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Taxation, Innovation, and Entrepreneurship*

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Abstract

We explore optimal and politically feasible growth policies in the form of basic research investments and taxation. Basic research is a public good that benefits innovating entrepreneurs, but its provision and financing also affect the entire economy – in particular, occupational choices of potential entrepreneurs, wages, dividends, and aggregate output. We show that the impact of basic research on the general economy rationalizes a taxation pecking order to finance basic research. More specifically, in a society with desirably dense entrepreneurial activity, a large share of funds for basic research should be financed by labor taxation, while a minor share should be left to profit taxation. Such tax schemes will induce a significant proportion of agents to become entrepreneurs, thereby rationalizing substantial investments in basic research that fosters their innovation prospects. These entrepreneurial economies, however, may make a majority of workers worse off, giving rise to a conflict between efficiency and equality. We discuss ways of mitigating this conflict and thus strengthening the political support for growth policies.

Keywords basic research · economic growth · entrepreneurship · income taxation · political economy

JEL Classification D72 · H20 · H40 · O31 · O38

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1 Introduction

The contribution of innovative entrepreneurship to economic growth and 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). In this paper, we will be examining two key drivers – basic research and taxation – that shape entrepreneurial activities and growth, and that are prominent in academic and policy debates.¹ We will first derive optimal growth policies and then discuss their political implementability.

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

Providing and financing basic research is an intricate task. Taxation will not only help to fund these investments, it will also impact on the entire economy through a variety of 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 by final-good producers;
- aggregate output.

We address these interdependencies in a general equilibrium framework. We develop a

¹Cf. 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 strengthened tax incentives for entrepreneurship and innovation (Government of the Netherlands, 2010).

²The positive effect of basic research on applied research has been the subject of several studies (cf. Gersbach et al. (2010) for a discussion of the literature). Link and Rees (1990) and Acs et al. (1994) provide evidence suggesting that small firms may benefit particularly strongly from university R&D.

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, as basic researchers, or they can become entrepreneurs. Entrepreneurs can benefit from basic research provided by the government and invest in applied research to develop labor-saving technologies for intermediates. Successful entrepreneurs will earn monopoly profits. In addition, entrepreneurship has immaterial costs (such as entrepreneurial effort cost) and benefits (such as 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, profit, and (potentially) lump-sum taxes. This financing decision also affects the occupational choice made by potential entrepreneurs and hence impacts on the effectiveness of basic research investments.

Results

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

However, labor-saving innovations lead to declining real wages so optimal policies in an entrepreneurial economy will harm workers with little shareholdings. These distributional effects can give rise to a conflict between efficiency and equality that will undermine 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 if shareholdings are skewed to the right the median voter may reject any

growth-stimulating entrepreneurial policies. Then the society is ‘trapped’ in a *stagnant economy*. Furthermore, even if the median voter supports a growth-stimulating entrepreneurial economy, her preferred basic research investments and tax policy will be more moderate vis-à-vis the optimal growth policy. Importantly, we find that more ambitious growth policies can be implemented when larger top tax rates are feasible. Then tax incentives for entrepreneurs (efficiency) and the redistribution of gains from innovation (equality) can be better aligned. Larger upper bounds on taxation allow for more redistribution to the median voter, thus potentially satisfying equity concerns and making 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 income and profits, which is decisive for entrepreneurship and innovation and hence for efficiency concerns. We will illustrate the forces that determine the political feasibility of entrepreneurial policies by means of a numerical example using OECD data.

Implications

As politically implementable basic research investments tend to be too low, our political economy results provide a rationale for the surprisingly high rates of return to public investments in (basic) research that are typically found in empirical studies.³

Moreover, the insights above may also 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.⁴ We show that while low upper tax bounds do indeed protect firm-owners if growth policies are given, they may actually

³Cf. Salter and Martin (2001) for an overview of such studies and Toole (2012) for a more recent example.

⁴Tax provisions are repeatedly at the center of constitutional court rulings, and in many countries there are implicit tax bounds, which derive from constitutional principles of taxation. For example, in Germany the Federal Constitutional Court’s ‘half-division principle’ (Halbteilungsgrundsatz) as ruled in 1995 for the taxation of assets says that the overall tax load on after-tax assets (‘consolidated assets’) must not exceed a 50 percent mark (BVerfGE 93:138) (von Arnould and Zimmermann, 2013). And the French constitutional court has stated that a total tax burden of 90.5% would not be admissible (cf. Conseil Constitutionnel de la République Française, 2013). Supermajority rules for tax increases are an alternative to bounds on tax rates. Several US states, for example, have such provisions, and they have also been proposed at the federal level in the past (cf., for example, National Conference of State Legislatures, 2010; Gradstein, 1999). An example for explicit constitutional tax bounds is Switzerland where direct taxes at the federal level are restricted as follows: ‘*The Confederation may levy a direct tax: a. of a maximum of 11.5 per cent on the income of private individuals; b. of a maximum of 8.5 per cent of the net profit of legal entities*’ (Article 128.1, Federal Constitution of the Swiss Confederation).

harm firm-owners if these 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 in a constitutional design phase behind the veil of ignorance bounds on taxation are likely to be rejected.

Alternatively, tax bounds may implicitly arise from fiscal capacity, ‘*economic institutions inherited from the past*’ (Besley and Persson, 2009, p. 1219) that determine the government’s ability to collect taxes. Cross-country data indicate a strong positive relationship between fiscal capacity and GDP per capita. We provide a political economy rationale explaining why weak fiscal institutions may harm growth prospects. In a nutshell, weak fiscal institutions do not allow for sufficient redistribution to let a critical mass of the population participate in gains from growth-stimulating policies. Accordingly, they may undermine the political support needed for the implementation of such policies.⁵

The paper is organized as follows: section 2 situates 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, while section 7 discusses further implications of our main results. Finally, section 8 concludes. We provide some additional details on the political economy of financing basic research in the appendix, and several robustness checks for our pecking order result in the working-paper version of our paper (Gersbach et al., 2014). Also, all the proofs are to be found in the appendix.

2 Literature

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

⁵Weak fiscal institutions are typically associated with developing countries, which are also the main focus of Besley and Persson (2009). However, industrialized economies may also suffer from weak fiscal institutions. As an example, the European Commission (2012, p. 12) advances the view that ‘*currently Greece suffers from a lack of capacity to [...] collect taxes*’. While it is certainly concerned about rebalancing Greek public finances, it is also concerned about the ‘*fairness of the tax system*’ (p. 11) and about ensuring that the ‘*burden of adjustment is fairly distributed*’ (p. 13).

Effects of basic research and financing

In this paper, we start from the assumption that there is a need for public funding of basic research.⁶ Our first main question is then how optimally chosen basic research expenditures should be financed. Our paper is thus related to the literature on financing productive government expenditures. In this literature, surveyed comprehensively by Irmen and Kuehnel (2009), government expenditures increase the productivity of goods production in the economy directly. By contrast, our model is rooted in the tradition of R&D-based endogenous growth models, notably those that explicitly take into account the hierarchical order of basic and applied research (see, for example, Arnold, 1997; Morales, 2004; Gersbach et al., 2010). In these 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. In our case, basic research affects the innovation probability of entrepreneurs engaging in applied research. Using more public funds for basic research improves the chances of success for private entrepreneurs at the cost of diverting resources away from intermediate- and final-good production.

This implies that financing basic research has to fulfill a second important role. Suppose basic research is 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. Hence it influences the number of innovating entrepreneurs in our economy. To sum up, a socially efficient financing scheme for basic research must simultaneously provide the funds for these investments and must induce a socially desirable share of agents to become entrepreneurs.

⁶The case for the public funding of basic research is well established in the literature, at least since the seminal papers of Nelson (1959) and Arrow (1962) (cf. Gersbach et al. (2014) and Gersbach et al. (2015) for a brief discussion of the main arguments). This rationale is also borne out by the empirical evidence. Gersbach et al. (2013) report data showing that for a selection of 15 countries the average share of basic research performed in the government and higher-education sector was approximately 75% in 2009. The OECD research and development statistics tell us that across OECD member countries around 80% of total research performed in the government or higher-education sector is also funded by the government (cf. Gersbach et al. (2015) for further details). Taken together, these findings suggest that a major share of basic research investments are indeed publicly funded. This evidence is also in line with US data on the source of funds for basic research, as reported in National Science Board (2012, Table 4-3).

Optimal taxation in an economy with entrepreneurship

We will analyze the optimal mix of basic research and tax policies. Accordingly, our paper is also related to the literature on optimal income taxation in the tradition of Mirrlees (1971). 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. While they restrict tax rates to make them the same for both types of labor, in our model the government can distinguish between taxes on profits and taxes on labor income.⁷ Kanbur (1981) considers a model with an endogenous occupational choice on the part of homogeneous agents between becoming a worker earning a safe wage and an entrepreneur earning risky profits. While he considers entrepreneurial risk-taking under occupation-dependent taxation, he does not derive optimal tax policies. In this regard, his work is close in nature to calibrated dynamic general equilibrium models used to assess the effects of stylized tax reforms (see, for example, Meh, 2005; Cagetti and De Nardi, 2009).

Moresi (1998) and Scheuer (2013) analyze optimal tax policies in models of asymmetric information with occupational choice, where the government faces a trade-off between efficiency and equality.⁸ The distinctive feature of our model is that we analyze optimal tax policies and the investment of tax revenues in basic research. This means that the government can simultaneously affect the share of entrepreneurs in an economy and their innovativeness. We show that in such circumstances efficient policies make use of a taxation pecking order. Notably, in our model investments in basic research that allow for efficiency gains in aggregate should be accompanied by low profit taxes and high labor income taxes.

