neighborhood of  $\bar{\tau}$  according to Assumption 1. Consequently, if  $L_B > L_{B,min}$ , the government will increase  $\tau$  to its maximum to make entrepreneurship most attractive. The opposite is the case if  $L_B < L_{B,min}$ . Then the government aims at reducing the number of entrepreneurs to a minimum by setting  $\tau$  to its lowest level.<sup>24</sup> The government's tax policy is indeterminate when  $L_B = L_{B,min}$  and we assume that it sets  $\tau = \bar{\tau}$  in this case. We summarize our finding in the next proposition.

**Proposition 2 (Optimal tax policy)**

*For a given amount of basic research,  $L_B$ , the government levies taxes such that*

$$\tau = \begin{cases} \bar{\tau} & \text{if } L_B \geq L_{B,min} \\ \underline{\tau} & \text{if } L_B < L_{B,min} \end{cases}. \quad (12)$$

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<sup>23</sup>Note that  $L_{B,min}$  is positive by Assumption 1(i) stating that without basic research the entrepreneurs are not as productive in producing labor saving innovations as in working in final good production. This assumption is not necessary for our results in section 5. With  $\chi(0) \geq 1$ , the government would always choose a tax policy  $\tau = \bar{\tau}$  and basic research investments, if positive, will further increase the number of entrepreneurs. The latter is due to the fact that by our specification of the immaterial utility component of entrepreneurship, the corner solution  $L_E = 1$  is precluded.

<sup>24</sup>Note that for  $L_B < L_{B,min}$ , there are typically multiple tax policies that entirely discourage entrepreneurship. For instance, by Assumption 1(ii), for  $L_B = 0$  the government is indifferent between any tax policies  $(t_L, t_P)$  satisfying  $\tau \in [\underline{\tau}, 1]$ . For simplicity, we assume that the government implements  $\underline{\tau}$ , i.e.  $t_L = \underline{t}_L$ ,  $t_P = \bar{t}_P$  in such cases.

We will now determine the optimal basic research investments in the second step of the government's optimization problem. Given Proposition 2, we can split the maximization problem at the second step into one where  $L_B$  is constrained on  $L_B \geq L_{B,min}$  and another for  $L_B < L_{B,min}$ . Regarding the first problem

$$\begin{aligned} \max_{\{L_B \geq L_{B,min}\}} \quad & C(L_B, \tau) = y(L_B, \tau) , \\ \text{s.t.} \quad & \tau = \bar{\tau} , \end{aligned}$$

we obtain the necessary conditions for a maximum

$$\frac{\partial L_E(L_B, \bar{\tau})}{\partial L_B} [\chi(L_B) - 1] + L_E(L_B, \bar{\tau}) \chi'(L_B) - 1 \leq 0 , \quad (13a)$$

$$\frac{\partial L_y(L_B, \bar{\tau})}{\partial L_B} (L_B - L_{B,min}) = 0 . \quad (13b)$$

Marginally increasing basic research investments has three different effects on final good production: First, it improves the innovation prospects of “old” entrepreneurs as reflected by the second term in equation (13a).<sup>25</sup> Second, the increase in innovation prospects attracts additional entrepreneurs as reflected in the first term of equation (13a). Note that by  $L_B \geq L_{B,min}$  (and hence  $\chi(L_B) \geq 1$ ), this rise in entrepreneurship is beneficial for final good production. The optimal choice of  $L_B$  trades-off these gains from investments in basic research against the loss of the marginal unit of labor used in basic research rather than in final good production. This marginal labor cost of basic research is reflected by the term  $-1$  in equation (13a). Let us denote the solution of this constrained maximization problem by  $\tilde{L}_B(\bar{\tau})$ . Note that if  $\tilde{L}_B(\bar{\tau}) > L_{B,min}$ , it will satisfy (13a) with equality.

With respect to the maximization problem constrained by  $L_B < L_{B,min}$ , which implies tax policy  $\tau = \underline{\tau}$ , we can directly infer that the solution will be  $\tilde{L}_B(\underline{\tau}) = 0$ . The reason is that basic research affects consumption only by improving the success probabilities of entrepreneurs. However, for all  $L_B < L_{B,min}$  entrepreneurship negatively affects final output and by Assumption 1 the government is able to deter such inefficient entrepreneurship by not providing basic research.

Consequently, the government decides between implementing the policies  $(\tilde{L}_B(\bar{\tau}), \bar{\tau})$  or  $(0, \underline{\tau})$ . In the first situation with positive basic research and entrepreneurship, we speak of an *entrepreneurial* economy and refer to the second situation without basic research investments and entrepreneurship as a *stagnant* economy. The government implements the

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<sup>25</sup>The term “old” refers to those entrepreneurs that would have chosen entrepreneurship rather than working in production even without the increase in basic research investments.

policy with positive basic research investments and a tax policy favoring entrepreneurship if and only if this leads to higher labor supply in final good production and hence higher consumption vis-à-vis the stagnant economy. In the stagnant economy, labor supply for final good production is given by  $L_y = \bar{L} - m$ . Hence, we observe from Proposition 1 that the government opts for the entrepreneurial economy if and only if it satisfies the following condition

$$-\tilde{L}_B(\bar{\tau}) + \left[ 1 - \frac{1}{\bar{\tau}b\chi(\tilde{L}_B(\bar{\tau}))} \right] \left[ \chi(\tilde{L}_B(\bar{\tau})) - 1 \right] \geq 0. \quad (\text{PLS})$$

We can now characterize the optimal policy schemes as follows:

**Proposition 3**

*Suppose the government maximizes aggregate consumption using  $(t_L, t_P, t_H, L_B)$  as policy instruments. Then:*

- (i) *If and only if condition (PLS) is satisfied, there will be an entrepreneurial economy with  $\tau^* = \bar{\tau}$ ,  $L_B^* = \tilde{L}_B(\bar{\tau})$  and  $L_E = 1 - \frac{1}{\bar{\tau}b\chi(\tilde{L}_B(\bar{\tau}))}$ .*
- (ii) *Else, there will be a stagnant economy with  $\tau^* = \underline{\tau}$ ,  $L_B^* = 0$  and  $L_E = 0$ .*

We next analyze condition (PLS) more closely in order to deduce when an entrepreneurial economy is likely to be optimal.

**Corollary 1**

*Suppose the government maximizes aggregate consumption using  $(t_L, t_P, t_H, L_B)$  as policy instruments. Then, the higher  $m$ ,  $b$ , and  $\bar{\tau}$ , and the lower  $\gamma$ , the more likely it is that an entrepreneurial economy is optimal.*

The proof of Corollary 1 is given in Appendix C.3. Corollary 1 implies that the more valuable innovations are, i.e. the higher is  $m$  and the lower is  $\gamma$ , the more likely it is that we will observe an entrepreneurial economy. Further, an entrepreneurial economy is the more likely the higher is the maximum admissible level of  $\tau$ ,  $\bar{\tau}$ , and the higher are the utility benefits (the lower are the utility cost) derived from becoming an entrepreneur, i.e. the higher is  $b$ . Intuitively, the higher  $\bar{\tau}$  and  $b$ , the higher is the number of entrepreneurs that are willing to take up basic research investments in the entrepreneurial economy and hence the more attractive are entrepreneurial policies.

Note that with lump-sum taxes, separating the choice of  $L_B$  from that of the ratio between labor and profit taxes as captured in  $\tau$  was feasible.<sup>26</sup>

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<sup>26</sup>Upon request, we provide a proof that the pecking order result also holds when lump-sum taxes or

## 6 The Political Economy of Financing Basic Research

So far, we have taken the viewpoint of a government seeking to maximize aggregate consumption, without caring about distributional effects. Our analyses of the previous sections suggest that innovation stimulating investments in basic research should be complemented by a pecking order of taxation. However, such innovation policies might have substantial distributional effects that will leave a share of individuals worse off under an entrepreneurial policy vis-a-vis a stagnant economy. It is therefore not obvious that a change to an entrepreneurial policy can be supported politically. In this section we explore these distributional effects and characterize when policies fostering entrepreneurship are politically viable.

In our framework, the government has two main policy areas at its discretion to foster entrepreneurship and innovation in the economy: basic research and tax policy. These policies have direct distributional effects: (a) labor income and profit taxes allow for redistribution of wealth between workers on the one hand and entrepreneurs and shareholders of the final good producer on the other hand. (b) Basic research investments have a direct effect on entrepreneurs by improving their chances of success. However, these direct effects are accompanied by important general equilibrium feedback effects. In particular, basic research investments support labor-saving technological progress in the intermediate good sectors. As a consequence of innovations, labor is set free in the intermediate good sectors and additionally supplied to final good production. This increases output and the profits of the representative final good producer but lowers wages.<sup>27,28</sup> Hence, while ownership in

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transfers are not available.

<sup>27</sup>These implications are consistent with the common trend across industrialized economies that labor income - in particular labor income of low skilled workers - as a share of total value added is decreasing over time. Timmer et al. (2010), for example, show that for the European Union workers' share in total value added decreased from 72.1% in 1980 to 66.2% in 2005. In the US, this share decreased from 66.8% to 63.2%. At the same time, the share of high-skilled workers' income in total value added increases rapidly over time: In the EU, this share increased from 8.3% in 1980 to 16.0% in 2005, whereas in the US it increased from 18.5% to 30.4%.

<sup>28</sup>With divisible intermediate goods, labor saving technological progress in the intermediate good sector would not result in a decrease in wages. Still, there would be a conflict between efficiency and equality in our economy as discussed here, at least if innovations are non-drastic as in Acemoglu et al. (2006): With divisible intermediates, an innovating entrepreneur would preferably charge a price  $p_i = \frac{mw\gamma}{\alpha}$ . For  $\gamma > \alpha$  this is not feasible due to competition from the standard technology and the innovating entrepreneur sets price  $p_i = mw$  instead. In that sense innovations are *non-drastic*.  $p_i = mw \forall i$ , implies that  $w = [1 - \alpha]^{(1-\alpha)} \left[\frac{\alpha}{m}\right]^\alpha$  and hence the wage rate is independent of the innovation step  $\gamma$  in the economy. Intuitively, wages depend on the marginal product of labor in final good production and hence on the ratio of labor to intermediates. With constant intermediate good prices, this is the same irrespective of the production technology in the intermediate good sector. The monopoly distortion in the intermediate good sector prevents the introduction of more intermediate good-intense production processes in final good production and hence

the final-good firm is irrelevant for the consumption maximizing policies, it is crucial for the distributional effects of such policies.

## 6.1 The political set-up

In our political economy analysis, we focus on a politically decisive individual, whom we refer to as the median voter, and ask whether the median voter's preferred policy will be an entrepreneurial policy or a stagnant policy. We assume that the median voter is an employee (i.e. worker in final or intermediate good production or basic researcher) with  $\hat{s}$  shares of the final-good producer.<sup>29</sup> Consequently, her after tax income is

$$I = (1 - t_L)w + (1 - t_P)\hat{s}\pi_y - t_H.$$

We argue that an entrepreneurial policy is politically viable if the median voter prefers some entrepreneurial policy over the stagnant economy, that is, if her income is larger in the entrepreneurial economy than in the stagnant economy. Several interpretations apply to this set-up. Ordering voters according to their shares in final good production, we may interpret the decisive individual as the voter with the median amount of shares whose preferred policy will be adopted as the platform of two parties in a Downsian framework of party competition. In Appendix B.2, we rationalize this interpretation within our model set-up. Moreover, the political process might be influenced by lobbying activities or other forms of political influence such that the decisive individual differs from the individual with the median amount of shares. Our political economy analysis is flexible enough to accommodate such settings by adjusting the share holdings  $\hat{s}$  under consideration.

Of course, since relative to a stagnant economy, an efficient entrepreneurial policy means falling wages and increasing final good profits, the median voter will support an entrepreneurial

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a higher marginal product of labor. Note that with constant gross wages, a conflict between equality and efficiency follows from tax policies: in the entrepreneurial economy, workers contribute to the provision of basic research and hence end-up with lower net wages than in the stagnant economy where government spendings are zero. Obviously, with constant returns to scale and divisible intermediates, the final-good producer earns zero profits and benefits from innovation accrue with the successful entrepreneurs. Hence, shareholdings in the final-good firms do not matter for the distribution of the gains from innovation.

<sup>29</sup>Of course, this includes the special case where the median voter is a worker without any stocks. For example, a fraction  $\frac{1}{2} < \mu < 1$  of the population are workers who do not own shares in the final good producer. The situation with a majority of the population being workers who are not engaged in the stock market is in line with empirical evidence on stock market participation rates. For example, Guiso et al. (2008) show for a selection of 12 OECD member states percentages of households that are engaged in the stock market. Even if indirect shareholdings are also considered, Sweden is the only country where a majority of households is engaged in the stock market with most countries having a share of households that is engaged in the stock market of less than one third.

economy if she possesses a sufficient amount of shares of the final good firms. The more realistic and interesting case is when income is skewed such that the median voter possesses less than the per capita claims on final good profits. In particular we assume that  $\hat{s} \in \left[0, \frac{1}{L+(1-\gamma)m}\right)$ , which implies that the median voter's gross income,  $w + \hat{s}\pi_y$  decreases in aggregate output.<sup>30</sup> The resulting trade-off follows immediately: In the stagnant economy, wages are higher and the median voter can maximally redistribute profits without considering incentives for occupational choice by potential entrepreneurs. On the other hand, the tax base is higher in an efficient entrepreneurial economy, potentially allowing for higher redistributive transfers even if profit tax rates are lower. For this reason, an entrepreneurial economy might be preferred to a stagnant economy with maximal profit tax.