⁷Allen (1982) had previously presented a model with two types of workers, skilled and unskilled, who can choose between two types of labor. In his model, however, workers perfectly select into these types of labor on the basis of their skill-group. In that sense, his model is closer in nature to Feldstein (1973) and Stiglitz (1982), who consider optimal taxation with two types of workers but no occupational choice. All of these papers also consider one tax instrument only.

⁸Hauffer 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 has 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 the case of failure.

Growth policies can have important distributional effects. In the case of basic research investments and taxation, these effects can be particularly pronounced. Our paper is thus related to a large literature on the political feasibility of growth policies.

A classical benchmark on majority voting on linear income taxes as developed in Romer (1975), Roberts (1977), and Meltzer and Richard (1981) suggests that if income distribution is skewed to the right voting will result in inefficiently high tax rates. Persson and Tabellini (1994) and Alesina and Rodrik (1994) were among the first to incorporate such politico-economic considerations 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. We consider an R&D-based growth model as opposed to an investment-based growth model. As in Alesina and Rodrik (1994), the government can engage in productive government expenditures which, however, only affect the economy indirectly via innovating entrepreneurs. We show that in our model greater inequality also hinders growth-stimulating policies. However, this conflict of interests between growth policies and redistribution can be resolved if (constitutional) tax bounds are sufficiently flexible. The intuition is that tax policies impact indirectly on economic growth via the occupational choice of potential entrepreneurs, which is shaped by relative, rather than by absolute tax rates.

Our main results have a series of other interesting implications. Among others, they relate to the literature on constitutional design for tax policies and on fiscal capacity. We detail these implications and the associated literature in section 7.

3 The model

The economy is populated by a continuum of households of measure $\bar{L} > 1$. Households derive utility $u(c) = c$ from a final consumption good. Each household either inelastically supplies one unit of homogeneous labor or chooses to become an entrepreneur, as shown below. Households are indexed by k ($k \in [0, \bar{L}]$).

3.1 Production

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

We assume that intermediate goods x are indivisible, i.e. $x(i)$ is either 1 or 0.⁹ The final good is chosen as the numéraire with its price 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 its profits π_y :

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

by choosing the quantities $x(i) \in \{0, 1\}$ and the amount of labor L_y . The variable w denotes the wage prevailing in the market for labor. If the final-good producer chooses $x(i) = 1$ for all i , the demand for labor in final-good production will be:¹⁰

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

3.2 Behavior of intermediate-good producers

Each intermediate good can be produced by a given standard technology using $m > 0$ units of labor. Hence, marginal production costs when using the standard technology

⁹As we explain in more detail later, we consider the case of labor-saving technological progress in the intermediate-good 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 and hence to political conflicts in our economy. We discuss these in detail in section 6. Three remarks are in order at this stage: first, our finding of the optimality of a taxation pecking order relies neither on labor-saving technological innovation nor on the indivisibility of intermediates. It follows rather from the complementarity of basic research and the occupational choice of potential entrepreneurs. Second, we believe that the conflict between equality and efficiency in our economy is broadly in line with the decreasing shares of labor income in aggregate income, in particular for low-skilled labor, that can be observed in the EU and the US (cf. footnote 44). 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 45).

¹⁰We will show that $x(i) = 1 \forall i$ indeed holds in the unique equilibrium with positive production.

are mw . We assume that the standard technology is freely available. If an entrepreneur engages in research and development and successfully innovates, the labor input per unit of the respective intermediate good declines by a factor γ ($\gamma < 1$), leading to marginal production costs of γmw for this good. The innovating entrepreneur obtains a monopoly and offers his unit of the intermediate good at a price equal to the marginal cost of potential competitors, mw , thereby gaining profit $\pi_{xm} = (1 - \gamma)mw$.^{11,12} If no innovation takes place, Bertrand competition yields an equilibrium price of mw as well, implying zero profits for all producers of the intermediate good under consideration.¹³

Our set-up involves distributional conflicts regarding the desirability of labor-saving innovations. The innovative entrepreneur possesses the market power to reap the entire direct benefit of innovation while the final good firm benefits indirectly through lower wages leading to higher output and profits. Workers are harmed as wages decline. Our set-up is partly motivated by declining labor shares in aggregate income (Timmer et al., 2010; Karabarbounis and Neiman, 2014) and the literature relating this trend to innovations that replace low-skilled labor (Acemoglu and Restrepo, 2016, 2017; Hemous and Olson, 2014).¹⁴ If innovation rents were shared more broadly, for example, by directly increasing consumer surplus, the redistributive conflict may weaken but will

¹¹We refer to the process of innovative entrepreneurs capturing the market for the respective intermediate good with a new technology as *creative destruction*. Creative destruction is often used in the context of the innovator destroying the profits of an incumbent. The small difference in our case is that the market for the old technology is destroyed, but no profits, as the old technology is freely available. We discuss the political economy implications of introducing incumbents' profits in section 7.

¹²While the model is static, for an interpretation in a dynamic context we assume that a new innovative technology becomes publicly available for use after one period. This means that patents expire after one period or, if secrecy protects the monopoly rents, that the technological knowledge will spill over after one period.

¹³As we explain in section 3.3, we consider the case of no duplication of research efforts implying that there will be at most one successful innovator for each intermediate good. Note that there would also be only one successful innovator if we allowed for patent races as in this case the unique subgame perfect equilibrium would be such that upon successful innovation by one entrepreneur any competing entrepreneur would immediately terminate his R&D efforts anticipating that Bertrand competition among successful entrepreneurs would eliminate profits. Patents or secrecy then result in monopoly power of the innovative entrepreneur. Therefore, there is no competition pushing prices down to the marginal production costs under the new technology γmw . Intermediate good producers with the old technology are driven out of the market by the innovative entrant via limit pricing, similar to a set-up with divisible intermediate goods but non-drastic innovation (cf. footnote 45). However, if there is no successful innovation on the production of an intermediate good, Bertrand competition will ensue as the final good producer demands exactly one unit of the intermediate good and the old technology is not protected from use. This yields a price equal to marginal costs and zero profits in the intermediate sectors without innovation. At a more general level, this resembles the characteristics of perfectly competitive markets that would be the natural outcome in intermediate good sectors without innovation if the intermediate goods were divisible.

¹⁴We discuss this point further in footnote 44.

not disappear unless wages increase from innovation as well. On the other hand, there may exist even stronger distributional conflicts if incumbent intermediate firms can earn positive profits. We will allow for varying degrees of distributional conflicts in our political economy analysis by letting the median voter own a fraction s of final good producers' profits, and will discuss an extension with positive incumbents' profits in section 7. We note that if the tax system is able to support entrepreneurial policies in the set-up studied in this paper, it will also be possible in situations with more moderate distributional conflicts.

3.3 Innovation

There is a subset of individuals with measure 1, $[0, 1] \subset [0, \bar{L}]$, 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 and where 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 to take into account immaterial costs (such as cost from exerting effort 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, or social status) associated with entrepreneurial activity.^{15,16} Agents with a higher index k have lower utility factors. A utility factor $\lambda_k < 1$ represents net immaterial cost of being an entrepreneur, while factor $\lambda_k > 1$ represents net immaterial benefits.¹⁷ For individuals k with $\lambda_k = 1$, and thus $k = 1 - \frac{1}{b}$, immaterial costs and benefits associated with entrepreneurial activities cancel out. We define $k^{crit} = \max\{1 - \frac{1}{b}, 0\}$. If b is small and hence k^{crit} is small or even zero, the society is characterized by a population of potential entrepreneurs for whom effort costs matter most. If b is large and hence k^{crit} is large, the potential entrepreneurs enjoy being one compared to a worker. We assume that λ_k is private

¹⁵We use a multiplicative rather than an additive form to capture costs and benefits from entrepreneurship. A detailed rationale will be provided in footnote 30.

¹⁶Cf. footnote 31 for a discussion on how differences in risk-attitudes may give rise to occupational choice effects similar to the ones arising from our immaterial benefit factor λ_k .

¹⁷Our concept of immaterial utilities associated with being an entrepreneur is in line with empirical evidence (cf. Douglas and Shepherd, 2000; Hamilton, 2000; Praag and Versloot, 2007; Benz and Frey, 2008; Benz, 2009; Fuchs-Schündeln, 2009). Most studies find that entrepreneurship involves positive non-monetary benefits. Fuchs-Schündeln (2009) shows that there is heterogeneity across the population in such immaterial utilities and that they may be negative for some households.

information and hence only observed by agent k .¹⁸

The chances of entrepreneurs of successfully innovating can be fostered by basic research. Basic research generates knowledge that can be taken up by entrepreneurs and transformed into innovations that improve their production process. Specifically, suppose that the government employs L_B ($0 \leq L_B \leq \bar{L}$) researchers in basic research. Then the probability that an entrepreneur will successfully innovate is given by $\eta(L_B)$, where $\eta(L_B)$ fulfils $\eta(0) \geq 0$, $\eta'(\cdot) > 0$, $\eta''(\cdot) < 0$ and $\eta(\bar{L}) \leq 1$.¹⁹ Depending on whether $\eta(0) = 0$ or $\eta(0) > 0$, basic research is a necessary condition for innovation or not.