We also note that we restrict our analysis in two ways: first, we do not consider inefficient entrepreneurial policies where larger entrepreneurship leads to lower output; second, we focus on lump-sum redistribution and leave considerations regarding targeted transfers to only a fraction of workers for future research.<sup>31</sup> To simplify the exposition, we furthermore assume common tax bounds for labor income and for profit taxes. That is, we assume  $\bar{t}_P = \bar{t}_L = \bar{t} \in [0, 1 - \varepsilon]$  and  $\underline{t}_P = \underline{t}_L = \underline{t} \in [0, 1 - \varepsilon]$  for some arbitrarily small  $\varepsilon > 0$  and  $\bar{t} \geq \underline{t}$ . Consequently,  $\tau \in [\underline{\tau}, \bar{\tau}] \equiv \left[\frac{1-\bar{t}}{1-\underline{t}}, \frac{1-\underline{t}}{1-\bar{t}}\right]$  and  $\bar{\tau} < \infty$ .

The trade-off faced by the median voter as described previously can be captured in a nice way by separating the two parts of the median voter's income: gross earnings and net transfers.

$$I = (1 - t_L)w + (1 - t_P)\hat{s}\pi_y - t_H = w + \hat{s}\pi_y + NT, \quad (14)$$

where  $w + \hat{s}\pi_y$  reflects the median voter's gross income and  $NT = -t_H - t_Lw - t_P\hat{s}\pi_y$  denotes net transfers to her. We obtain the lump sum tax,  $t_H$ , from the government's budget constraint as

$$t_H = \frac{1}{\bar{L}} \left[ -t_Lw (\bar{L} - L_E) - t_P (\pi_y + \eta(L_B)L_E\pi_{xm}) + wL_B \right]. \quad (15)$$

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<sup>30</sup>Note that when the population is ordered according to shareholdings in the final-good sector, we must have  $\hat{s} \in \left[0, \frac{2}{\bar{L}}\right]$ .

<sup>31</sup>Analytically we remain within the framework introduced in section 5.2. Note that without lump-sum taxes, redistribution via tax policies is no longer feasible and it turns out that an aggregate output stimulating entrepreneurial economy is no longer supported by the median voter if shareholdings are sufficiently skewed. In particular, the median voter will always prefer the stagnant economy over the entrepreneurial economy if he owns less than a fraction  $\frac{\bar{L}}{L+(1-\gamma)m}$  of the per-capita shares in the final good producer. Intuitively, in the proof of Proposition 5 we argue that in this case the gross income of the median voter is decreasing in aggregate output and hence he can be no better off in the entrepreneurial economy than in the stagnant economy with  $t_L = t_P = 0$ . We note that the condition discussed here is sufficient but never necessary for our result.

An important observation is that for given basic research investments, the level of entrepreneurship and production is determined only by the ratio of tax rates,  $\tau = \frac{1-t_P}{1-t_L}$ , but not by the absolute values of tax rates. Hence, the median voter's gross income is uniquely determined by the choices of  $\tau$  and  $L_B$ . The levels of the labor and profit tax rates only matter for the degree of redistribution as apparent when inserting the lump sum transfers (15) into the formula for the net transfers  $NT$ .<sup>32</sup> As a consequence, we can determine the median voter's most preferred policy by the following procedure: First, we derive the optimal amount of redistribution by choosing the levels of  $t_L$  and  $t_P$  for given  $\tau$  and  $L_B$ . This will allow us to write the median voter's objective as a function of  $\tau$  and  $L_B$  and consequently to determine the median voter's most preferred levels of  $\tau$  and basic research investments  $L_B$ .

## 6.2 Implementability of entrepreneurial policies

We discuss the median voter's maximization problem in detail in Appendix B.2. Of course, the first step in the optimization problem (for given  $\tau$  and  $L_B$ ) aims at setting  $t_L$  and  $t_P$  to maximize net transfers  $NT$ . In particular, in the typical case we observe that the median voter will either push  $t_L$  or  $t_P$  to its boundary  $\bar{t}$ . As a consequence, for any policy  $\tau, L_B$ , the level of redistribution that can be realized is constrained by the economy's upper bound on tax rates, which, as discussed in the introduction, might be constitutional in nature or reflecting the state's capacity to collect taxes. Intuitively, any efficient entrepreneurial economy involves a welfare loss for the median voter that needs to be compensated by transfers to be politically viable. Whether the transfers are sufficiently large depends crucially on the upper bounds of taxation. As stated in the following proposition, any efficient entrepreneurial policy can be supported by sufficient redistribution when  $\bar{t}$  is close enough to one.

### Proposition 4

*If there exists an entrepreneurial economy  $(\hat{\tau}, \hat{L}_B)$  with higher aggregate output than a stagnant economy, then there also exists a constitutional upper limit of tax rates  $\bar{t}$  such that  $\hat{\tau} \in [\underline{\tau}, \bar{\tau}]$  and the median voter will prefer the entrepreneurial policy over a stagnant*

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<sup>32</sup>Substituting the profits by their equilibrium values as provided in Proposition 1 we obtain for the net transfers to the median voter

$$NT = \frac{w}{\bar{L}} \left[ t_P \left[ \left( \frac{\alpha}{1-\alpha} L_Y - m \right) (1-s) + \chi(L_B)L_E \right] - t_L L_E - L_B \right], \quad (16)$$

where  $s = \hat{s} * \bar{L}$  denotes the share of labor employed in intermediate good production in the stagnant economy.

economy.

A formal proof is given in Appendix C.5. The intuition is straightforward: with  $\bar{t}$  sufficiently close to 1, it is feasible to implement any  $\tau$  with  $t_P$  close to 1. Hence, all profits can effectively be redistributed in the entrepreneurial economy via the lump-sum transfer, allowing all workers to benefit from the increase in aggregate output.

The main insight of Proposition 4 is that incentives for entrepreneurship by a high value of  $\tau$  as well as redistribution of profits by a sufficiently high value of  $t_P$  can be reconciled, if the upper boundary on tax rates is very close to 1. However, if the upper and lower bounds on taxation are too low, providing both incentives for economic feasibility and redistribution for political viability of an entrepreneurial economy will not be possible.

**Proposition 5**

*Let  $\underline{t} = 0$ . If  $\bar{t}$  is sufficiently low, the median voter will support a stagnant economy.*

A proof of Proposition 5 is given in Appendix C.6. Intuitively, for sufficiently restrictive tax bounds, redistribution of profits via the lump-sum taxes can no longer compensate for the decrease in labor income associated with the entrepreneurial economy and the median voter prefers the stagnant economy.

Using the results in Propositions 4 and 5, we will now argue that for every efficient entrepreneurial policy, there exists a unique level of  $\bar{t}_c$  such that the policy is politically viable in an economy with  $\bar{t} \geq \bar{t}_c$  but not implementable if  $\bar{t} < \bar{t}_c$ .<sup>33</sup> Consequently, if we consider the entire set of efficient entrepreneurial policies, each associated with a unique  $\bar{t}_c$ , we will be able to determine the infimum  $\bar{t}_{inf} = \inf \bar{t}_c$ . This infimum of critical upper tax bounds is particularly interesting as it tells us that an economy will only be able to escape a stagnant policy regime if its constitutional upper bound on taxes, respectively its state capacity, is sufficiently large to satisfy  $\bar{t} \geq \bar{t}_{inf}$ .

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<sup>33</sup>More formally, let  $\underline{t} = 0$  and  $s \leq \frac{\bar{L}}{L+(1-\gamma)m}$  and fix any entrepreneurial policy  $(\hat{\tau}, \hat{L}_B)$  with  $\hat{L}_y \geq L_y^S$ . Proposition 4 implies that this entrepreneurial economy is preferred over the stagnant economy by the median voter if  $\bar{t}$  is sufficiently high. Proposition 5 implies that this is no longer the case if  $\bar{t}$  is sufficiently low. In principle, there are two possibilities why this might happen: First,  $\bar{t}$  might prevent sufficiently large transfers to the median voter. Second, for  $\bar{t}$  too low  $\hat{\tau}$  might no longer be available, i.e. we might have  $\hat{\tau} \notin [\underline{\tau}, \bar{\tau}]$ . Let us say that the entrepreneurial economy  $(\hat{\tau}, \hat{L}_B)$  is feasible in the median voter framework if  $\hat{\tau} \in [\underline{\tau}, \bar{\tau}]$  and if it is preferred over the stagnant economy by the median voter. Then, for every such entrepreneurial economy there must exist a threshold value  $\bar{t}_c^l$  such that the entrepreneurial economy is no longer feasible if  $\bar{t} < \bar{t}_c^l$  and a threshold value  $t_c^u$  such that the entrepreneurial economy is feasible if  $\bar{t} \geq t_c^u$ . We summarize these insights in the following Proposition and show that these two threshold values coincide. Note that in principle,  $I^E - I^S$  may be non-monotonous and hence we might have  $\bar{t}_c^l \neq \bar{t}_c^u$ .

**Proposition 6**

Let  $\underline{t} = 0$ . For any efficient entrepreneurial policy  $(\hat{\tau}, \hat{L}_B)$ , there exists a critical value  $0 < \bar{t}_c < 1$  such that  $\hat{\tau} \in [\underline{\tau}, \bar{\tau}]$  and the median voter will prefer the entrepreneurial policy over the stagnant economy if and only if  $\bar{t} \geq \bar{t}_c$ .

The proof of Proposition 6 is given in Appendix C.7.

From Proposition 6, we immediately obtain the following Corollary.<sup>34</sup>

**Corollary 2**

The median voter will opt for an efficient entrepreneurial economy if and only if  $\bar{t} \geq \bar{t}_{inf}$ . Else, the median voter supports the stagnant economy.

Note that  $\bar{t}_{inf} > 0$  follows directly from Proposition 5. Corollary 2 implies that entrepreneurial policies are precluded if upper tax bounds are too low and the society is “trapped” in a stagnant economy. An interesting implication of our result is that oftentimes upper bounds on taxation specified in the constitution are intended to protect against expropriation, in particular to protect the wealthy members of society. Our analysis suggests that such policy instruments need not always be efficient. While for a *given* policy choice  $\tau, L_B$ , workers with large shareholdings (i.e.  $\tilde{s} > 1 - \frac{L_E[\chi(L_B) - \frac{1}{\tau}]}{\frac{\alpha}{1-\alpha}L_Y - m}$ ) prefer having a low upper tax bound,<sup>35</sup> this is not necessarily the case if the policy choice  $\tau, L_B$  is determined in the political process. As Corollary 3 shows, wealthy households with at least as many shares as the median voter may prefer having a higher  $\bar{t}$  in this case.

**Corollary 3**

Consider two upper tax bounds  $\bar{t}_h$  and  $\bar{t}_l$  satisfying  $\bar{t}_h > \bar{t}_{inf} > \bar{t}_l$ . Then, we can always find parameter values such that the wealthy households with shareholdings  $\tilde{s} > s$  prefer living in an economy with  $\bar{t}_h$  over living in an economy with  $\bar{t}_l$ .

Corollary 3 follows immediately from considering the limiting case of  $\bar{L} = \frac{m}{\alpha}$ . Then, the final good producer earns 0 profits in the stagnant economy and shareholdings are worthless, irrespective of tax policies. Corollary 1 implies that the median voter with  $s$  shares prefers any  $\bar{t} \geq \bar{t}_{inf}$  over any alternative  $\bar{t} < \bar{t}_{inf}$ . As all individuals with shareholdings larger than  $s$  will benefit even more from the profits accruing in an entrepreneurial economy, they will also prefer  $\bar{t}_h > \bar{t}_{inf}$ .<sup>36</sup>

<sup>34</sup>Remember that we disregard policies with inefficient entrepreneurship and / or basic research.

<sup>35</sup>The result follows from the fact that by equation (23) their net transfers decrease in  $t_P$ .

<sup>36</sup>A formal argument that all individuals with larger shareholdings than the median prefer an entrepreneurial economy if the median does is provided in Appendix B.2.

Such unintended harmful effects are not limited to constitutional tax bounds but may also apply to alternative means of protecting against excessive taxes. In particular, in our model supermajority rules might have similar effects.<sup>37</sup> In the proof of Proposition 3 we have shown that the difference between a worker’s income in an entrepreneurial economy and the stagnant economy is increasing in the worker’s shareholdings. Therefore, some entrepreneurial economies that are supported by the median voter may not be supported by voters with less shares and hence may not pass supermajority requirements. It follows that for  $\bar{t}$  given, a society with supermajority requirements may be “trapped” in a stagnant economy whereas an entrepreneurial economy would be politically feasible in the median voter framework. In Appendix B.3, we illustrate our political economy results with a numerical example.