Accordingly, if a subset of measure L_E of the population decided to become entrepreneurs and the probability of success for each of them was $\eta(L_B)$, the share of intermediate-good industries with successful innovation would be equal to $\eta(L_B)L_E$, and the aggregate labor saved through innovations in the intermediate good sector is given by $\chi(L_B)L_E$, where:²⁰

$$\chi(L_B) := \eta(L_B)m(1 - \gamma) . \quad (4)$$

This is illustrated in Figure 1a), which depicts the amount of labor employed in intermediate good production by the successfully innovating entrepreneurs and by those producing with the old technology. The shaded area reflects the total amount of labor saved through innovations in the intermediate good sector. We note that property $L_E \leq 1$ enables entrepreneurs to perform research on a variety of the intermediate good different from others.²¹

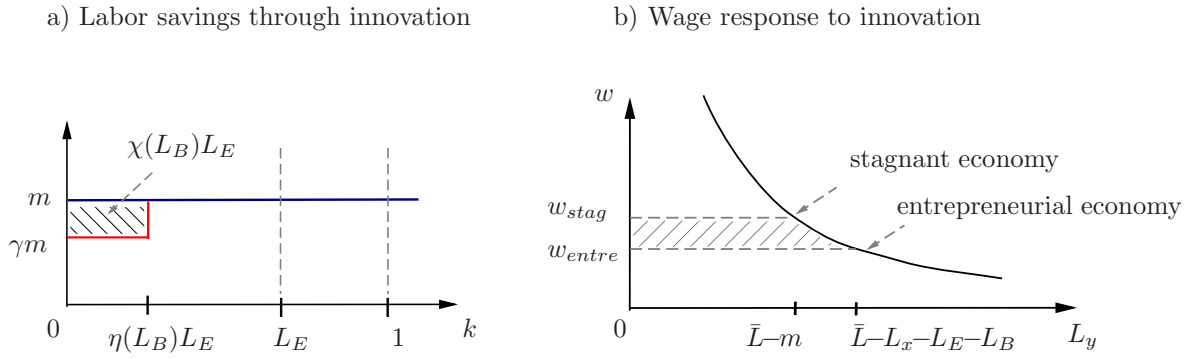
¹⁸This does preclude conditioning taxation on λ_k . We note that if λ_k is common knowledge but tax policies do not condition thereon our results will remain unaffected.

¹⁹ $\eta'(\cdot)$ and $\eta''(\cdot)$ denote the first and second derivative, respectively, of $\eta(\cdot)$ with respect to L_B .

²⁰We can apply the law of large numbers to a continuum of random variables as e.g. developed by Uhlig (1996).

²¹Strictly speaking, we assume that there is no duplication of research efforts. If research duplication is included in the model as a purely wasteful activity, formulations in which several researchers compete for innovation on one variety would imply decreasing benefits from basic research for entrepreneurs and for the society. Next to being a purely wasteful activity, increased competition among applied or basic researchers could reduce the expected time for new research results or patents to be produced. If several research teams work on similar topics, they may also produce some complementary results. In this way, there is a trade-off between some wasteful research duplication and competition. It ultimately depends on the precise costs and benefits whether competition may be beneficial. With respect to basic research, for example, the government would certainly not fund several Large Hadron Colliders, but might be willing to give research grants to several groups of economists working on optimal tax policy and economic growth.

Figure 1: Labor saving innovation in intermediate good sector and wage response



3.4 Financing scheme

Public expenditures on basic research are financed by taxes. There are many reasons why basic research should be – and actually is, to a large extent – publicly funded.²² One of them is its public-good characteristics, together with the non-patentability of basic research. This is the reason for public financing of basic research in our model. While entrepreneurs could, in principle, invest in basic research, they have no incentive to do so as their influence on the aggregate amount of basic research, which determines their innovation probability, is negligible.²³ There are two sources of income on which the government can levy taxes: labor income or profits (in intermediate- and final-good production). We consider two scenarios involving lump-sum taxation. In our base case, we assume that the government can levy lump-sum taxes or make lump-sum transfers.²⁴ In the working-paper version of our paper (Gersbach et al., 2014), we examine the case where 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 the lump-sum tax or transfer. We assume that there are upper bounds (and potentially lower bounds) for labor income and profit taxes. Upper bounds on taxation may either be specified explicitly in the constitution or they may arise implicitly from

²²We provided reasons for public funding of basic research in footnote 6.

²³Technically speaking the impact is zero, as an individual entrepreneur is of measure zero in the continuum of entrepreneurs.

²⁴Our model allows for unsuccessful entrepreneurs earning zero profits. Consequently, if 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 that could be drawn upon by the government in this case. Moreover, we will be examining the case where lump-sum taxation is not feasible.

fiscal capacities in the spirit of Besley and Persson (2009), for example.²⁵ We denote the upper and lower bounds by \bar{t}_j and \underline{t}_j , $j \in \{L, P\}$, respectively.²⁶ For our theoretical analysis we assume that the upper bounds are strictly smaller than 1, i.e. $\bar{t}_j \leq 1 - \varepsilon$ for some arbitrarily small $\varepsilon > 0$.²⁷

The government is free to set the tax rates within these bounds, however, we assume that it needs to run a balanced budget, i.e. the government budget constraint is given by:

$$wL_B = t_L(\bar{L} - L_E)w + t_P(\pi_y + \eta(L_B)L_E\pi_{xm}) + t_H\bar{L}, \quad (5)$$

where $t_H = 0$ in the scenario without lump-sum taxes.²⁸

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

²⁵Alternatively, 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 may 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 may affect the labor/leisure choice of workers and hence be effectively bound from above.

²⁶Lower bounds on profit taxes, in particular, may 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 that is intended to tackle harmful competition in the field of business taxation (European Union, 1998). Although this code of conduct does not explicitly define 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.

²⁷We choose $\varepsilon > 0$, as tax rates of 100% are economically implausible and to avoid dealing with $\tau := \frac{1-t_P}{1-t_L} = \infty$, which will feature prominently in our subsequent analyses. Note, however, that our formal results do not depend on ε being positive.

²⁸We assume that the tax bounds are exogenous to the government, since the sources such as the quality of tax institutions, constitutional bounds, limits to taxation arising from Laffer curve effects, or international tax competition are taken as given. Tax bounds may be endogenous at least in the long run, potentially giving rise to commitment problems for governments who might be tempted to attract entrepreneurs by promising strong tax incentives and to ex-post tax away the innovation gains to benefit the majority of their electorate. While such time-inconsistency problems can be a serious obstacle to foster an entrepreneurial economy, they may be less relevant in practice for at least three reasons. First, if tax bounds are enforced by independent constitutional courts, the government cannot quickly affect such decisions. Second, exploiting current entrepreneurs by high profit taxes simultaneously destroys the incentives of the next generation to become entrepreneurs, and thus turns an entrepreneurial economy into a stagnant one. As long as the future is sufficiently important, a government would refrain from imposing high profit tax rates. Third, any potential bounds arising from Laffer curve effects or international tax competition are mostly exogenous to national governments also in the long-run.

and chooses a financing scheme.

- (2) A share L_E of the population decide to become entrepreneurs. With probability $\eta(L_B)$ they will 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 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 for given policies

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 (a) employment as workers and (b) the attempt 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. If both occupations are chosen in equilibrium, the marginal entrepreneur has to be indifferent between being employed as a worker and becoming an entrepreneur. The expected net profit of an entrepreneur who sells $x(i) = 1$ 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:

$$\chi(L_B) := \eta(L_B)m(1 - \gamma) ,$$

scaled by the wage rate net of profit taxes.²⁹ Hence the expected utility for an individual k with (dis-)utility factor $\lambda_k = (1 - k)b$ from being an entrepreneur is:³⁰

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

If $EU^E(k) = (1 - t_L)w$, the individual is indifferent between being employed as a worker and becoming an entrepreneur. Solving for the indifferent entrepreneur's index k yields the equilibrium amount of entrepreneurs denoted by L_E^e as:³¹

$$L_E^e = \max \left\{ 0; 1 - \frac{1 - t_L}{1 - t_P} \frac{1}{\chi(L_B)b} \right\} . \quad (6)$$

We note that L_E^e is independent of the wage level. Higher wages are associated with higher profits from entrepreneurship and, of course, imply higher labor income. In the following we use:

$$\tau := \frac{1 - t_P}{1 - t_L} \quad (7)$$

as an abbreviation for $\frac{1 - t_P}{1 - t_L}$, with the upper and lower bounds of τ denoted by $\bar{\tau}$ and $\underline{\tau}$ being defined by the respective bounds of t_L and t_P . τ is a measure of tax incentives

²⁹The total profits by the entrepreneurs are implicitly captured by the shaded area in Figure 1a), which reflects the total amount of labor-saving by innovation in the intermediate good sector. Multiplying the size of this area by the wage rate w therefore yields the entrepreneurs' profits.

³⁰Note that we have chosen a multiplicative functional form. An alternative approach is to use an additive functional form by deducting the cost (see, for example, Boadway et al., 1991; Scheuer, 2013). 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 in reflecting effort costs and social status benefits, in particular, as these would typically be related to profits. For $\lambda_k < 1$ the effort costs 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.

³¹In our model potential entrepreneurs differ in their immaterial costs 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 entrepreneurs. We note that a similar result for the occupational choice would arise if agents differed in their 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 $F_{r_k}(0) = 0$ and $\frac{dF_{r_k}(\cdot)}{dr_k} > 0, \forall r_k \in [0, 1)$. 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. Now, if $(1 - t_P)m(1 - \gamma) \leq 1 - t_L$, the after tax profit of a successful entrepreneur is smaller than his after tax wage, implying that there will always be 0 entrepreneurship in equilibrium. Suppose, by contrast, that $(1 - t_P)m(1 - \gamma) > 1 - t_L$. Then all potential entrepreneurs with $r_k \leq 1 - \frac{\ln(\eta(L_B))}{\ln(1 - t_L) - \ln((1 - t_P)m(1 - \gamma))}$ will become entrepreneurs and the equilibrium number of entrepreneurs is given by $L_E = F_{r_k}(r^{crit})$, where $r^{crit} = \max \left\{ 0; 1 - \frac{\ln(\eta(L_B))}{\ln(1 - t_L) - \ln((1 - t_P)m(1 - \gamma))} \right\}$. As for the case with heterogeneous immaterial costs and benefits from being an entrepreneur, entrepreneurship is increasing in m , t_L , and L_B , decreasing in t_P and γ , and independent of w . However, basic research has an additional effect here. Besides increasing the expected profit from being an entrepreneur, it affects associated entrepreneurial risks.

given to (potential) entrepreneurs.³² Moreover, let $\bar{\tau} \geq 1 \geq \underline{\tau}$, implying that a neutral tax policy $t_L = t_P$ is always possible.