### 6.3 Discussion

In this section we have analyzed the political economy of financing basic research investments. The political process implies that tax policies can be inefficient, in the sense that aggregate output is not maximal, if the income distribution (in our case the distribution of shareholdings) is skewed to the right as in the classical result by Romer (1975), Roberts (1977), and Meltzer and Richard (1981). However, in our model such inefficiencies can arise both at the extensive and at the intensive margin: if bounds on taxation are too restrictive, then the median voter prefers a stagnant economy over any growth stimulating entrepreneurial policy and his policy choice is inefficient at the extensive margin. If by contrast his preferred policy choice is an entrepreneurial policy, then inefficiency arises vis-à-vis the optimal policies at the intensive margin: The inefficiency follows immediately from the fact that  $t_P = 0$  in the aggregate consumption maximizing entrepreneurial policy which can never be optimal from the point of view of the median voter. Both inefficiencies are the more severe, the less shares the median voter possesses, i.e. the more skewed the income distribution. However, if  $\bar{t} \rightarrow 1$ , then the inefficiencies generally become arbitrarily

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<sup>37</sup>Several US states have supermajority rules for tax increases (cf. National Conference of State Legislatures (2010); Gradstein (1999) provides a historic overview). Similar clauses have also been proposed at the federal level in the past, but have not been accepted (cf. Knight (2000)). These supermajority rules have also been addressed in the literature. Gradstein (1999) rationalizes them as a precommitment device for a benevolent government in a model with time-leading private productive investments. In his model, supermajority rules can help resolving the time-inconsistency in the government’s preferences which post-investment would like to ignore the adverse effects of taxation on private investment. Knight (2000) presents US-based evidence suggesting that supermajority requirements do indeed have a dampening effect on taxes.

small, irrespective of the median voter's shareholdings.<sup>38</sup>

The inefficiency also concerns basic research investments. Consider any choice of labor income and profit taxes,  $\hat{t}_L, \hat{t}_P$ , such that  $\hat{L}_B = \tilde{L}_B(\hat{\tau}) > 0$ , i.e. such that given this tax policy it is socially desirable to invest in basic research.<sup>39</sup> Then,  $\frac{\partial L_y}{\partial L_B} \Big|_{\hat{t}_L, \hat{t}_P, \hat{L}_B} = 0$  but  $\frac{\partial L}{\partial L_B} \Big|_{\hat{t}_L, \hat{t}_P, \hat{L}_B} \neq 0$  in general. For  $\hat{\tau} \geq 1$ , this can be shown analytically.<sup>40</sup> Interestingly, with the median voter investing less than the social optimum in basic research, the political equilibrium can help explaining the surprisingly high rates of return to public (basic) research typically found in empirical studies.<sup>41</sup>

With bounds on taxation being at center stage in our model, these results also have important implications for constitutional design. For example, which tax bounds would be chosen by individuals behind the veil of ignorance in our framework? While answering this question comprehensively involves an additional analysis, suppose for simplicity that the only uncertainty individuals face behind the veil of ignorance is their own amount of shares they will possess. When knowing that after the resolution of the uncertainty the median voter will exhaust her possibilities to maximize net transfers, a tax bound close to one will be implemented in the constitution. First, this high tax bound will guarantee each individual her expected income before lifting the veil of ignorance and second will be able to resolve the conflict between efficiency and redistribution which is present for lower constitutional tax bounds.<sup>42</sup>

An alternative view on the upper bounds on taxation is to interpret them as a reduced form for fiscal capacity as in Besley and Persson (2009) and Acemoglu (2005). Then, our model provides a new and intuitive political economy rationale for why weak fiscal capacity might have a detrimental effect on economic growth: In the absence of strong fiscal capacities and with imperfect trickle-down-effects of growth oriented supply-side policies, it may not be viable to sufficiently redistribute the gains from innovation for a majority of the population to support such policy changes.

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<sup>38</sup>This is not necessarily the case if the median voter can earn more than  $\bar{y}_{opt}$ , the per capita income in the aggregate production maximizing entrepreneurial economy.

<sup>39</sup>Remember that we limit attention to efficient entrepreneurial economies. Given any  $\hat{t}_L, \hat{t}_P$  such that  $\hat{L}_B = \tilde{L}_B(\hat{\tau}) = 0$  no such economy exists.

<sup>40</sup>Suppose by contradiction that the median voter invests  $L'_B > \tilde{L}_B(\hat{\tau})$  in basic research. Note that for  $L_B = 0$  we have  $L_y(0, \hat{\tau}) \leq L_y^S$  and that by assumption we have  $L_y(L'_B, \hat{\tau}) \geq L_y^S$ . Then, by continuity of  $y$  in  $L_B$  and by the optimality of  $\tilde{L}_B(\hat{\tau}) \exists \check{L}_B < L'_B$  such that  $L_y(\check{L}_B, \hat{\tau}) = L_y(L'_B, \hat{\tau})$ . Now, the median voter's gross income is the same for both choices of  $L_B$ . However,  $\chi(L'_B) > 1$  and  $\hat{\tau} \geq 1$  imply that net transfers are larger for  $\check{L}_B$  than for  $L'_B$ , a contradiction to  $L'_B$  being optimal for the median voter.

<sup>41</sup>Cf. Salter and Martin (2001), for example.

<sup>42</sup>The detailed argument will be provided upon request.

## 7 Conclusions

We have outlined a rationale for a pecking order of taxation to finance basic research investments, thus presenting a new perspective on the theory of optimal income taxation. We then have assumed a political economy perspective and characterized the conditions under which the optimal taxation scheme is politically viable. In particular, our political economy analysis suggests that entrepreneurial policies might harm workers with little shareholdings. We have shown that upper bounds on taxation - explicitly specified in the constitution or implicitly arising from fiscal institutions - can undermine the political support for growth stimulating policies. Hence, our analysis provides a political economy rationale for why weak fiscal capacities are associated with low income levels in the future: The political process tends to result in inefficient policies vis-à-vis the social optimum. This inefficiency includes the amount of basic research investments which tends to be too low. Our work may therefore also explain the surprisingly high rates of return to public investments in (basic) research frequently found in empirical studies. The above findings have further implications for the design of tax constitutions: While upper bounds on taxation are sometimes proposed as a means for protecting investors from excessive indirect expropriation, the mechanisms considered here suggest that such measures might be efficient only *given* growth policies. If growth policies are subject to the political process, they might actually harm the firm owners they are meant to protect.

Future work might combine tax policies with alternative means of fostering innovative entrepreneurship such as patent protection, for example. With such additional policy instruments, the burden of stimulating entrepreneurship in the economy with tax policies is lower, potentially allowing for more egalitarian policies. It would also be interesting to further integrate our analysis of optimal financing of basic research investments into the theory on optimal taxation in the tradition of Mirrlees (1971). With concave utilities and traditional supply side effects of labor income taxation, optimal policies would account for losses in aggregate utility from income inequality and for potential adverse effects on labor supply. These additional equity- / efficiency trade-offs might push optimal tax policies towards a more egalitarian economy. Finally, in the presence of incomplete markets, concave utilities might also allow for additional beneficial effects of basic research on entrepreneurship and thus innovation in the economy as basic research can reduce idiosyncratic risks. While some of these extensions might mitigate the effects considered here, we believe that the underlying mechanisms are still at play and that they need to be taken into consideration when analyzing growth policies, both from a normative and from a positive perspective.

# Appendix

## A Robustness of Pecking Order of Taxation

In this section we analyze the case of a government that aims to maximize aggregate utility rather than aggregate consumption. In our model, aggregate utility,  $W$ , is given by

$$W = (1 - t_P)\pi_y + \int_0^{L_E} (1 - t_P)\lambda_k\eta(L_B)\pi_{xm} - t_H dk + \int_{L_E}^{\bar{L}} (1 - t_L)w - t_H dk . \quad (17)$$

Combining (17) with the government budget constraint, (4), the labor market clearing condition, (7), and the aggregate income identity,  $y = \pi_y + \eta(L_B)L_E\pi_{xm} + (L_x + L_y)w$ , yields

$$W = y + (1 - t_P)\eta(L_B)\pi_{xm} \int_0^{L_E} \lambda_k - 1 dk .$$

Substituting  $y$  and  $\pi_{xm}$  by their respective equilibrium values given in part (i) of Proposition 1 and solving the integral using  $\lambda_k = (1 - k)b$  it follows

$$W = L_y^{1-\alpha} + (1 - t_P)\chi(L_B)(1 - \alpha)bL_y^{-\alpha}L_E \left[ 1 - \frac{1}{b} - \frac{L_E}{2} \right] . \quad (18)$$

The government's decision problem is to maximize (18) subject to the non-negativity constraint of the final good producer and equilibrium conditions (1) and (3) given in Proposition 1.

Comparing the expression for aggregate welfare given in equation (18) with the expression for aggregate consumption given in equation (10) it becomes apparent that aggregate welfare corresponds to aggregate consumption plus the immaterial benefits (cost) of entrepreneurs. This immaterial utility term is scaled by  $(1 - t_P)$ , i.e. profit taxes allow the government to directly affect this term. So when maximizing aggregate welfare, not only the relative size of  $(1 - t_P)$  compared to  $(1 - t_L)$  matters, but also its absolute size. The imposition of labor income taxes affects the occupational choice of potential entrepreneurs and hence the equilibrium number of entrepreneurs that exploit the basic research provided. The imposition of profit taxes also influences the occupational choice of potential entrepreneurs, but in addition affects the utility received by those who opt to become entrepreneurs. Proposition 7 shows that this implies that in any welfare optimum with strictly positive entrepreneurship at least one tax measure is located at the boundary of its feasible set. The intuition is that for any strictly interior combination of tax measures, there is a continuum of

combinations of  $t_L$  and  $t_P$  yielding the same  $\tau$  and hence the same level of entrepreneurship in the economy. Now, if for a given  $\tau$  the immaterial utility term in the aggregate welfare is positive, then the welfare maximizing combination of  $t_L$  and  $t_P$  yielding this  $\tau$  is the  $t_P$ -minimizing which requires that either  $t_L = \underline{t}_L$  or  $t_P = \underline{t}_P$  or both. A similar argument reveals that either  $t_L = \bar{t}_L$  or  $t_P = \bar{t}_P$  or both if the immaterial utility term in the aggregate welfare is negative. The case where the aggregate immaterial utility term is exactly equal to zero is somewhat more involved. The intuition here is that in this case aggregate welfare reduces to aggregate consumption which we have shown previously to be maximized at either  $\bar{\tau}$  or  $\underline{\tau}$ .

**Proposition 7**

*Let  $(t_L^*, t_P^*, L_B^*)$  be a welfare optimum such that  $\tau^* := \frac{1-t_P^*}{1-t_L^*} > \frac{1}{\chi(L_B^*)b}$ . Then at least one tax measure is at the boundary of its feasible set, i.e.  $t_P^* = \underline{t}_P$ ,  $t_P^* = \bar{t}_P$ ,  $t_L^* = \underline{t}_L$  or  $t_L^* = \bar{t}_L$ .*

The proof of Proposition 7 can be found in appendix D. It implies that no interior optimum exists for tax policies. We next characterize the optimal tax policy for a given  $L_B$  in more detail. Consider the expected marginal reduction of labor used in intermediate good production from marginally increasing the measure of entrepreneurs:  $\chi(L_B)$ .  $\chi(L_B) \gtrless 1$  has three important implications for the welfare optimal policy: First,  $\chi(L_B) \gtrless 1$  determines whether increasing the number of entrepreneurs,  $L_E$ , increases or decreases in expectation the labor available for final good production,  $L_y$ , and hence output of the final good. From this it follows that  $\chi(L_B) \gtrless 1$  determines whether or not increasing the number of entrepreneurs rises the monopoly profits of successful entrepreneurs and hence escalates the immaterial utility from being entrepreneur. In particular, if  $\chi(L_B) > 1$ , then monopoly profits decrease with entrepreneurship in the economy which dampens the immaterial utility of each entrepreneur and hence aggregate immaterial utility in the economy. Finally, for  $b \geq 1$ ,  $\chi(L_B) \gtrless 1$  determines whether given tax neutrality, i.e.  $t_L = t_P$ , the marginal entrepreneur earns positive or negative immaterial utility from being entrepreneur.

As we have argued previously, depending on whether or not the immaterial utility term in the aggregate welfare is positive, it is optimal to either implement the desired  $\tau$  in the  $t_P$ -minimizing or the  $t_P$ -maximizing way. We now take on the opposite viewpoint and consider the optimal level of  $\tau$  given  $t_P$  and show that tax neutrality, i.e. a tax policy satisfying  $t_L = t_P$ , is not welfare maximizing in general.