Knowing L_E^e from (6), we obtain the amount of labor employed in the production of intermediates as:

$$L_x^e = \int_0^1 L_x(i) di = m - \chi(L_B)L_E^e, \quad (8)$$

if $x(i) = 1 \forall i$. This corresponds to the amount of labor necessary to produce the intermediate goods with standard 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 characterize the equilibrium for given basic research and given tax policy. Due to the indivisibility of the different varieties of the intermediate goods, we have to consider the case where despite diminishing returns to intermediate goods in final-good production, the final-good firm will not use all the different varieties or may even go out of business and not produce at all. In appendix B.1, we show that in any equilibrium with positive production in the final-good sector, the final-good producer will use all varieties of intermediate goods and intermediate-good producers supplying their product will charge $p(i) = mw$.

Naturally, a positive level of production in the final good sector will only occur if profits are non-negative.³³ This depends on the particular governmental policy (L_B, τ) and we

³²Empirical evidence in the literature suggests that the tax structure does indeed influence the level of entrepreneurial activities in an economy. Using cross-sectional data from US personal income tax returns, Cullen and Gordon (2007) estimate the impact of various tax measures on entrepreneurial risk-taking as proxied by an indicator variable for whether or not an individual reports business losses greater than 10% of reported wage income. They find that a cut in personal income tax rates significantly reduces entrepreneurial risk-taking. The evidence for a cut in corporate tax rates is less clear. Depending on the model specification used, such a cut is predicted to either raise or not significantly affect entrepreneurial risk-taking. As the risk-sharing of non-diversifiable entrepreneurial risks with the government is positively related to the corporate income tax rate, Cullen and Gordon interpret their results as being in line with their theory. 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 significantly adverse effect on aggregate investment and entrepreneurship. Da Rin et al. (2011) find that corporate income taxes significantly reduce firm entry in a panel of 17 European countries. Gentry and Hubbard (2000) analyze 1979 to 1992 data from the Panel Study on Income Dynamics and find that less progressive tax rates significantly increase entrepreneurship.

³³As the final-good producer always uses one unit of each intermediate, the cost of intermediates are essentially 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 operations are not large enough to compensate for these fixed costs.

provide the precise Positive Profit Condition in appendix B.1.³⁴ We need to distinguish the different cases in the equilibrium characterization.

Proposition 1

(i) If L_B and τ allow for positive profits of the final-good producer, there is a unique equilibrium with $x^e(i) = 1 \forall i$ and:

$$(1) L_E^e = \max \left\{ 0; 1 - \frac{1}{\tau\chi(L_B)b} \right\}$$

$$(2) L_x^e = m - \chi(L_B)L_E^e$$

$$(3) L_y^e = \bar{L} - L_B - m + L_E^e [\chi(L_B) - 1]$$

$$(4) w^e = (1 - \alpha) (L_y^e)^{-\alpha}$$

$$(5) p^e(i) = m(1 - \alpha) (L_y^e)^{-\alpha} \forall i$$

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

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

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

(ii) If L_B and τ do not allow for positive profits of the final-good producer, there is a unique equilibrium with $x^e(i) = 0 \forall i$, $L_E^e = L_x^e = L_y^e = 0$, zero output, and zero profits.

In appendix B.1, we derive the Positive Profit Condition regarding governmental policy (τ, L_B) and provide the proof of Proposition 1. In the remainder of the paper, we will use the equilibrium of Proposition 1, and simplify the notation by disposing of superscript e in all expressions. We will focus on case (i) of Proposition 1, in which the economic activities are viable. In particular, we make the following assumption.

Assumption 1

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

Assumption 1 ensures that any aggregate-consumption-optimal policy (t_L, t_P, t_H, L_B) will yield an equilibrium with positive final-good production. As we show in 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 the Positive Profit Condition, then so does the optimal policy choice. Assumption 1 guarantees that there will be non-negative profits

³⁴This condition depends only on parameters of the model and on government policy.

in a stagnant economy with zero basic research and innovation and it therefore allows us to neglect the Positive Profit Condition in the government's optimization problem.³⁵

5 Optimal growth policies

The government can affect the previously established equilibrium outcomes by investing in basic research and via the tax scheme. We begin our discussion of optimal growth policies with some preliminary considerations before turning to the government's maximization problem.

5.1 Preliminary considerations

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 entrepreneurial activity, the individual saves in expectation more labor in intermediate-good production than the unit of labor he could provide the labor market with himself. However, even if entrepreneurship had a negative impact on labor supply in final-good production and hence on output (i.e. if $\chi(L_B) < 1$), individuals may find it worthwhile to become entrepreneurs due to immaterial benefits and tax policy τ . To allow for both corner and interior solutions for entrepreneurship and output-increasing and output-decreasing entrepreneurship, we make the following assumption:

Assumption 2

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

Assumption 2(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 second inequality in (ii) enables the government to preclude output-reducing entrepreneurship by implementing a neutral tax policy and not investing in basic research. That is, the government can fully suppress entrepreneurship by choosing $L_B = 0$ and $\tau = 1$. By contrast, the first inequality in (ii) ensures that in the situation with output-increasing entrepreneurship, the government will be able to induce a positive measure of individuals to become entrepreneurs via its tax policy.

³⁵Assumption 2(ii) below will guarantee that such a stagnant economy is always feasible.

We now derive optimal policies when lump-sum taxes or lump-sum 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 τ , the assumption of lump-sum transfers enables us to separate the choice of L_B from the choice of the government's tax incentives to (potential) entrepreneurs.³⁶ If no lump-sum taxes and transfers are available, the choices of τ and L_B cannot be separated in all cases. We discuss these issues in the appendix of the working-paper version of our paper (Gersbach et al., 2014) and leave out of account such problems in the next section.

5.2 Optimal growth policy

We focus on a government seeking to maximize material welfare.³⁷ The government's problem 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, τ , while either levying an additional lump-sum tax if labor and profit taxes satisfying optimal τ do not suffice to finance the desired amount of L_B or making a lump-sum transfer in the case of the revenue generated by τ being larger than required for basic research expenditures:

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

³⁶Given that basic research investments account for a share of government expenditures only, the scenario with lump-sum taxes may 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 that can be produced by a one-to-one transformation of the consumption good and enters households' utilities as follows: $u(c, g) = c + \frac{g}{L}$.

³⁷In the working-paper version of our paper (Gersbach et al., 2014), we consider the case where the government's objective additionally includes the immaterial welfare component, the entrepreneurs' (dis-)utility from being an entrepreneur. We show that our main insight regarding the taxation pecking order prevails and may be reinforced with the broader welfare measure that additionally accounts for the utility costs and benefits from becoming an entrepreneur. The scenario where the government only considers material welfare is arguably more realistic, as the utility from being an entrepreneur cannot be observed directly by the government. Moreover, it is the key benchmark for our subsequent political economy analysis.

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:

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

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:

$$y(\tau, L_B) = [\bar{L} - L_B - m + L_E[\chi(L_B) - 1]]^{1-\alpha} . \quad (9)$$

Maximizing (9) is equivalent to maximizing $L_y = \bar{L} - L_B - m + L_E[\chi(L_B) - 1]$, which we will use in the following. Figure 1 illustrates the underlying trade-off: Higher basic research expenditures (L_B) and higher tax incentives for entrepreneurship (τ), on the one hand, reduce L_y by increasing L_B and L_E [see Figure 1 b)] and, on the other hand, increase L_y by decreasing L_x via labor saving innovation [shaded area in Figure 1a)]. Consequently, the government will only increase L_B and τ if justified by the additional labor savings in the intermediate good sector.

It will be useful and 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 optimal basic research investments. In the first step of optimization, the Kuhn-Tucker conditions with respect to the optimal tax policy are:

$$\frac{\partial L_E}{\partial \tau} [\chi(L_B) - 1] (\tau - \underline{\tau}) \geq 0 , \quad (10a)$$

$$\frac{\partial L_E}{\partial \tau} [\chi(L_B) - 1] (\bar{\tau} - \tau) \leq 0 , \quad (10b)$$

$$\frac{\partial L_y}{\partial \tau} (\tau - \underline{\tau}) (\tau - \bar{\tau}) = 0 . \quad (10c)$$

The term in brackets on the left-hand side of (10a) and (10b) expresses how much labor in intermediate-good production will be saved in expectation by an additional entrepreneur. We also observe in (10a) and (10b) 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 as when working in final-good production. From the definition of $\chi(L_B)$ (see equation (4)), we observe that only if the amount of basic research is larger than $L_{B,min} :=$

$\max\{0, \eta^{-1}(1/[m(1-\gamma)])\}$, where $\eta^{-1}(\cdot)$ denotes the inverse of $\eta(\cdot)$, will an increase in entrepreneurship be favorable for aggregate consumption.³⁸ Note that from (6) $\frac{\partial L_E}{\partial \tau}$ is non-negative and with $L_B \geq L_{B,min}$ strictly positive for τ in the neighborhood of $\bar{\tau}$ according to Assumption 2. Consequently, if $L_B > L_{B,min}$, the government benefits from increasing τ to its maximum to make entrepreneurship as attractive as possible. The opposite is the case if $L_B < L_{B,min}$. Then the government will aim at reducing the number of entrepreneurs to a minimum by setting τ at its lowest level.³⁹ The government's tax policy is indeterminate when $L_B = L_{B,min}$, and we assume that in this case it will set $\tau = \bar{\tau}$. Taken together, a strong version of a *taxation pecking order* is optimal where tax rates are located at opposing bounds of their respective feasible sets.