For  $t_P$  given,  $\tau$  is determined by  $t_L$  which only affects entrepreneurship in the economy. In particular, the following relationship between the marginal effect of labor income taxes and

entrepreneurship on aggregate welfare holds

$$\frac{\partial W}{\partial t_L} = \begin{cases} \frac{\partial W}{\partial L_E} \frac{1}{(1-t_P)\chi(L_B)b} & , \quad \text{if } \frac{1-t_L}{(1-t_P)\chi(L_B)b} \leq 1 \\ 0 & , \quad \text{if } \frac{1-t_L}{(1-t_P)\chi(L_B)b} > 1 . \end{cases}$$

We will make use of this close relationship between  $\tau$ ,  $t_L$ , and  $L_E$  for  $t_P$  and  $L_B$  given and analyze welfare effects of entrepreneurship directly which yields the most insights. The partial derivative of  $W$  with respect to  $L_E$  is given by

$$\frac{\partial W}{\partial L_E} = (1-\alpha)L_y^{-\alpha} \left\{ (\chi(L_B) - 1) + (1-t_P)\chi(L_B)b \left[ \left(1 - \frac{1}{b} - L_E\right) - \alpha(\chi(L_B) - 1)L_y^{-1} \left(1 - \frac{1}{b} - \frac{L_E}{2}\right) L_E \right] \right\} .$$

Rearranging terms yields

$$\begin{aligned} \frac{\partial W}{\partial L_E} &= - (1-\alpha)L_y^{-\alpha} + (1-\alpha)L_y^{-\alpha}\chi(L_B)b(1-L_E) \\ &\quad - t_P(1-\alpha)L_y^{-\alpha}\chi(L_B)b \left(1 - \frac{1}{b} - L_E\right) \\ &\quad - (1-t_P)\alpha(1-\alpha)L_y^{-1-\alpha}\chi(L_B)b(\chi(L_B) - 1) \left(1 - \frac{1}{b} - \frac{L_E}{2}\right) L_E . \end{aligned} \quad (19)$$

Equation (19) characterizes the trade-offs faced by the social planner when considering to marginally increase entrepreneurship in the economy. It reveals why tax neutrality, i.e.  $t_L = t_P$ , is not welfare maximizing in our economy in general.

The first summand represents the marginal product of labor used in final good production - which corresponds to the pre-tax wage in equilibrium,  $(1-\alpha)L_y^{-\alpha}$  - lost as the marginal entrepreneur is not available for the labor market anymore.  $(1-\alpha)L_y^{-\alpha}\chi(L_B)b(1-L_E)$  is the pre-tax expected utility that this marginal entrepreneur can earn. Assume tax neutrality, then the first two summands exactly reflect the trade-off faced by the marginal entrepreneur and hence they cancel. To see this, note that under tax neutrality each potential entrepreneur  $k$  compares his pre-tax wage earned in the labor market,  $(1-\alpha)L_y^{-\alpha}$ , with the pre-tax expected utility from being an entrepreneur,  $(1-\alpha)L_y^{-\alpha}\chi(L_B)b(1-k)$ . The result then follows from  $k = L_E$  for the marginal entrepreneur.

By contrast, the remaining two summands in equation (19) are not 0 in general under tax neutrality.  $-t_P(1-\alpha)L_y^{-\alpha}\chi(L_B)b \left(1 - \frac{1}{b} - L_E\right)$  captures the immaterial utility of the marginal entrepreneur that is lost due to profit taxes. For the occupational choice of the marginal entrepreneur, only the relation of profit to labor income taxes matters, i.e. his choice would remain the same for any  $t_L = t_P$ . Furthermore, with regard to consumption,

for a constant  $\tau$ ,  $t_L$  and  $t_P$  have purely distributional effects which do not matter for aggregate welfare in our economy. However,  $t_P$  does not only decrease expected after-tax profits of the marginal entrepreneur, but also his immaterial utility. This reduction in immaterial utility of the marginal entrepreneur is lost for aggregate welfare. It could be eliminated by having  $t_L = t_P = 0$ .

Still, the last summand would remain. This summand captures the effect of the marginal entrepreneur on equilibrium wages, which affects the immaterial utility earned by all other entrepreneurs. The sign of this effect depends on two different factors: First, on  $1 - \frac{1}{b} - \frac{L_E}{2} \geq 0$  which determines whether this immaterial utility is positive or negative in aggregate. And second, on  $\chi(L_B) - 1 \geq 0$  which determines whether the marginal entrepreneur has a positive or a negative effect on equilibrium wages. This term is not 0 in general for  $t_L = t_P = 0$ .

In summary, we have argued that any given level  $\tau$  should be implemented either in a  $t_P$ -minimizing or in a  $t_P$ -maximizing way and that tax neutrality is not optimal in general. Taken together, these two observations give rise to *pecking orders of taxation* and hence reinforce our main insights from the analysis of aggregate consumption maximizing policies. Proposition 8 establishes the welfare maximizing pecking orders formally, where  $(t_L^*, t_P^*, L_E^*)$  denote again optimal policy choices and  $L_E^*$  denotes the resulting equilibrium level of entrepreneurship in the economy.

**Proposition 8 (Welfare Optimal Pecking Order of Taxation)**

*The welfare optimal tax policy for economies in which entrepreneurs are active can be characterized as follows:*

- (i) if  $L_E^* < \min \left\{ 1 - \frac{1 - \underline{t}_L}{(1 - \underline{t}_P)\chi(L_B^*)b}, 2 \left( 1 - \frac{1}{b} \right) \right\}$ , then  $t_P^* > \underline{t}_P$  and  $t_L^* = \underline{t}_L$ ;
- (ii) if  $1 - \frac{1 - \underline{t}_L}{(1 - \underline{t}_P)\chi(L_B^*)b} < L_E^* < 2 \left( 1 - \frac{1}{b} \right)$ , then  $t_P^* = \underline{t}_P$  and  $t_L^* > \underline{t}_L$ ;
- (iii) if  $2 \left( 1 - \frac{1}{b} \right) < L_E^* < 1 - \frac{1 - \bar{t}_L}{(1 - \bar{t}_P)\chi(L_B^*)b}$ , then  $t_P^* = \bar{t}_P$  and  $t_L^* < \bar{t}_L$ ;
- (iv) if  $L_E^* > \max \left\{ 1 - \frac{1 - \bar{t}_L}{(1 - \bar{t}_P)\chi(L_B^*)b}, 2 \left( 1 - \frac{1}{b} \right) \right\}$ , then  $t_P^* < \bar{t}_P$  and  $t_L^* = \bar{t}_L$ .

A proof that includes all cases, including knife-edge cases, is given in appendix D.

Cases (i) and (iii) of Proposition 8 give rise to a pecking order with profit taxes first in a sense that either  $t_L$  is at its lower bound and  $t_P$  is not or  $t_P$  is at its upper bound and  $t_L$  is not. Conversely, cases (ii) and (iv) give rise to a pecking order with labor income tax first.

Optimal tax policies are driven by the endeavor to implement any preferred  $\tau$  either in a  $t_P$ -maximizing or in a  $t_P$ -minimizing way, as discussed above. In cases (i) and (ii) of

Proposition 8, for example, the aggregate extra (dis)-utility of entrepreneurs is positive ( $L_E^* < 2(1 - \frac{1}{b})$ ) and hence the government seeks to have a minimal  $t_P$  in order not to lose this extra utility and primarily uses  $t_L$  to induce the desired level of entrepreneurship. If entrepreneurship is desirable from a social welfare perspective, the government opts for  $t_L^* > \underline{t}_L$  to incentivize entrepreneurship (case (ii)). If entrepreneurial activity becomes less attractive, the government first responds by decreasing  $t_L$  to discourage entrepreneurship and once  $t_L$  cannot be relied upon any further because it reached its lower bound, it increases  $t_P$ , thereby trading-off the social welfare gain from further discouraging entrepreneurship against the cost of losing some of the extra utility earned by entrepreneurs (case (i)).

We further note that for the two cases that yield the same pecking order according to Proposition 8 the underlying motives are different. Consider for example case (iii) of Proposition 8 as opposed to case (i) which both motivate a pecking order with profit taxes first. Here, the aggregate extra (dis)-utility term of entrepreneurs is negative ( $L_E^* > 2(1 - \frac{1}{b})$ ) and hence the government chooses  $t_P^* = \bar{t}_P$  in order to minimize these welfare losses for any given level  $L_E$ . In addition, it uses  $t_L$  to further discourage entrepreneurship and hence chooses  $t_L < \bar{t}_L$ .

Finally, it is important to note that albeit the just discussed differences between the pecking orders identified, they share the same fundamental motive: The pecking order with profit taxes first is preferable whenever the desired level of entrepreneurship is relatively low. By contrast, the pecking order with labor income tax first is preferable whenever the desired level of entrepreneurship is relatively high. In the setting considered here, a relatively high level of entrepreneurial activity refers to:

- a level larger than the one implied by  $t_L = \underline{t}_L$  and  $t_P = \underline{t}_P$  if aggregate immaterial utility from entrepreneurship is positive (case (ii));
- a level larger than the one implied by  $t_L = \bar{t}_L$  and  $t_P = \bar{t}_P$  if aggregate immaterial utility from entrepreneurship is negative (case (iv)).

We summarize these qualitative results in the following Corollary:

**Corollary 4**

*Suppose the government maximizes aggregate welfare, equation (18), using  $(t_L, t_P, t_H, L_B)$  as policy instruments. Then:*

- (i) *If the welfare optimal level of entrepreneurial activity is relatively high, then the government opts for the pecking order with labor income tax first.*

- (ii) *If the welfare optimal level of entrepreneurial activity is relatively low, then the government opts for the pecking order with profit tax first.*

The welfare optimal level of entrepreneurial activity depends on a variety of different factors. In particular, it depends on the effectiveness of entrepreneurship in terms of labor saved in intermediate good production,  $\chi(L_B^*)$ , and on the immaterial benefits from entrepreneurship as determined by  $b$ .

Proposition 8 limits attention to economies in which entrepreneurs are active, i.e.  $L_E > 0$ . Economically, this is not very restrictive for the purpose of our analysis as in an economy where  $L_E^* = 0$ , trivially  $L_B^* = 0$  combined with any tax policy ensuring that  $L_E^* = 0$  would be welfare maximizing. Proposition 9 analyzes when  $L_E^* > 0$  is welfare optimizing for  $L_B$  given. Whether or not  $L_E^* > 0$  is only interesting for cases where  $L_E = 0$  and  $L_E > 0$  are both feasible and hence attention is limited to these cases.<sup>43</sup>

**Proposition 9**

*Suppose that  $L_B = L_B^*$  and let  $L_E = 0$  and  $L_E > 0$  both be feasible. Then  $L_E^* > 0$ , i.e. for  $L_B^*$  given the welfare maximizing tax policy is one that yields positive entrepreneurship, if*

$$\chi(L_B^*) > \frac{1}{1 + (1 - \tilde{t}_P)(b - 1)}, \quad (20)$$

where

$$\tilde{t}_P = \begin{cases} \min\left(\bar{t}_P, 1 - \frac{1 - \bar{t}_L}{\chi(L_B^*)^b}\right) & \text{if } b \leq 1 \\ \max\left(\underline{t}_P, 1 - \frac{1 - \underline{t}_L}{\chi(L_B^*)^b}\right) & \text{if } b > 1 \end{cases}. \quad (21)$$

A proof of Proposition 9 is given in appendix C.8. Proposition 9 implies quite intuitively that  $L_E^* > 0$  is welfare optimal whenever  $\chi(L_B^*)$  is large, i.e. whenever the expected labor saved for final good production from increasing the number of entrepreneurs is large.

## B Details on Political Economy Analysis

### B.1 Applicability of median voter theorem

In this section, we give sufficient conditions under which the median voter theorem applies in our model framework. We start by elaborating on whether the preferences of the individuals satisfy the single-crossing condition over the policy space.

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<sup>43</sup>We note that in our model feasibility of a given level  $L_E$  does not only require the existence of a combination of tax measures  $t_L$  and  $t_P$  that yield the desired level of entrepreneurial activity given  $L_B$ , but also that this results in non-negative profits of the final good producer.

Let us consider the policy space  $\mathcal{P}$  with policies  $p = (L_B, t_L, t_P, t_H)$  that either reflect a stagnant economy with  $L_B = 0$  or efficient entrepreneurial policies with  $L_B > 0$ . We order the policies according to their implied net final-good profit,  $(1 - t_P)\pi_y$ , such that if  $p_2 > p_1$  then  $(1 - t_P^2)\pi_y^2 > (1 - t_P^1)\pi_y^1$ . Let us order the voters according to their shareholdings. Then the single-crossing condition requires that if  $p > p'$  and  $s < s'$ , or if  $p < p'$  and  $s > s'$ , then from  $EU_s(p) > EU_s(p')$  follows that  $EU_{s'}(p) > EU_{s'}(p')$ . In the condition,  $EU_s(p)$  refers to the expected utility of an individual with shareholdings  $s$  under policy  $p \in \mathcal{P}$ , which can be written as

$$EU_s(p) = (1 - t_L)w - t_H + s(1 - t_P)\pi_y + \mathbb{1}_{k \in [0,1]} \max[(1 - t_P)\pi_{xm}\eta(L_B)(1 - k)b - (1 - t_L)w, 0]. \quad (22)$$

We can immediately see that the single-crossing condition holds for the preferences of the employees, i.e. all individuals without an index  $k \in [0, 1]$ . Consider two policies  $p_1$  and  $p_2$  with  $p_2 > p_1$ , then if a worker with shareholdings  $s_1$  prefers policy  $p_2$ , so will a worker with shareholdings  $s_2 > s_1$ . Further if the person with shares  $s_2$  prefers  $p_1$  over  $p_2$ , so will the individual with shares  $s_1$ . Intuitively, under each policy, the labor income and lump-sum transfers are the same, but the worker with the higher amount of shares benefits more from a policy involving higher net profits in final good production. We summarize this finding in the following lemma.