We summarize our findings in the next proposition.

Proposition 2 (Taxation Pecking Order)

For a given amount of basic research, L_B , the government levies taxes according to:

$$\tau = \begin{cases} \bar{\tau} & \text{if } L_B \geq L_{B,min} \\ \underline{\tau} & \text{if } L_B < L_{B,min} \end{cases} . \quad (11)$$

We 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 $L_B < L_{B,min}$. The first problem is:

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

³⁸Note that $\eta^{-1}(\cdot)$ exists since $\eta' > 0$ and that $L_{B,min}$ is positive by Assumption 2(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 strictly increase the number of entrepreneurs further. This is due to the fact that by our specification of the immaterial utility component of entrepreneurship, the corner solution $L_E = 1$ is precluded.

³⁹Note that for $L_B < L_{B,min}$, there are typically multiple tax policies that entirely discourage entrepreneurship. For instance, by Assumption 2(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 in such cases the government will implement $\underline{\tau}$, i.e. $t_L = \underline{t}_L, t_P = \underline{t}_P$.

which yields the necessary conditions for a maximum:

$$\frac{\partial L_E(L_B, \bar{\tau})}{\partial L_B} [\chi(L_B) - 1] + L_E(L_B, \bar{\tau}) \chi'(L_B) - 1 \leq 0, \quad (12a)$$

$$\frac{\partial L_y(L_B, \bar{\tau})}{\partial L_B} (L_B - L_{B,min}) = 0. \quad (12b)$$

Marginally increasing basic research investments has three different effects on final-good production. First, it improves the innovation prospects of the pool of entrepreneurs as reflected by the second term in equation (12a). Second, the increase in innovation prospects attracts additional entrepreneurs as reflected in the first term of equation (12a). Note that since $L_B \geq L_{B,min}$ (and hence $\chi(L_B) \geq 1$), this rise in entrepreneurship increases 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, which is the third effect. This marginal labor cost of basic research is reflected by the last term -1 in equation (12a). We use $\tilde{L}_B(\bar{\tau})$ to denote the solution of this constrained maximization problem. Note that if $\tilde{L}_B(\bar{\tau}) > L_{B,min}$, it will satisfy (12a) with equality.

With respect to the maximization problem constrained by $L_B < L_{B,min}$ with associated 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 will negatively affect final output and by Assumption 2 the government will be able to deter such inefficient entrepreneurship by not providing basic research.

Overall, 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*. The second situation without basic research investments and entrepreneurship is called a *stagnant economy*. The government will implement the policy with positive basic research investments and a tax policy favoring entrepreneurship if and only if this will lead 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 (equations (1) and (3)) that the government will opt for the entrepreneurial economy if and only if L_y in this case is larger than $\bar{L} - m$ and thus if

and only if it satisfies the following Positive Labor Savings (PLS) condition:⁴⁰

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

We summarize 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) Otherwise, 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 γ , the more likely it is that an entrepreneurial economy will be optimal.

The proof of Corollary 1 is given in appendix B.2. Corollary 1 implies that the more valuable innovations are, i.e. the higher m is and the lower γ is, the more likely it is that we will observe an entrepreneurial economy. Further, an entrepreneurial economy is more likely, the higher the maximum admissible level of τ , $\bar{\tau}$, is and the higher the utility benefits (the lower the utility costs) derived from becoming an entrepreneur will be, i.e. the higher b is. Intuitively, the higher $\bar{\tau}$ and b are, the higher the number of entrepreneurs will be who are willing to take up knowledge from basic research investments in the entrepreneurial economy and hence the more attractive entrepreneurial policies will be.⁴¹

⁴⁰This case is illustrated in Figure 1, where the condition says that the amount of labor employed in final good production in the entrepreneurial economy is larger than in the stagnant economy. Rewriting condition PLS as $L_B + L_E \leq \chi(L_B)L_E$ reveals the trade-off described earlier: Labor saving in the intermediate good sector must be larger than the number of basic researchers and entrepreneurs.

⁴¹An entrepreneur compares the wage with the utility received from being an entrepreneur. This is the key trade-off a potential entrepreneur faces and determines the private value of entrepreneurship. The occupational choice of a potential entrepreneur, however, has various further effects on the economy which determine the social value of entrepreneurship. In particular, this choice will impact wages,

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 τ was feasible. In the working-paper version of our paper (Gersbach et al., 2014), we show that the pecking order result also holds when lump-sum taxes or transfers are not available.⁴²

6 Political constraints on growth-oriented entrepreneurial policies

So far we have adopted the viewpoint of a government that seeks to maximize aggregate consumption and disregards distributional effects. Our analyses of the previous sections suggest that innovation-stimulating investments in basic research should be complemented by a taxation pecking order. However, such innovation policies may have substantial distributional effects, in particular when there is inequality in the shareholdings of the final-good producer. Since basic research investments support labor-saving technological progress in the intermediate-good sector, labor is set free in the intermediate-good sector and additionally supplied to final-good production.⁴³

which in turn will feed back into profits earned by final good producers and by other entrepreneurs. Further, a higher number of entrepreneurs increases the marginal product of the public good ‘basic research’, and therefore affects the amount of basic research provided by the government. Being a pure public good, the additional amount of public research increases the innovation success probabilities of all entrepreneurs. With sufficiently high basic research, the net effect of entrepreneurship will be positive, inducing the government to attract additional entrepreneurs via tax policies. This is the complementarity reflected in the optimal *joint* policies outlined in Proposition 3.

⁴²In our model, we assume that basic research is a public good that increases the probability of innovation by the same amount in the different intermediate good sectors. The survey by Salter and Martin (2001) shows that there is great heterogeneity in the relationship between basic research and innovation across sectors. Including such heterogeneity in our model would not substantially affect the main mechanisms considered here. It would imply, however, that the government wants to concentrate basic research spending in sectors with particularly high effect on innovation probabilities. Depending on whether or not there is asymmetric information about innovation prospects, entrepreneurs self select into sectors with the highest innovation probability and there may or may not be a case for differential tax treatment of entrepreneurship in different sectors, if possible. In reality, we observe some spending priorities of governments or supra-governmental bodies like the EU when it comes to basic research (such as e.g. priorities for basic research in the United Kingdom in House of Lords (2010), or the EU Horizon 2020 priorities under <https://ec.europa.eu/programmes/horizon2020/>). However, we do not normally observe different tax treatment of entrepreneurs in different sectors. One of the reasons is that sector classifications of profits can easily be manipulated in firms operating in multiple industries.

⁴³Note that without declining wages due to wage rigidities, the final good firms would not employ extra labor set free by labor saving innovation in the intermediate good sector. In this case, labor saving innovation will lead to unemployment rather than increased output. While several countries have rigid wages, they are typically nominally fixed so that they will decline over time in real terms due to inflation if such inflation is present. Moreover, in many European countries we observed labor market reforms that effectively reduced real wages and made labor markets more flexible to reduce

This increases output and the profits of the representative final-good producer, but it also lowers wages.^{44,45} Then, as we will see below, a share of individuals is worse off under an entrepreneurial policy vis-à-vis a stagnant economy. Hence, while ownership in the final-good firm is irrelevant for consumption-maximizing policies, it is crucial for the distributional effects of such policies. It is therefore by no means obvious that a change to an entrepreneurial policy will be supported politically. In this section we explore these distributional effects and indicate when policies fostering entrepreneurship are politically viable.

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

unemployment. Hence in some countries the increase in total output may realize over the medium term rather than in the short run. Additionally, high labor taxes may drive people into own employment where they live on low dividends. We note, however, that for workers to resort to an outside option possibly in the informal sector, this option must be at least as good as working in the formal sector. Including such an outside option with fixed income would then present a way of endogenously deriving the upper tax bound on labor taxes. Another very interesting extension would be to include a labor supply choice by the households who can decide on the hours they work in the formal sector or in own employment. In this case, higher labor taxes would reduce the labor supply at the margin, thereby moderating our results while keeping our main mechanism intact.

⁴⁴These 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 in the European Union the 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, while in the US it increased from 18.5% to 30.4%. See also Karabarbounis and Neiman (2014).

⁴⁵With 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 standard technology, and the innovative 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 innovation step γ 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 used in production. 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 a higher marginal product of labor. Note that with constant gross wages, a conflict between efficiency and equality 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 will earn zero profits, and benefits from innovation accrue to the successful entrepreneurs. So, in such circumstances, shareholdings in the final-good firms do not matter for the distribution of gains from innovation.

voter is an employee (i.e. a worker in final or intermediate-good production or a basic researcher) with a fraction $s \geq 0$ of the per-capita shares in the final-good producer's profits.⁴⁶ Consequently, her after tax income is:

$$I = (1 - t_L)w + (1 - t_P)s\frac{\pi y}{L} - t_H .$$

An entrepreneurial policy is politically viable if it is supported by the median voter. The most common interpretation is as follows: We order voters according to their shares in final-good production and 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 A.1 we rationalize this interpretation within our model set-up. Due to constitutional provisions or lobbying, etc., the decisive individual may differ from the individual with the median amount of shares. Our political economy analysis is flexible enough to accommodate such settings by adjusting the shareholdings of the decisive individual, s , accordingly.