**Lemma 2**

*The preferences of the individuals with  $k \notin [0, 1]$  satisfy the single-crossing condition over the policy space  $\mathcal{P}$ .*

When we consider the entire set of preferences, that is, including the set of potential entrepreneurs, the single-crossing condition does not hold. This can be illustrated when restricting the vote to one between a stagnant and an entrepreneurial policy, for instance by assuming that the stagnant economy is the status quo which is challenged by an entrepreneurial policy proposal. Recall that for the single crossing condition to hold in this case, the following must be true. If the individual with the median amount of share prefers (disfavors) the entrepreneurial policy, so will all individuals with weakly higher (lower) shareholdings. It follows directly from equation (22) and Lemma 2 that the first statement, which we recall in the next lemma, is satisfied but the statement in parenthesis is not.

**Lemma 3**

*Suppose a worker with shareholdings  $s^*$  prefers an efficient entrepreneurial economy over the stagnant economy. Then, so do all voters with shareholdings  $s \geq s^*$ .*

Intuitively, the higher a worker's shareholdings, the more he can benefit from the increase in final good producer's profits associated with an efficient entrepreneurial economy. (This is implied by Lemma 2.) The result extends to potential entrepreneurs with shareholdings  $s \geq s^*$  as they will all be workers in the stagnant economy. Then, if they remain workers in the entrepreneurial economy, their trade-off is just the same as the one faced by a worker with the same shareholdings. If, by contrast, they opt to become entrepreneurs, they must prefer this option over being worker and the result follows. (This trade-off between becoming an entrepreneur or a worker is captured by the maximum term in equation (22).)

The reverse of Lemma 3 is not true because if a worker with shareholdings  $s$  prefers the stagnant economy, a potential entrepreneur with shareholdings equal to or less than  $s$  will not necessarily support a stagnant economy as well. This can be seen immediately in equation (22) from the fact that the utility gain from being an entrepreneur must be weakly positive.

Hence, regarding votes between a stagnant policy and an entrepreneurial policy the single-crossing condition does not hold for the entire set of preferences. Moreover, note that the single-crossing condition neither holds when voting on two different entrepreneurial policies. The reason is as follows. Suppose that  $p_1 > p_2$  and  $p_2$  involves more entrepreneurship than  $p_1$ . Consider an individual who will be an entrepreneur under both policies. Then the relative expected gain from being an entrepreneur rather than a worker will increase when moving from  $p_1$  to  $p_2$  as  $p_2$  involves higher entrepreneurship, however, the absolute expected gain as depicted in brackets in (22) might decline. Consequently, a worker with shareholdings  $s$  may prefer policy  $p_2$  with higher entrepreneurship, while an entrepreneur with the same or slightly higher shareholdings may prefer policy  $p_1$ .<sup>44</sup>

One way to circumvent the difficulties posed by the preferences of potential entrepreneurs for the application of the median voter theorem is to assume that there is a measure 1 of employees with the same median share of shareholdings among employees. In particular, when ordering employees according to their shareholdings and give each an index beginning with zero for the first individual with the lowest amount of shares up to  $\bar{L} - 1$ , then we require that a measure 1/2 of the employees with the median amount of shares has an index smaller than the median and a measure 1/2 of the employees with the median share has a higher index. If this requirement is satisfied, the single-crossing condition on the set of

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<sup>44</sup>The reason is that the wage rate might decline so much that the absolute expected gain decreases while the relative expected gain, derived by dividing the terms in the bracket in (22) by the wage rate, increases. In this situation there will be more entrepreneurship under  $p_2$ , but the individuals who will be entrepreneurs under both policies will lose in terms of expected utility from entrepreneurship.

employee preferences implies that if the median among the employees prefers a policy  $p_1$  over  $p_2$ , so will either all  $\frac{\bar{L}-1}{2} + \frac{1}{2} = \frac{\bar{L}}{2}$  employees with shareholdings  $s \leq s_m$  or all  $\frac{\bar{L}}{2}$  employees with shareholdings  $s \geq s_m$ . In essence this implies that the votes of the entrepreneurs are not relevant to determine the voting outcome.

In summary, the individual with the median amount of shares among the employees will be the politically decisive individual under the condition that a measure one of employees equally distributed around the median employee will possess the same amount of shares. If this condition is not satisfied, we can state that if the employee with the median amount of shares prefers an entrepreneurial over a stagnant policy, the former will be supported by a majority vote.

## B.2 Most Preferred Policy of the Median Voter

In this section, we consider the median voter's problem of deriving her most preferred policy. As described in the main text, we start with a given  $(\tau, L_B)$  and derive the optimal choice of  $t_P$  and  $t_L$ . Then, we elaborate on the desired levels of  $(\tau, L_B)$ .

With  $\tau$  given, we can substitute  $t_L$  by  $1 - (1 - t_P)/\tau$  in expression (16) reflecting the net transfers. Then, taking the derivative of the net transfers with respect to  $t_P$  yields:

$$DNT \equiv \left. \frac{\partial NT}{\partial t_P} \right|_{\tau} = w \left[ \left( \frac{\alpha}{1 - \alpha} l_Y - l_m \right) (1 - s) + \chi(L_B) l_E - \frac{l_E}{\tau} \right]. \quad (23)$$

Note that with lump-sum transfers, a marginal increase in the profit tax constitutes a redistribution of profits (from entrepreneurs and the final good firm) to workers while an increase in the labor tax redistributes from workers to entrepreneurs.<sup>45</sup> The redistribution of profits is captured by the first two summands in (23), where the first summand reflects the additional redistribution of the final good firm's profits, and the second summand represents the additional redistribution of entrepreneurial profits. By the assumption that the median voter is a worker, redistribution of entrepreneurial profits is beneficial for him. The factor  $1 - s$  indicates that the redistribution of the final good firm's profits is only favorable if the share of profits he can claim is less than  $1/\bar{L}$ . The latter results from the fact that transfers are lump sum. Finally, keeping  $\tau$  constant, an increase in the profit tax  $t_P$  by a marginal unit must be matched by an increase in the labor tax  $t_L$  of  $1/\tau$ . The resulting amount of redistribution of labor income to entrepreneurs is captured by the last summand in  $DNT$ .

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<sup>45</sup>The increase in the labor tax does not per se describe a redistribution towards the owners of the shares of the final good firm, as these are also either workers or entrepreneurs.

If  $DNT$  is positive, net transfers for the median voter are maximized by the highest possible profit tax rate, while the opposite is true if  $DNT$  is negative. However, the optimal choice of  $t_P$  (and  $t_L$ ) in consequence will depend on the particular value of  $\tau$ . The following table shows the optimal levels of  $t_P$  and  $t_L$  depending on  $DNT$  and  $\tau$ . Note that since profits of the final good firm are non-negative ( $w(\frac{\alpha}{1-\alpha}l_Y - l_m) \geq 0$ ), the case where  $DNT < 0$  and  $\tau \geq 1$  can only occur if entrepreneurship is inefficient (i.e.  $\chi(L_B) < 1$ ) and/or  $s > 1$ .

|              | $\tau \geq 1$   | $\tau < 1$   |
|--------------|---|--|
| $DNT \geq 0$ | $t_L = \bar{t}$ ,<br>$t_P = 1 - \tau(1 - \bar{t})$              | $t_L = 1 - (1 - \bar{t})/\tau$ ,<br>$t_P = \bar{t}$            |
| $DNT < 0$    | $t_L = 1 - (1 - \underline{t})/\tau$ ,<br>$t_P = \underline{t}$ | $t_L = \underline{t}$ ,<br>$t_P = 1 - \tau(1 - \underline{t})$ |

Table 1: Optimal labor and profit tax rates given  $\tau$  and  $L_B$ .

We use  $\hat{t}_L(\tau, L_B)$  and  $\hat{t}_P(\tau, L_B)$  to refer to the optimal labor and profit tax rates for given  $\tau$  and  $L_B$ . Using these tax rates, we can write the net transfers and consequently the median voter's income as a continuous function of  $\tau$  and  $L_B$ .

**Lemma 4**

Using  $\hat{t}_L(\tau, L_B)$  and  $\hat{t}_P(\tau, L_B)$ , the median voter's income is a continuous function on  $[\underline{\tau}, \bar{\tau}] \times [0, \bar{L}]$ .

The proof is given in Appendix C.4. Note that the median voter's income is not differentiable at the values of  $\tau$  and  $L_B$  where  $DNT = 0$ . With these results, we will now move on to the second part of the median voter's maximization problem concerning the level of  $\tau$  and the amount of basic research investments. Using Lemma 4, the median voter seeks the maximum of a continuous function over a compact set. Hence, by the Weierstrass extreme value theorem, the maximum will be reached. However, the set of maximizers may not be single-valued. It is instructive to discuss some properties of the median voter's income maximization problem, by approaching it in the two-step procedure used in the previous sections.

Consider the optimization of the median voter's income (14) with respect to  $\tau$  for given basic research investments  $L_B$

$$\max_{\tau} I(\tau, L_B) = w(\tau, L_B) \left[ 1 + s \left( \frac{\alpha}{1-\alpha} l_Y(\tau, L_B) - l_m \right) \right] + NT(\tau, L_B). \quad (24)$$

Regarding a marginal increase in  $\tau$ , the median voter's income is affected as follows<sup>46</sup>

$$\frac{dI(\tau, L_B)}{d\tau} = \frac{\partial NT}{\partial \hat{t}_P} \frac{\partial \hat{t}_P(\tau, L_B)}{\partial \tau} + \frac{\partial NT}{\partial \hat{t}_L} \frac{\partial \hat{t}_L(\tau, L_B)}{\partial \tau} + \frac{\partial I(\tau, L_B)}{\partial L_E} \frac{\partial L_E}{\partial \tau}. \quad (25)$$

Note that  $\frac{dI(\tau, L_B)}{d\tau}$  must be zero for an interior solution  $\tau$  other than the critical value of  $\tau$  implying  $DNT = 0$ . An increase in  $\tau$  has two fundamental effects: it increases the relation between labor and profit taxes and it (weakly) increases the number of entrepreneurs. The first two summands in (25) reflect the decline in redistribution from profits to labor income due to the relatively lower profit taxes. Note that one of the summands is zero as either  $\hat{t}_P$  or  $\hat{t}_L$  remains at the boundary of the feasible set  $[\underline{t}, \bar{t}]$ . The last term in (25) captures the effect of an increase in the number of entrepreneurs on the median voter's income.<sup>47</sup> In the case where entrepreneurship is efficient, i.e.  $\chi(L_B) > 1$ , an increase in entrepreneurship will increase profits and total output but will lead to a lower wage rate. Consequently, a median voter with a small amount of stocks faces the following trade-off regarding  $\tau$ . On the one hand, a marginally higher level of  $\tau$  decreases her gross income (as the wage payments are the major income source) and lowers the share of profits that are redistributed.<sup>48</sup> On the other hand, a larger  $\tau$  increases total output and therefore the tax base for the profit tax. This reflects a standard Laffer-curve trade-off.

As the set of maximizers may contain several values of  $\tau$ , we cannot proceed as in the previous sections by defining a function  $\tau(L_B)$ , inserting back into the objective function and then solving for the optimal value of  $L_B$ . Instead, we could derive the correspondence  $L_B(\tau)$  which maximizes the median voter's income with respect to basic research investments for a given level of  $\tau$ . Candidates of optimal policies for the median voter will lie in the intersection of the two correspondences. Those with the highest income level then constitute the median voter's preferred policies. As in the previous section, we refer to an *entrepreneurial economy* if  $L_B > L_{B,min}$  and  $L_E > 0$  with total output  $y$  exceeding the total output when  $L_E = L_B = 0$ . We speak of a *stagnant economy* if  $L_E = L_B = 0$ . With inefficient entrepreneurship, i.e.  $\chi(L_B) < 1$ , an economy's total output will be less than the output without basic research and entrepreneurship. As inefficient entrepreneurship decreases the labor input in final good production and hence increases wages, a median voter with little or no stocks may find it beneficial to foster such inefficient entrepreneur-

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<sup>46</sup>Note that the terms  $\frac{\partial \hat{t}_P(\tau, L_B)}{\partial \tau}$  and  $\frac{\partial \hat{t}_L(\tau, L_B)}{\partial \tau}$  differ according to the different cases in Table 1. At the critical values  $\tau_c$ , as defined in the proof of Lemma 4, and  $\tau = 1$ , equation (25) refers to the right-sided derivative.

<sup>47</sup>Note that for small values of  $L_B$  and  $\tau$ ,  $L_E$  will remain at zero in response to a marginal increase in  $\tau$ .

<sup>48</sup>Obviously, if  $\tau$  is increased via an increase of  $t_L$  rather than a decrease of  $t_P$ , a higher share of labor income is redistributed to entrepreneurs.

ship by investing in basic research. Even without entrepreneurship, a median voter may try to maximize wages by investments in basic research to reduce the labor supply in final good production. As this scenario might not be the most realistic one, we neglect it in the following and concentrate on stagnant economies with  $L_E = L_B = 0$ .<sup>49</sup>

### B.3 Numerical Illustration

We specify the other parameters in the model such that the entrepreneurial economy matches OECD-data on basic research expenditures and entrepreneurship and assume that output is 5.7% higher than in the baseline stagnant economy. This corresponds to the average rate of total factor productivity growth of OECD-countries between 1996 and 2006. Further, we use data on profit and labor taxation from Djankov et al. (2010). We consider an economy with population  $\bar{L} = 20$ , which represents the total labor force. To calibrate our model, we assume the following concave functional form for  $\eta(L_B)$ :  $\eta(L_B) = \eta(0) + (L_B/0.3)^\beta(1 - \eta(0))$ , where  $\eta(0) = \xi(m(1 - \gamma))^{-1}$ . This specification allows for a positive innovation probability without basic research if  $\xi > 0$ . For all  $\xi < 1$ , entrepreneurship is inefficient when no basic research is provided by the government.<sup>50</sup> This leaves us with six parameter values to be specified:  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $b$ ,  $m$  and  $\xi$ . In doing so, we make use of two basic economies: A stagnant and an entrepreneurial economy. Regarding the entrepreneurial economy, we require that it exhibits some average key characteristics of OECD member states observed from the data. We start by requiring that total investments in basic research amount to a share of 0.33% of GDP, which corresponds to the simple average of basic research intensities of OECD-member states.<sup>51</sup> This yields the following condition

$$(1 - \alpha) \frac{L_B}{L_y} = 0.0033 . \quad (26)$$

Next, we turn attention to entrepreneurship. In our model, entrepreneurship is innovative. We therefore choose  $L_E$  according to

$$L_E = 0.0314\bar{L} , \quad (27)$$

where 3.14% is the average share of the labor force engaged in entrepreneurial activities bringing new products to the market.<sup>52</sup> We combine these requirements with information

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<sup>49</sup>Note that with maximal redistribution in the stagnant economy,  $t_P = \bar{t}$  and  $t_L = \underline{t} \leq \bar{t}$  implies  $\tau \leq 1$  and, hence,  $L_B = 0$  implies  $L_E = 0$  by Assumption 1.

<sup>50</sup>Also note that this specification implies that the innovation probability approaches one when  $L_B = 0.3$ , which is three times as much as the actual average of basic research investments in OECD countries.

<sup>51</sup>*Source:* Own calculation based on OECD (2012b). Data refer to centered 5-year moving averages in 2006.

<sup>52</sup>*Source:* Own calculations based on Global Entrepreneurship Monitor (2013). Data refer to centered 5-year moving averages in 2006. The definition by GEM: New product early stage entrepreneurial activity.

on output shares of intermediate goods and of labor to derive the standard production technology for intermediates in our economy. In particular, we follow Jones (2011) in requiring that in our entrepreneurial economy the output share of intermediates is 0.5. With all intermediates selling at price  $p_i = mw$ , this corresponds to the following condition

$$(1 - \alpha) \frac{m}{L_y} = 0.5 . \quad (28)$$

Concerning labor income shares, we refer to data provided by the EU KLEMS project and require that<sup>53,54</sup>

$$(1 - \alpha) \frac{L_y + L_x + L_B}{L_y + (1 - \alpha)L_B} = 0.628 . \quad (29)$$

From the labor market clearing condition we get

$$L_y + L_x + L_B = \bar{L} - L_E .$$

Combining this result with equations (26) to (29) and solving for  $m$ , we get

$$m \approx 15.2 .$$

Next, we require that output in the entrepreneurial economy is 5.7% larger than in the stagnant economy<sup>55</sup>

$$\left[ \frac{L_y}{\bar{L} - m} \right]^{1-\alpha} = 1.057 . \quad (30)$$

From equation (28), we can substitute  $L_y$  by  $2m(1 - \alpha)$  yielding

$$\left[ \frac{2(1 - \alpha)m}{\bar{L} - m} \right]^{1-\alpha} = 1.057 .$$

With the solution for  $m$  given above, we can solve this equation numerically for  $\alpha$  to get

$$\alpha \approx 0.79 .$$

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<sup>53</sup>Source: Own calculations based on EU KLEMS (2011). The value of 0.628 refers to the average labor income share of OECD countries considered in the EU KLEMS database in year 2005 (centered 5-year moving averages have been used). The labor income share has been computed as:

$\frac{\text{labor compensation}}{\text{labor compensation} + \text{capital compensation}}$ .

<sup>54</sup>In our model, basic research investments are publicly provided, implying that wage income earned by basic researchers do not enter the aggregate income identity. To better mimic labor shares observed from the data, we therefore add basic research investments to both, labor income and final good production when computing the labor share in our model. As an alternative, we could compute the labor share as  $\frac{w[L_y + L_x]}{y}$ . The results would essentially be the same.

<sup>55</sup>A 5.7% increase corresponds to the average total factor productivity growth for the OECD member states included in the EU KLEMS database for the period of time of 1996 to 2006 (Source: Own calculations based on EU KLEMS (2011)).

We now turn to  $b$ ,  $\beta$ ,  $\gamma$  and  $\xi$ , the parameters characterizing entrepreneurship and innovation in our economy. We set  $\xi = 0.9$  and then need three conditions to calibrate the other parameters. A first condition follows immediately from using our previously derived results in the labor market clearing condition

$$L_y = \bar{L} - L_B - m + L_E [\chi(L_B) - 1] . \quad (31)$$

With the previous parameter values, this condition pins down the expected amount of labor savings by an additional entrepreneur,  $\chi(L_B)$ . Setting  $\tau = 1.01$ , which is in line with effective tax rates for OECD member countries,<sup>56</sup> we obtain the value for  $b$  of 0.723 from the equilibrium condition for  $L_E$

$$L_E = 1 - \frac{1}{\tau \chi(L_B) b} . \quad (32)$$

Finally, we have to specify  $\beta$  and  $\gamma$ . We require the parameter values to match the value of  $\chi(L_B)$  derived previously as well as the marginal gains of basic research estimated in the literature. Let  $BR := L_B w$  denote basic research investments. Then, in our model the marginal return to basic research is given by

$$\begin{aligned} \frac{\partial y}{\partial BR} &= \frac{\partial y}{\partial L_B} \frac{\partial L_B}{\partial BR} \\ &= w \frac{\partial L_y}{\partial L_B} \left[ \frac{1}{w} + \frac{\alpha BR}{w^2 L_y} \frac{\partial y}{\partial BR} \right] \\ &= \frac{\partial L_y}{\partial L_B} \left[ 1 + \alpha \frac{LB}{L_y} \frac{\partial y}{\partial BR} \right] . \end{aligned} \quad (33)$$

Salter and Martin (2001) review the literature estimating the rates of return to publicly funded R&D. These estimates suggest on average that the rate of return is as high as 38.2%.<sup>57</sup> We therefore choose  $\frac{\partial y}{\partial BR} = 0.382$  in equation (33) above.<sup>58</sup> This gives us values of  $\beta = 0.33$  and  $\gamma = 0.64$ .

We will now illustrate the effects of different upper bounds of taxation in our model. When moving from panel a) to d) in Figure 2, the maximally feasible tax rate increases from 0.5 to 0.95. In each of the panels in Figure 2, the black lines represent the smallest and largest level of  $\tau$  that is feasible with the respective upper tax bound. The green line in the policy space  $(\tau, L_B)$  indicates where the condition (PLS) is equal to zero, thereby separating the efficient entrepreneurial policies on the upper right of the line from the inefficient entrepreneurial

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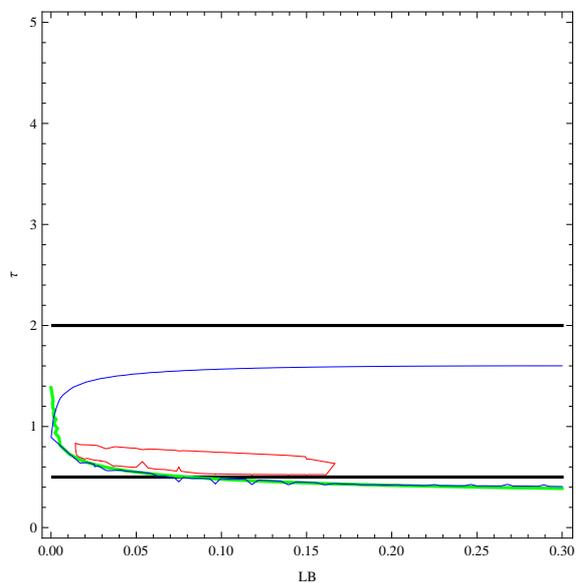
<sup>56</sup>Source: Own calculations based on Djankov et al. (2010).

<sup>57</sup>Source: Own calculations based on Salter and Martin (2001). Whenever a range has been specified for the rate of return to public R&D, the midpoint has been taken.

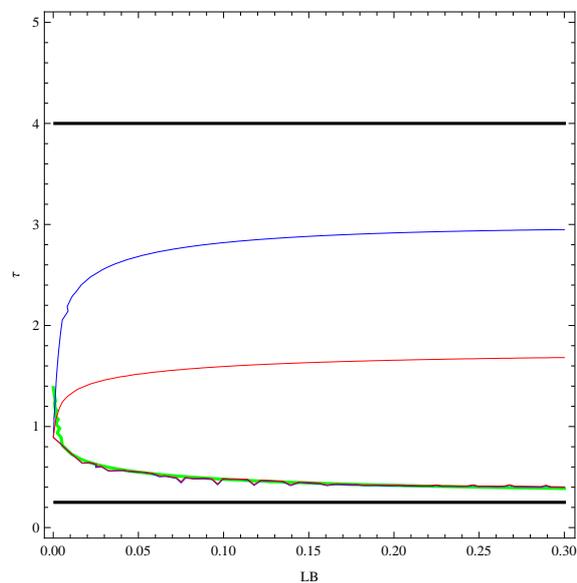
<sup>58</sup>Results would essentially be the same when choosing  $\frac{\partial y}{\partial BR} = 0.1$  instead.

policies on the lower left. As an efficient entrepreneurial economy in our context means that the wage rates are lower than in a stagnant economy, the median voter with a sufficiently small amount of shares in final-good production will not support an entrepreneurial economy without compensating net transfers.

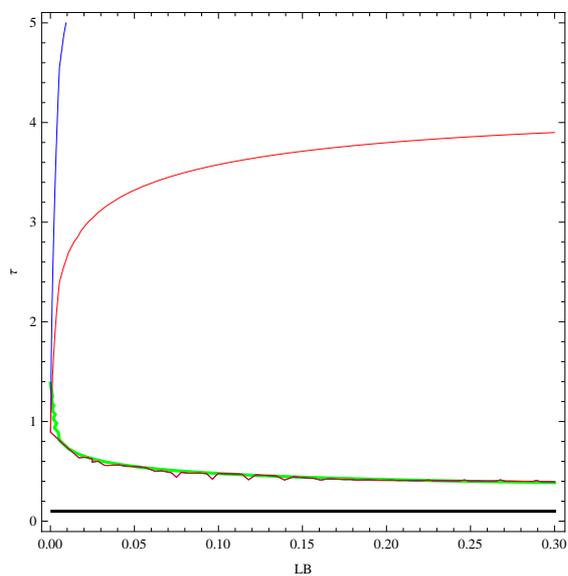
a)  $\bar{t} = 0.5$



b)  $\bar{t} = 0.75$



c)  $\bar{t} = 0.9$



d)  $\bar{t} = 0.95$

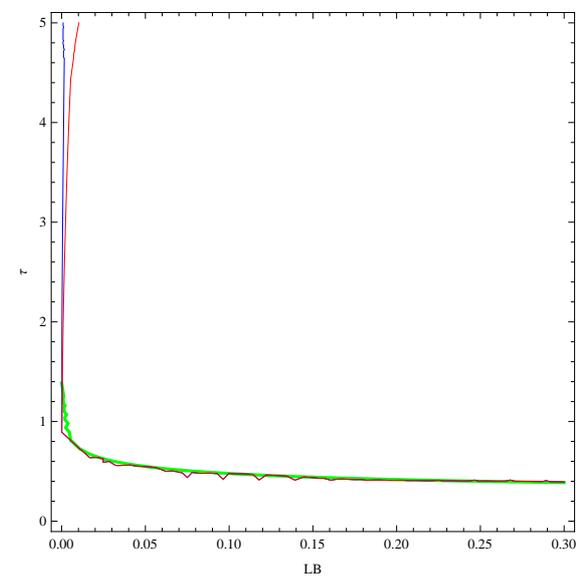


Figure 2: Illustration of politically feasible entrepreneurial policies for different upper limits on tax rates.

Given the upper limits on tax rates  $\bar{t}$ , we can derive the median voter's optimal amount of net transfers associated with the different entrepreneurial policies. In the different panels

of Figure 2, we show the difference of the net transfers in the entrepreneurial relative to the stagnant economy. The blue line reflects the policies where the net transfer difference is zero. Only in the area enclosed by the blue line is the net-transfer difference positive and we can potentially hope for political support of the entrepreneurial economy. Summing gross income differences and net transfer differences of the entrepreneurial policies relative to their stagnant counterparts yields the net income difference between the respective efficient entrepreneurial policy and the stagnant policy. As for the median voter, gross income falls when moving from the stagnant policy to an efficient entrepreneurial policy, the set of entrepreneurial policies where the net income difference is positive must be a subset of the policies where the net transfer difference is positive. This policy set is enclosed by the red line in each of the panels and indicates the politically viable entrepreneurial policy changes away from the stagnant economy.