We will now characterize the preferred policy of the median voter. In doing so, we restrict our analysis in two ways: first, we restrict attention to *growth-oriented* entrepreneurial policies, where here and below we say that an entrepreneurial policy (and the associated entrepreneurial economy) is growth-oriented if it yields an increase in final-good production vis-à-vis the stagnant economy. Second, we focus on lump-sum redistribution and leave to future research considerations regarding targeted transfers to a fraction of workers only.⁴⁷ To simplify the exposition we further 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,

⁴⁶Of course, this includes the special case where the median voter is a worker without any shares. This occurs when a fraction $\frac{1}{2} < \mu < 1$ of the population are workers who do not own shares in the final-good producer. The situation where a majority of the population are workers who are not engaged in the stock market is in line with empirical evidence on stock market participation rates. Guiso et al. (2008), for example, establish for a selection of 12 OECD member states percentages of households that are engaged in the stock market. Even if indirect shareholdings are taken into consideration, Sweden is the only country where a majority of households is engaged in the stock market. In most countries, fewer than one-third of households hold shares.

⁴⁷Analytically, 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 a growth-oriented 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 she owns less than a fraction $\frac{\bar{L}}{L+(1-\gamma)m}$ of the per-capita shares in the final-good producer. The reason is that in such case the gross income of the median voter is decreasing in aggregate output, as shown in the proof of Proposition 5. Hence she can be no better off in the growth-oriented entrepreneurial economy than in the stagnant economy with $t_L = t_P = 0$. Note that the condition discussed here is sufficient but not necessary for our result.

$$\tau \in [\underline{\tau}, \bar{\tau}] := \left[\frac{1-\bar{t}}{1-\underline{t}}, \frac{1-t}{1-\bar{t}} \right] \text{ and } \bar{\tau} < \infty.$$

Of course, since relative to a stagnant economy a growth-oriented entrepreneurial policy means falling wages and increasing final-good profits, the median voter will support an entrepreneurial economy if she possesses a sufficient amount of shares in the final-good firms. The more realistic and interesting case is when income is skewed in such a way that the median voter possesses less than the per-capita claims on final-good profits. In particular, we assume that $s \in \left[0, \frac{\bar{L}}{L+(1-\gamma)m} \right)$, which implies that the median voter's gross income, $w + s\frac{\pi_y}{L}$, decreases in aggregate output (see proof of Proposition 5 in appendix B.4).⁴⁸ The resulting trade-off follows immediately. On the one hand, wages are higher in the stagnant economy, and the median voter can maximally redistribute profits using the highest possible tax rate without considering incentives for occupational choice by potential entrepreneurs. On the other hand, the tax base is higher in a growth-oriented entrepreneurial economy, potentially allowing for higher redistributive transfers even if profit tax rates are lower. For this reason, an entrepreneurial economy may be preferred to a stagnant economy with maximal profit tax.

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

$$I = (1 - t_L)w + (1 - t_P)s\frac{\pi_y}{L} - t_H = w + s\frac{\pi_y}{L} + NT, \quad (13)$$

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

$$t_H = \frac{1}{L} \left[-t_Lw (\bar{L} - L_E) - t_P (\pi_y + \eta(L_B)L_E\pi_{xm}) + wL_B \right]. \quad (14)$$

One 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 τ and L_B . The levels of the labor- and profit-tax rates only matter for the degree of redistribution, as becomes apparent when we insert the lump-sum transfers (14) into the formula for the net transfers NT .⁴⁹

⁴⁸Note that when the population is ordered according to shareholdings in the final-good sector, we must have $s \in [0, 2)$.

⁴⁹Substituting the profits by their equilibrium values as provided in Proposition 1, we obtain for

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 τ and L_B . This will allow us to write the median voter's objective as a function of τ and L_B and consequently to determine the median voter's most preferred levels of τ and basic research investments L_B .

We discuss the median voter's maximization problem in detail in appendix A.2. In the first step in the optimization problem (for given τ and L_B), the median voter aims at setting t_L and t_P to maximize net transfers NT . In particular, we observe in the typical case that the median voter will either push t_L or t_P to its boundary \bar{t} . As a consequence, for any policy (τ, 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, may be constitutional in nature or reflect the state's capacity to collect taxes. Now any growth-oriented entrepreneurial economy involves a loss in gross income for the median voter that needs to be compensated for by transfers if it is to be politically viable. Whether the transfers are sufficiently large depends crucially on the upper bounds on taxation. As stated in the following proposition, any growth-oriented 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 economy over a stagnant economy.

The proof is given in appendix B.3. The intuition is straightforward: with \bar{t} sufficiently close to 1, it is feasible to implement any τ 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 τ 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

the net transfers to the median voter:

$$NT = \frac{w}{\bar{L}} \left[t_P \left[\left(\frac{\alpha}{1-\alpha} L_y - m \right) (1-s) + \chi(L_B) L_E \right] - t_L L_E - L_B \right]. \quad (15)$$

upper and lower bounds on taxation are too low, it will not be possible to provide both incentives for economic feasibility and redistribution for the political viability of an entrepreneurial economy.

Proposition 5

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

The proof of Proposition 5 is given in appendix B.4. 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, so the median voter will prefer the stagnant economy.

Using the results in Propositions 4 and 5, we argue in the next proposition that for every growth-oriented entrepreneurial policy there exists a unique level of \bar{t}_c making the policy politically viable in an economy with $\bar{t} \geq \bar{t}_c$ but not if $\bar{t} < \bar{t}_c$.⁵⁰

Proposition 6

Let $\underline{t} = 0$. For any growth-oriented 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 B.5. The key observation is now that each growth-oriented entrepreneurial policy is associated with a unique \bar{t}_c . Hence, considering the entire set of growth-oriented entrepreneurial policies, we can 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 or its fiscal capacity is sufficiently large to satisfy $\bar{t} \geq \bar{t}_{inf}$. We summarize this insight in the next corollary, which follows immediately from Proposition 6:⁵¹

⁵⁰More formally, let $\underline{t} = 0$ and fix any entrepreneurial policy $(\hat{\tau}, \hat{L}_B)$ with $\hat{L}_y > L_y^S$. Proposition 4 implies that this entrepreneurial economy will be preferred to 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 to 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 \bar{t}_c^u such that the entrepreneurial economy is feasible if $\bar{t} \geq \bar{t}_c^u$. We summarize these insights in Proposition 6 and show in appendix B.5 that these two threshold values coincide.

⁵¹Recall that we are disregarding policies with output-decreasing entrepreneurship and/or basic research.

Corollary 2

The median voter will opt for a growth-oriented entrepreneurial policy if and only if $\bar{t} \geq \bar{t}_{inf}$. Otherwise, the median voter will support 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. Upper bounds on taxation specified in the constitution are frequently 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 τ, L_B , workers with large shareholdings (i.e. $\tilde{s} > 1 + \frac{L_E[\chi(L_B) - \frac{1}{\tau}]}{\frac{\alpha}{1-\alpha}L_y - m}$) will prefer to have a low upper tax bound,⁵² this is not necessarily the case if the policy τ, L_B is determined in the political process. In such cases, wealthy households with at least as many shares as the median voter may prefer to have a higher \bar{t} . The following corollary is a manifestation of this logic:

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 $\tilde{s} > s$ will prefer living in an economy with \bar{t}_h to living in an economy with \bar{t}_l .

Corollary 3 follows immediately from consideration of the limiting case of $\bar{L} = \frac{m}{\alpha}$. Here the final-good producer has zero profits in the stagnant economy and shareholdings are worthless, irrespective of tax policies. Corollary 2 implies that the median voter with s shares will prefer any $\bar{t} \geq \bar{t}_{inf}$ to any alternative $\bar{t} < \bar{t}_{inf}$. As all individuals with shareholdings larger than s will benefit even more from the profits accruing in a growth-oriented entrepreneurial economy, they will also prefer $\bar{t}_h > \bar{t}_{inf}$ to $\bar{t}_l < \bar{t}_{inf}$.⁵³

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, supermajority rules might have similar effects in our model.⁵⁴ Some entrepreneurial

⁵²The result follows from the fact that for τ and L_B given, their net transfers decrease in t_P by equation (A.2).

⁵³A formal argument why all individuals with larger shareholdings than the median voter will prefer an entrepreneurial economy if the median voter does so is provided in appendix A.1.

⁵⁴Several US states have supermajority rules for tax increases (cf. National Conference of State Legislatures (2010); Gradstein (1999) provides a historical overview). In the past, similar clauses have also been proposed at the federal level, but they 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, there is a time-inconsistency in the government’s preferences, as

economies supported by the median voter may not be supported by voters with fewer shares and hence may not pass supermajority requirements.⁵⁵ 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.

6.1 Data overview and numerical example

In this section, we add empirical observations to our theoretical predictions. Unfortunately, the lack of data hinders a thorough empirical comparison of stagnant and entrepreneurial economies. We therefore pursue a dual approach. We begin by briefly describing the empirical counterparts of our key policy variables: basic research investments, corporate and labor income taxes. Table 6.1 depicts the values for all three variables in 2013 for a subset of OECD countries.⁵⁶ We provide information on all OECD countries in appendix C. Based on this data and data on fiscal capacity, we present a preliminary view on the relationship between tax bounds and basic research and tax stimuli for entrepreneurship, respectively. Second, we present a calibrated version of our theoretical model to illustrate entrepreneurial policies in an ‘ideal’ economy that exhibits key average characteristics of OECD member states.