When moving from panel a) to d) the upper tax bound becomes larger thereby increasing the possibilities for redistribution. As our theory predicts, this increases the set of entrepreneurial policies with a positive net transfer difference that is, it increases the area enclosed by the blue lines in the different panels. Of course, the higher redistributive possibilities imply that the balance between efficiency and redistribution can be achieved for a greater set of entrepreneurial policies. Consequently, the area enclosed by the red lines increases as well. In accordance with Proposition 4 we observe in panel d) that when  $\bar{t}$  approaches 1, the entire area comprising efficient entrepreneurial policies will be politically viable. In the first panel a), we observe the opposite case, where the tax bound is just sufficient to guarantee median voter support for a very small set of efficient entrepreneurial policies. If the tax bound were even lower, no efficient entrepreneurial policy could be supported politically.

## C Proofs

### C.1 Proof of Lemma 1

We prove each part of Lemma 1 in turn.

(i) We consider innovative and non-innovative intermediate good producer separately.

Intermediate goods in non-innovative industries are produced using the freely available standard technology. Perfect competition implies that these intermediate goods are sold at cost in equilibrium, i.e. non-innovative intermediate good producer will offer their goods at price  $p(i) = mw$ .

The cost of production of innovative intermediate good producer are reduced to  $\gamma mw$ . These firms are still confronted with competition from non-innovative intermediate good producers in their industry. Taken together, this implies that an innovative intermediate good producer will charge a price  $p(i) = \delta_i mw$  with  $\delta_i \in [\gamma, 1]$ . We now show by contradiction that  $\delta_i \in [\gamma, 1)$  cannot be optimal. We show that there do not exist symmetric equilibria such that all innovative intermediate good producer charge the common price  $p(i) = \delta mw$ , with  $\delta \in [\gamma, 1)$  and leave it to the reader to verify that no non-symmetric equilibrium exists with  $\delta_i < 1$  for some  $i$ .

Let us define  $\tilde{X} := \int_{i|p(i)=\delta mw} x(i)^\alpha di$  and  $\hat{X} := \int_{i|p(i)=mw} x(i)^\alpha di$ . This allows us to write the maximization problem of the final good producer as

$$\begin{aligned} \max_{L_y, X} \pi_y &= L_y^{1-\alpha}(\tilde{X} + \hat{X}) - wL_y - \delta mw\tilde{X} - mw\hat{X} \\ &= \tilde{X}(L_y^{1-\alpha} - \delta mw) + \hat{X}(L_y^{1-\alpha} - mw) - wL_y. \end{aligned} \quad (34)$$

$\delta < 1$  implies that  $L_y^{1-\alpha} - \delta mw > 0$  is a necessary condition for the final good producer to operate making non-negative profits.  $L_y^{1-\alpha} - \delta mw$  is the net marginal benefit of the final good producer from using intermediate good  $x(i)$  offered at price  $p(i) = \delta mw$  in production. Hence,  $L_y^{1-\alpha} - \delta mw > 0$  implies first, that if the final good producer is operating he always demands  $x(i) = 1$  of every intermediate offered at price  $p(i) = \delta mw$ . And second, that the innovative intermediate good producer  $i$  would want to set a price  $\tilde{p}(i) = \delta mw + \epsilon$ ,  $\epsilon > 0$  but small, such that  $L_y^{1-\alpha} - \tilde{p}(i) > 0$ . Then the net marginal benefit of the final good producer from using intermediate good  $x(i)$  in production remains positive. Furthermore, given that each intermediate good producer has measure 0, it would not affect the profitability of the representative final good firm. Hence, the final good firm would still demand  $x(i) = 1$ , a contradiction to  $p(i) = \delta mw$  being profit maximizing for intermediate good producer  $i$ .

The contradiction establishes the result.

(ii) Let us define  $X := \int_0^1 x(i)^\alpha di$ .  $X$  assumes the value 0 if  $x(i) = 0 \forall i$ , 1 if  $x(i) = 1 \forall i$ , and values between 0 and 1 only if a subset of the varieties is used. If  $p_i = mw \forall i$ , the maximization problem of the final good producer can be written as

$$\max_{L_y, X} \pi_y = L_y^{1-\alpha}X - wL_y - mwX = X(L_y^{1-\alpha} - mw) - wL_y. \quad (35)$$

Hence, the profit function is linear in  $X$ . A necessary condition for non-negative profits is  $L_y^{1-\alpha} - mw > 0$ . As a consequence, if it is optimal for the final good producer to operate, i.e. to demand  $X > 0$  then it must hold that  $L_y^{1-\alpha} - mw > 0$  and hence profits are maximized by setting  $X = 1$ .

## C.2 Proof of Proposition 1

From Lemma 1 and the expositions in the main text, we know that if condition (PPC) is satisfied, the final good producer is operating and he uses all varieties in production. Conversely, if condition (PPC) is not satisfied, he is not operating and  $L_E^e = L_x^e = L_y^e = 0$  and zero profits follow immediately. It remains to show that in case (i) the other variables take on the unique equilibrium values stated in the Proposition.

(i) Conditions (1), (2), and (4), and (7) have been derived in the main text. Condition (3) follows from using  $L_E^e$  and  $L_x^e$  in the labor market clearing condition. Combining  $w^e$  with the observation that  $p(i) = mw \forall i$  yields condition (5). Condition (6) follows from  $x(i) = 1 \forall i$  and the production technology in the final good sector. Finally, condition (8) follows from using  $w^e$  in the expression for profits of a monopolistic intermediate good producer.

## C.3 Proof of Corollary 1

By Proposition 3 there will be an entrepreneurial economy if and only if condition (PLS) is satisfied. Now, in response to a change in  $m$ ,  $b$ ,  $\tau$ , or  $\gamma$ , the government could leave  $\tilde{L}_B(\tau)$  unaffected. Hence, if it opts for a  $\hat{L}_B(\tau) \neq \tilde{L}_B(\tau)$ , then we must have  $c\left(\tau, \hat{L}_B(\tau)\right) \geq c\left(\tau, \tilde{L}_B(\tau)\right)$ , which implies

$$\begin{aligned} & -\hat{L}_B(\tau) + \left[1 - \frac{1}{\tau\chi\left(\hat{L}_B(\tau)\right)b}\right] \left[\chi\left(\hat{L}_B(\tau)\right) - 1\right] \geq \\ & -\tilde{L}_B(\tau) + \left[1 - \frac{1}{\tau\chi\left(\tilde{L}_B(\tau)\right)b}\right] \left[\chi\left(\tilde{L}_B(\tau)\right) - 1\right] . \end{aligned}$$

A proof then follows from the fact that for a constant  $\tilde{L}_B(\tau)$

$$\left[1 - \frac{1}{\tau\chi\left(\tilde{L}_B(\tau)\right)b}\right] \left[\chi\left(\tilde{L}_B(\tau)\right) - 1\right]$$

is increasing in  $m$ ,  $b$ , and  $\tau$  and decreasing in  $\gamma$ .

## C.4 Proof of Lemma 4

We first show the continuity of  $I$  in  $\tau$  for given  $L_B$  and then the continuity of  $I$  in  $L_B$  for any given  $\tau$ .

(1) Since the median voter's gross income is a continuous function of  $\tau$  and  $L_B$ , it is sufficient to focus on net transfers  $NT(\tau, L_B)$ .

(2) Regarding the different cases of optimal profit and labor taxes for given  $(\tau, L_B)$  as shown in Table 1, the net transfers are continuous within each of the different subsets of  $(\tau, L_B)$  defined by the four different cases. Potential discontinuities may exist at the transition from one case to another. In this respect, we define the critical values  $\tau^c(L_B)$  and  $L_B^c(\tau)$  by  $DNT(\tau^c, L_B) = 0$  for any given  $L_B$  in the feasible set and  $DNT(\tau, L_B^c) = 0$ .

(3) As can be observed in Table 1, there are two critical values of  $\tau$  for a given  $L_B$ :  $\tau^c(L_B)$  and  $\tau = 1$ . The former is only interesting if  $\tau^c(L_B) \in [\underline{\tau}, \bar{\tau}]$ , while the latter will always be in the feasible set by our assumptions in Section 3. Now consider any two sequences  $\{\tau_n\}$  and  $\{\tau_k\}$  with  $\lim_n \tau_n = \tau_c$ ,  $\tau_n \leq \tau_c$  and  $\lim_k \tau_k = \tau_c$ ,  $\tau_k \geq \tau_c$ . As  $DNT(\tau^c, L_B) = 0$  means that a change in tax rates  $t_P, t_L$  does not affect net transfers  $[NT(\tau^c, L_B)]$  as long as  $\tau^c$  remains unchanged, we must obtain  $\lim_n NT(\tau_n, L_B) = \lim_k NT(\tau_k, L_B)$ . Hence,  $NT(\tau, L_B)$  is continuous at  $\tau^c$  for a given  $L_B$ .

(4) At the critical value  $\tau = 1$ , both tax rates  $t_P$  and  $t_L$  are identical. Consequently, for two sequences with  $\lim_n \tau_n = 1$ ,  $\tau_n \leq 1$  and  $\lim_k \tau_k = 1$ ,  $\tau_k \geq 1$ , we also obtain  $\lim_n NT(\tau_n, L_B) = \lim_k NT(\tau_k, L_B) = NT(1, L_B)$ . Thus, net transfers are continuous in  $\tau$  at  $\tau = 1$ .

(5) We can use the same argument as in (3) with respect to sequences  $\{L_{B,n}\}$  and  $\{L_{B,k}\}$  with limit  $L_B^c$  for given  $\tau$ .

## C.5 Proof of Proposition 4

Note that income per capita can be written as

$$\bar{y} = \frac{y}{L} = w \left[ 1 + \frac{\alpha}{1-\alpha} l_Y - l_m + l_E(\chi(L_B) - 1) - l_B \right], \quad (36)$$

which reduces to

$$\bar{y}^S = \frac{y^S}{L} = w^S \left[ 1 + \frac{\alpha}{1-\alpha} l_Y^S - l_m \right], \quad (37)$$

in the stagnant economy. The median voter's income in the entrepreneurial economy and the stagnant economy are given by the following equations.

$$I^E = w \left[ 1 + \left( \frac{\alpha}{1-\alpha} l_Y - l_m \right) (s + t_P(1-s)) + l_E(t_P \chi(L_B) - t_L) - l_B \right]. \quad (38)$$

In the stagnant economy

$$I^S = w^S \left[ 1 + \left( \frac{\alpha}{1-\alpha} l_Y^S - l_m \right) (s + t_P(1-s)) \right]. \quad (39)$$

Due to the assumption  $s < 1$ , the median voter maximally redistributes profits  $t_P = \bar{t}$  in the stagnant economy.<sup>59</sup>

Consider any policy  $(\hat{\tau}, \hat{L}_B)$  for which  $\bar{y} > \bar{y}^S$  (such a policy necessarily implies  $L_B > 0$  and  $L_E > 0$ ). With  $s < 1$ , we have that  $I^S \leq \bar{y}^S$ . Hence it suffices to show that for  $(\hat{\tau}, \hat{L}_B)$ , we can find a  $\bar{t}$  such that  $I^E(\hat{\tau}, \hat{L}_B) > \bar{y}^S$ . Note that  $\lim_{t_P \rightarrow 1, t_L \rightarrow 1} I^E = \bar{y}$ . Since  $\bar{y}(\hat{\tau}, \hat{L}_B) > \bar{y}^S$ , the desideratum follows from the fact that for any  $\delta > 0$ , we can find a pair  $(t_P, t_L) < (1, 1)$  yielding  $\hat{\tau}$  and

$$\bar{y}(\hat{\tau}, \hat{L}_B) - I^E(\hat{\tau}, \hat{L}_B) \leq \delta.$$

This completes the proof.

## C.6 Proof of Proposition 5

To show the result, note first that the restriction to  $s \leq \frac{\bar{L}}{L+(1-\gamma)m}$  is a sufficient condition for a negative derivative of the median voter's gross income with respect to  $L_y$ . The value of  $s \leq \frac{\bar{L}}{L+(1-\gamma)m}$  follows from the fact that  $L_y < \bar{L} - \gamma m$ .

Now, suppose that  $\bar{t} = 0$ . Then, the median voter's income corresponds to his gross income minus his share in the cost for providing basic research and he strictly prefers the stagnant economy over the entrepreneurial economy.<sup>60</sup> The result then follows from the continuity of the median voter's income, implying that he will also prefer the stagnant economy for sufficiently small  $\bar{t} > 0$ .

## C.7 Proof of Proposition 6

Fix any entrepreneurial policy  $(\hat{\tau}, \hat{L}_B)$  with  $\hat{L}_y \geq L_y^S$ . From Proposition 4 we know that for  $\bar{t} \rightarrow 1$  the following two conditions are satisfied:

1.  $\hat{\tau} \in [\underline{\tau}, \bar{\tau}]$ ,
2. the median voter with  $s \leq \frac{\bar{L}}{L+(1-\gamma)m}$  will prefer the entrepreneurial policy  $(\hat{\tau}, \hat{L}_B)$  over the stagnant economy.

From Proposition 5 we know that for  $\bar{t}$  small the median voter supports the stagnant economy, implying that at least one of the two conditions above is no longer satisfied. Hence, it remains to show that for every entrepreneurial policy  $(\hat{\tau}, \hat{L}_B)$ , there exists a unique threshold level  $\bar{t}_c$  such that both conditions above are satisfied if and only if  $\bar{t} \geq \bar{t}_c$ .

<sup>59</sup>Note that the labor tax does not affect the median voter's income in the stagnant economy as all individuals are workers. The population only differs with respect to stocks of the final good firm.

<sup>60</sup>Note that  $L_y \geq L_y^S$  and  $L_B > 0$  in the entrepreneurial economy.

For every  $\hat{\tau} \in (0, 1)$ , there exists a unique  $\bar{t}_c^1$  such that  $\hat{\tau} \in [\underline{\tau}, \bar{\tau}]$  if and only if  $\bar{t} \geq \bar{t}_c^1$ . Hence, we can limit attention to  $\bar{t} \geq \bar{t}_c^1$  and the result follows from showing that  $\hat{I}^E - I^S$  is monotonous in  $\bar{t}$ . Note that a decrease in  $\bar{t}$  such that  $\bar{t} \geq \bar{t}_c^1$  will only change net transfers but not the median voter's gross income. Hence, we can limit attention to the derivative of  $NT$  with respect to  $\bar{t}$  for  $\hat{\tau}$  and  $\hat{L}_B$  given. In the stagnant economy we have

$$\left. \frac{\partial NT^S}{\partial \bar{t}} \right|_{\substack{\hat{\tau} \\ \hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}} = w^S \left[ \left( \frac{\alpha}{1-\alpha} l_Y^S - l_m \right) (1-s) \right] \geq 0,$$

where lower case  $l$  denote per capita values, i.e.  $l_Y = L_Y/\bar{L}$  and  $l_m = m/\bar{L}$ , etc.. Note that  $\frac{\partial NT^S}{\partial \bar{t}}$  is constant. The monotonicity of  $\hat{I}^E - I^S$  then follows from  $\frac{\partial NT^E}{\partial \bar{t}}$  being constant as well which we show to hold for each of the four cases outlined in table 1 of Appendix B.2 separately.

**$DNT < 0, \hat{\tau} \geq 1$**  Not possible as  $\hat{L}_y \geq L_y^S$  implies  $\chi(\hat{L}_B) > 1$  and  $s \leq \frac{\bar{L}}{\bar{L} + (1-\gamma)m} < 1$ .

**$DNT < 0, \hat{\tau} < 1$**  The median voter optimally chooses  $\hat{t}_L = \underline{t} = 0$  and  $\hat{t}_P = 1 - \hat{\tau}$  implying that

$$\left. \frac{\partial NT^E}{\partial \bar{t}} \right|_{\substack{\hat{\tau} \\ \hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}} = 0$$

and hence  $\hat{I}^E - I^S$  is monotonous in  $\bar{t}$ .<sup>61</sup>

**$DNT \geq 0, \hat{\tau} \geq 1$**  The median voter optimally chooses  $\hat{t}_L = \bar{t}$  and  $\hat{t}_P = 1 - \hat{\tau}(1 - \bar{t})$ . Hence, the derivative of net transfers in the entrepreneurial economy with respect to  $\bar{t}$  writes

$$\left. \frac{\partial NT^E}{\partial \bar{t}} \right|_{\substack{\hat{\tau} \\ \hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}} = w^E \left[ \hat{\tau} \left( \left( \frac{\alpha}{1-\alpha} l_Y^E - l_m \right) (1-s) + \chi(\hat{L}_B) l_E \right) - l_E \right],$$

which is constant implying that  $\hat{I}^E - I^S$  is monotonous in  $\bar{t}$ .<sup>62</sup>

**$DNT \geq 0, \hat{\tau} < 1$**  The median voter optimally chooses  $\hat{t}_L = 1 - (1 - \bar{t})/\hat{\tau}$  and  $\hat{t}_P = \bar{t}$ , yielding the following derivative of net transfers in the entrepreneurial economy

$$\left. \frac{\partial NT^E}{\partial \bar{t}} \right|_{\substack{\hat{\tau} \\ \hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}} = w^E \left[ \left( \left( \frac{\alpha}{1-\alpha} l_Y^E - l_m \right) (1-s) + \chi(\hat{L}_B) l_E \right) - \frac{l_E}{\hat{\tau}} \right].$$

Again,  $\frac{\partial NT^E}{\partial \bar{t}}$  is constant, implying that  $\hat{I}^E - I^S$  is monotonous in  $\bar{t}$ .

<sup>61</sup>Note that  $\frac{\partial NT^E}{\partial \bar{t}} = 0$ ,  $\frac{\partial NT^S}{\partial \bar{t}} \geq 0$  and Proposition 4 imply that in the case considered here the median voter will prefer the entrepreneurial economy over the stagnant economy whenever feasible, i.e. we have  $\bar{t}_c = \bar{t}_c^1 = 1 - \hat{\tau}$ .

<sup>62</sup>In fact, we have  $\bar{t}_c > \bar{t}_c^1$ . This follows from  $t_P = 0$  and hence  $NT < 0$  for  $\hat{\tau} = \bar{\tau}$ .

## C.8 Proof of Proposition 9

For  $L_E = 0$ ,  $W$  does not depend on the choice of  $t_L$  and  $t_P$ . Hence,  $L_E > 0$  is optimal if  $\exists$  a tax policy,  $\hat{t}_L$  and  $\hat{t}_P$  such that  $L_E$  is just equal to 0, i.e.  $1 - \frac{1-\hat{t}_L}{(1-\hat{t}_P)\chi(L_B^*)b} = 0$ , and  $\frac{\partial W}{\partial L_E} \Big|_{\substack{\hat{t}_L \\ \hat{t}_P}} > 0$ . In what follows, we show that this is the case if and only if the condition stated in Proposition 9 is satisfied.

Differentiating  $W$  with respect to  $L_E$  yields

$$\frac{\partial W}{\partial L_E} = (1-\alpha)L_y^{-\alpha} \left\{ (\chi(L_B^*) - 1) + (1-t_P)\chi(L_B^*)b \left[ \left(1 - \frac{1}{b} - L_E\right) - \alpha(\chi(L_B^*) - 1)L_y^{-1} \left(1 - \frac{1}{b} - \frac{L_E}{2}\right) L_E \right] \right\} .$$

Evaluated at  $L_E = 0$ , this reduces to

$$\frac{\partial W}{\partial L_E} \Big|_{L_E=0} = (1-\alpha)(\bar{L} - L_B^* - m) [\chi(L_B^*) - 1 + (1-t_P)\chi(L_B^*)(b-1)] .$$

The non-negativity condition for profits of the final good producer combined with the feasibility of  $L_E = 0$  imply that  $\bar{L} - L_B^* \geq \frac{m}{\alpha}$  and hence  $(\bar{L} - L_B^* - m) > 0$ . We conclude

$$\frac{\partial W}{\partial L_E} \Big|_{L_E=0} > 0 \quad \text{if and only if} \quad \chi(L_B^*) > \frac{1}{1 + (1-t_P)(b-1)} .$$

We notice that whether or not  $\frac{\partial W}{\partial L_E} \Big|_{L_E=0} > 0$  depends on the choice of  $t_P$ . In particular, for  $(\bar{L} - L_B^* - m) > 0$

$$\frac{\partial W}{\partial L_E} \Big|_{L_E=0} \quad \text{is} \quad \begin{cases} \text{increasing in } t_P & \text{if } b < 1 \\ \text{independent of } t_P & \text{if } b = 1 \\ \text{decreasing in } t_P & \text{if } b > 1 \end{cases} .$$

We conclude that for  $b \leq 1$ ,  $\frac{\partial W}{\partial L_E} > 0$  for some choice of  $t_L$  and  $t_P$  satisfying  $1 - \frac{1-t_L}{(1-t_P)\chi(L_B^*)b} = 0$  if and only if  $\chi(L_B^*) > \frac{1}{1+(1-t_P)(b-1)}$  for the biggest possible  $t_P$  satisfying  $1 - \frac{1-t_L}{(1-t_P)\chi(L_B^*)b} = 0$ . Conversely, if  $b > 1$ ,  $\frac{\partial W}{\partial L_E} > 0$  for some choice of  $t_L$  and  $t_P$  satisfying  $1 - \frac{1-t_L}{(1-t_P)\chi(L_B^*)b} = 0$  if and only if  $\chi(L_B^*) > \frac{1}{1+(1-t_P)(b-1)}$  for the smallest possible  $t_P$  satisfying  $1 - \frac{1-t_L}{(1-t_P)\chi(L_B^*)b} = 0$ .  $\tilde{t}_P$  in condition (20) has been chosen accordingly.

## D Welfare Maximizing Tax Policy

Proposition 8 in the main text characterized the welfare optimal tax policies for  $L_B$  given, where optimal tax policies were dependent on the level of entrepreneurial activity.

## D.1 Proof of Proposition 7

The proof follows from the one of Proposition 8 (i) and (ii).

## D.2 Proof of Proposition 8 (i) and (ii)

We prove the result by contradiction.

$0 < L_E < 2(1 - \frac{1}{b})$  implies that the immaterial utility of entrepreneurs in the aggregate welfare,  $(1 - t_P)\chi(L_B)(1 - \alpha)bL_y^{-\alpha}L_E [1 - \frac{1}{b} - \frac{L_E}{2}]$ , is positive. Now, consider a policy choice  $(\hat{t}_L, \hat{t}_P, \hat{L}_B)$  such that  $\hat{t}_L > \underline{t}_L$ ,  $\hat{t}_P > \underline{t}_P$  and  $\chi(\hat{L}_B)(2 - b) < \frac{1 - \hat{t}_L}{1 - \hat{t}_P} < \chi(\hat{L}_B)b$  which is equivalent to  $0 < L_E < 2(1 - \frac{1}{b})$ . Then the following deviation is feasible

$$\begin{aligned} t'_P &= \hat{t}_P - \Delta_1, & \Delta_1 > 0, \text{ but small such that } t'_P &\geq \underline{t}_P \\ t'_L &= \hat{t}_L - \Delta_2, & \Delta_2 > 0, \text{ but small such that } t'_L &\geq \underline{t}_L \\ L'_B &= \hat{L}_B, \end{aligned}$$

and where  $\Delta_1$  and  $\Delta_2$  are chosen to satisfy

$$\frac{1 - \hat{t}_P}{1 - \hat{t}_L} = \frac{1 - t'_P}{1 - t'_L}.$$

Then  $L'_E = \hat{L}_E$ ,  $L'_y = \hat{L}_y$ , and hence  $W(t'_L, t'_P, L'_B) > W(\hat{t}_L, \hat{t}_P, \hat{L}_B)$ , a contradiction to  $(\hat{t}_L, \hat{t}_P, \hat{L}_B)$  being a welfare optimum.

The contradiction establishes the result.

## D.3 Proof of Proposition 8 (iii) and (iv)

We prove the result by contradiction.

With  $L_E > \max(0, 2(1 - \frac{1}{b}))$  the immaterial utility of entrepreneurs in the aggregate welfare,  $(1 - t_P)\chi(L_B)(1 - \alpha)bL_y^{-\alpha}L_E [1 - \frac{1}{b} - \frac{L_E}{2}]$ , is negative. Now, consider a policy choice  $(\hat{t}_L, \hat{t}_P, \hat{L}_B)$  such that  $\hat{t}_L < \bar{t}_L$  and  $\hat{t}_P < \bar{t}_P$  and where  $\frac{1 - \hat{t}_L}{1 - \hat{t}_P} < \min(\chi(\hat{L}_B)b, \chi(\hat{L}_B)(2 - b))$  which is equivalent to  $L_E > \max(0, 2(1 - \frac{1}{b}))$ . Then the following policy choice is feasible

$$\begin{aligned} t'_P &= \hat{t}_P + \Delta_1, & \Delta_1 > 0, \text{ but small such that } t'_P &\leq \bar{t}_P \\ t'_L &= \hat{t}_L + \Delta_2, & \Delta_2 > 0, \text{ but small such that } t'_L &\leq \bar{t}_L \\ L'_B &= \hat{L}_B, \end{aligned}$$

where  $\Delta_1$  and  $\Delta_2$  are chosen to satisfy

$$\frac{1 - \hat{t}_P}{1 - \hat{t}_L} = \frac{1 - t'_P}{1 - t'_L}.$$

Then  $L'_E = \hat{L}_E$ ,  $L'_y = \hat{L}_y$ , and hence  $W(t'_L, t'_P, L'_B) > W(\hat{t}_L, \hat{t}_P, \hat{L}_B)$ , a contradiction to  $(\hat{t}_L, \hat{t}_P, \hat{L}_B)$  being a welfare optimum.

The contradiction establishes the result.

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