Table 1: Data Overview^a

	Basic research exp. as perc. of GDP ^b	Corporate in- come tax rates ^c	Income tax rates at average wages ^c
Australia	0.45 ^d	30.0	23.1
Austria	0.56	25.0	34.4
Belgium	0.49	33.0	33.7
Chile	0.11	20.0	7.0
Czech Republic	0.62	19.0	14.6
Denmark	0.54	25.0	32.2
Estonia	0.37	21.0	16.4
France	0.54	38.0	22.7

the government would like to levy high taxes once private investments have been made. Supermajority rules can help resolve this time-inconsistency. Knight (2000) presents US-based evidence suggesting that supermajority requirements do indeed have a dampening effect on taxes.

⁵⁵Formally, in appendix A.1, we show that in our model the single-crossing condition holds for workers’ preferences over policies. In particular, in Lemma 2 we show that if a worker with shares \hat{s} prefers a growth-oriented entrepreneurial policy to the stagnant economy, then so do all workers with shares $s \geq \hat{s}$.

⁵⁶We have chosen the year 2013 as it gives a recent account and has one of the highest levels of data availability.

Table 1: Data Overview^a

	Basic research exp. as perc. of GDP ^b	Corporate in- come tax rates ^c	Income tax rates at average wages ^c
Greece	0.28	26.0	26.9
Ireland	0.30	12.5	14.3
Israel	0.40	25.0	16.4
Italy	0.33	27.5	28.8
Japan	0.44	28.1	20.0
Korea	0.75	22.0	12.9
Norway	0.29	28.0	26.7
Poland	0.23	19.0	20.8
Spain	0.27	30.0	19.0
Switzerland	0.90 ^e	8.5	14.0
United Kingdom	0.20	21.0	24.0
United States	0.48	35.0	20.6

^a All data is from the year 2013 if not noted otherwise.

^b *Source*: OECD (2016a).

^c *Source*: OECD (2016b).

^d Data from 2008.

^e Data from 2012.

Basic research amounts to non-trivial and growing-over-time shares of GDP: Most OECD countries devote a share of their GDP of around 0.4% to basic research. As table 6.1 illustrates, these investments vary across countries. While countries further away from the world technological frontier tend to spend less, e.g. Chile spends only slightly more than 0.1% of its GDP on basic research, Switzerland is an outlier at the top with almost 1% of GDP spent on basic research (OECD, 2016a).⁵⁷

Corporate income tax rates tend to be decreasing over time in most OECD countries, pointing to fiercer international tax competition which may be an important source of effective bounds on taxation in reality. The tax rates vary from lows of around 10% in Ireland and Switzerland to highs of around 35% in some countries including the U.S., with the vast majority of OECD countries having corporate income tax rates between 20% and 25% (OECD, 2016b).^{58,59} The personal income tax at average wages is within

⁵⁷Cf. Gersbach et al. (2015) for further details.

⁵⁸Note that profits of start-up entrepreneurs might first fall under the personal income tax scheme before the entrepreneurs incorporate. Moreover, depending on the tax bases as well as tax breaks and exemptions, the effective tax rates that companies have to pay on their profits can differ significantly from the statutory rates. We refer to Djankov et al. (2010) for a measure of effective corporate income tax rates in 2004 for 85 countries including almost all OECD countries.

⁵⁹In the case of Switzerland, cantons and local authorities levy additional taxes on corporate income. The corporate income tax rate therefore depends on the location of a firm. The effective tax rate can be as low as 12% in certain locations (<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-corporate-tax-rates.pdf>).

a range similar to the corporate income tax, with a low of less than 10% in Chile, and with most OECD countries between 15% and 25%. There seems to have been no trend over the last 15 years (OECD, 2016b). These tax rates apply to a person without children, and effective tax rates can vary with family status among other things. In trying to distil the essence of the large complexities of different countries' tax systems, Djankov et al. (2010) create a measure of effective corporate income tax rates in 2004 for 85 countries including almost all OECD countries. We use this data along with their data on labor taxes to construct our measure for the tax incentives for entrepreneurship τ . Among OECD member states, this measure varies from a low of around 0.74 in New Zealand to a high of around 1.38 in France.

Our theoretical analysis demonstrates that bounds on taxation may be important impediments to implementing growth policies in the political process. While, except for the case of Switzerland, countries do typically not have explicit constitutional bounds on taxation, such bounds in OECD countries implicitly arise from international agreements and from the following constitutional principles:

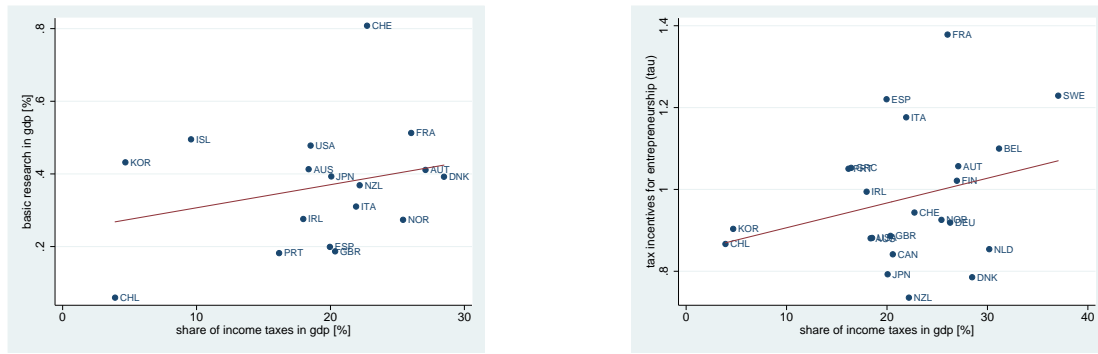
- the principle of equality, i.e. taxes must be applied impartially and equally
- the principle of ability to pay, i.e. taxpayers must be reasonably able to fulfill their fiscal obligations
- the principle of public purpose, i.e. a tax must have a public purpose and cannot be used for private ends.

For an in-depth analysis and comparative assessments see Vanistendael (1996); McLure and van Houtte (2011); De Caria (2017).

An alternative view on the tax constraints is that they arise from fiscal capacity. To give a first overview of the potential role of such constraints in shaping entrepreneurial policies, we combine the above data with a measure of the countries' capacity to collect taxes taken from Besley and Persson (2009): the countries' share of income taxes in GDP. We start with the relationship between basic research and fiscal capacity. It is well known that basic research is most and for all performed in industrialized countries, with developing countries spending very little.⁶⁰ While there are certainly other factors at play, considering that developing countries are precisely the ones with low fiscal capacity (cf. Figure 4 in section 7), this relationship is consistent with our theoretical predictions. Zooming in on OECD countries, the first graph in Figure 2 shows a positive

⁶⁰Cf. UNESCO (2015).

Figure 2: Fiscal capacity, basic research expenditures and tax incentives for entrepreneurship in OECD countries



Source: The underlying data is as described in the main body of the text. The data on the share of income taxes refers to averages from 1975 onwards. Data on basic research per GDP refers to 5-year-centered moving averages in 2005. Note that not all data were available for every OECD country.

relationship between fiscal capacity and basic research expenditures per GDP in OECD countries.⁶¹ We turn to tax incentives for entrepreneurship next. The second graph in Figure 2 plots for OECD countries our measure of τ against the share of income taxes in GDP. Although being far from conclusive, this illustration reflects the positive relation between fiscal capacity and tax incentives for entrepreneurship that we find in our theory.⁶² The data described are supposed to give a first overview of the real equivalents of the model's key variables, while a thorough empirical analysis of whether we can find stagnant and entrepreneurial economies in the data is beyond the scope of the paper and left for future research.

To illustrate the arguments behind the political feasibility of entrepreneurial policies, we consider a calibrated version of our economic model next. We specify the parameters in the model such that an entrepreneurial economy matches OECD data on basic research expenditures and entrepreneurship, and assume that output is 5.7% higher in the entrepreneurial than in a baseline stagnant economy. This corresponds to the average rate of total factor productivity growth in OECD countries between 1996 and 2006. With regard to policy variables, we choose a basic research intensity of 0.33% and $\tau = 1.01$, which correspond to the respective averages across OECD countries. Further details on our parameter value choices are provided in appendix A.3.

⁶¹The upward trend would be stronger if we included the remaining four (non-OECD) countries with data on both variables: Argentina, China, Singapore, and South Africa.

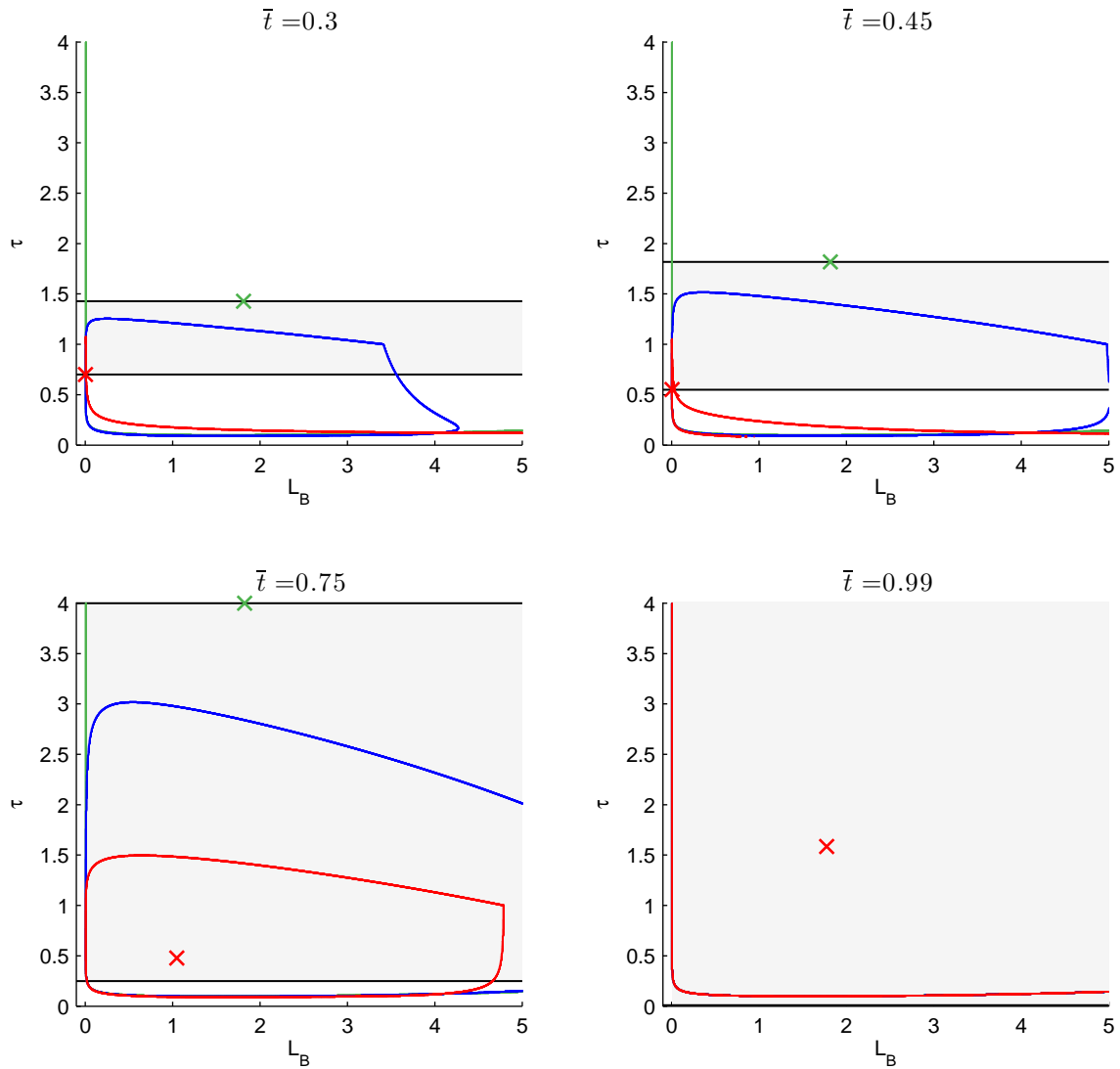
⁶²Interestingly, we do not find a similar relationship among non-OECD countries, arguably the ones for which basic research stimulated innovative entrepreneurship is less important.

We use the calibration of our model to illustrate the effects of a change in the upper bound on taxation. For that purpose, we consider a median voter with $s = 0.5$ shares.⁶³ Moving from the top-left panel to the bottom-right panel in Figure 3, the upper bound on tax rates, \bar{t} , increases from 0.3 to 0.99. In each of the panels in Figure 3, the black lines represent the smallest and largest level of τ that is feasible with the respective upper tax bound. Only policies inside the area enclosed by these two lines – shaded in gray in Figure 3 – are feasible in the sense that $\tau \in [\underline{\tau}, \bar{\tau}]$. The green line in the policy space (τ, L_B) indicates policy choices for which the condition (PLS) is equal to zero, thereby separating the growth-oriented entrepreneurial policies to the upper right of the line from the output-decreasing entrepreneurial policies on the lower left. A growth-oriented entrepreneurial policy in our context means that output is higher and the wage rates lower than in a stagnant economy. Accordingly, the median voter with a sufficiently small amount of shares in final-good production will not support a growth-oriented entrepreneurial policy without compensation from net transfers.

For each policy (τ, L_B) , we can derive the median voter’s optimal amount of net transfers given the upper bounds on tax rates, \bar{t} . We can then compare these net transfers to the net transfers in the stagnant economy. The blue lines in Figure 3 indicate entrepreneurial policies for which the net transfers are just as large as in the stagnant economy. Only in the area enclosed by these blue lines is the net transfer higher in the entrepreneurial economy, and we can thus hope for political support for a growth-oriented entrepreneurial policy. Adding up the differences in gross income and in net transfers between the entrepreneurial economy and the stagnant economy yields the difference in net income. All entrepreneurial policies for which this difference is positive are preferred by the median voter to the stagnant economy. In Figure 3, this is the case for all policies inside the areas enclosed by the red lines. All policies in the intersection of these areas with the areas shaded in gray are feasible in the sense that the median voter will prefer them to the stagnant economy and that $\tau \in [\underline{\tau}, \bar{\tau}]$. We note that the set of growth-oriented entrepreneurial policies supported by the median voter is a subset of the growth-oriented entrepreneurial policies where the net transfer difference is positive. This is because in the move from the stagnant policy to a growth-oriented entrepreneurial policy the median voter’s gross income will decline.

⁶³In the appendix of the working-paper version of our paper (Gersbach et al., 2014) we show results for $s = 0$ and for $s = 1$, respectively.

Figure 3: Illustration of politically feasible entrepreneurial policies for $\bar{L} = 20$: $s = 0.5$



Moving from the top-left panel to the bottom-right panel, the upper tax bound becomes larger, thereby increasing possibilities for redistribution. As our theory predicts, this increases the set of entrepreneurial policies with higher net transfers than in the stagnant economy, 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 the bottom-right panel that when \bar{t} approaches 1, the entire area comprising growth-oriented entrepreneurial policies will be politically viable. In the top-left panel we observe the opposite case, where the tax bound is too

restrictive and the median voter will prefer the stagnant economy, as indicated by the red cross, which marks her most preferred policy. As \bar{t} increases, this most preferred policy becomes more growth-oriented, i.e. the median voter will prefer a higher τ and a higher L_B . Yet this policy is clearly inefficient vis-à-vis the output-maximizing policy, as indicated by the green cross.

7 Extensions and further implications

The results presented above have a series of further interesting implications. In this section, we briefly discuss these implications in turn. We begin with a brief discussion of the robustness of our main insights with regard to alternative specifications.

Extensions

In our model, households own shares on final good firms, while the incumbent intermediate good firms make zero profits. The latter is due to our assumption that any technology can be used freely by competitors after one period (see footnote 12). An interesting extension is to consider the case where the monopoly position could be retained for longer and part of the voters also held shares of intermediate good producers. When it comes to entrepreneurial policies, these voters then face the additional cost of losing rents to innovative entrants into intermediate good production. Still our logic regarding the political feasibility of entrepreneurial policies would remain intact and, in fact, may be reinforced. Suppose the median voter owns shares in an incumbent intermediate good firm. Then redistribution of increased profits obtained in final good production and by entrants would not only need to compensate the median voter for a falling wage, but also for her expected loss of monopoly rents.

On top of that, the stagnant economy may be more appealing for the median voter. This would all the more be the case if it was possible to tax entrants' profits at a higher rate than incumbents' in the intermediate good sector. Then a median voter with substantial shares in incumbent intermediate firms may support such a policy to keep entrants out, thereby leading to a stagnant economy. However, if the upper bounds on taxation are sufficiently high, there will typically still exist ways of redistributing the additional gains in final good firms' and entrants' profits so as to make the median voter support an entrepreneurial economy nonetheless.

More generally, the availability of more sophisticated tax instruments will impact the

political feasibility of entrepreneurial policies. In particular, if distributional reasons prevent the existence of an entrepreneurial economy, it may be optimal to tax profits in the final-good sector differently from those in the innovative intermediate-good sector. This would allow redistribution of profits from final-good firms without affecting occupational choices. Typically, however, such tax discrimination is either not possible or is limited in its scope. For instance, intermediate-good firms and final-good firms would find it profitable to integrate and to shift profits through transfer pricing to intermediate-good production. Moreover, asymmetric information regarding innovation capabilities makes it impossible for the government to distinguish between firms with promising innovation prospects and those with no such prospects. Similar problems would exist if the government wanted to distinguish lump-sum transfers between workers and entrepreneurs. If this was possible, however, the government would have an additional instrument of increasing the attractiveness of entrepreneurship without affecting the tax on final good firms' profits which are the main aim for redistribution. This would make it easier for the government to gather political support for entrepreneurial policies. In general, political support for growth policies would be achieved most effectively if the government could target transfers to all voters losing out from entrepreneurial policies while possessing at least as many shares as the median voter.

However, in reality it is typically hard to assess the amount of wealth different individuals in society possess and target subsidies accordingly. For these reasons we argue it is sensible to focus on the tax instruments we emphasize. However, we acknowledge that the corporate tax system is very complex and may affect entrepreneurs differently from incumbent firms. Incorporating these details is beyond the scope of our paper and would certainly be interesting for future research.

Finally, it is worth emphasizing that our political economy results are valid beyond the specific set-up considered here. Whenever it is socially desirable to incentivize entrepreneurship via tax policies and innovation brings about distributional conflicts, an efficiency equality trade-off along the lines considered here arises that may result in the political conflict over growth policies we discuss.

Inefficiencies caused by the political process

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 distri-

bution of shareholdings) is skewed to the right as in the classical findings by Romer (1975), Roberts (1977), and Meltzer and Richard (1981).⁶⁴ We take the insights from this literature further as 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 will prefer a stagnant economy to any growth-oriented entrepreneurial policy and her policy choice is inefficient at the extensive margin. If her preferred policy choice is an entrepreneurial policy, then inefficiency will arise vis-à-vis the optimal growth policies at the intensive margin. This inefficiency follows directly from the fact that $t_P = 0$ maximizes aggregate consumption in an entrepreneurial economy and this can never be optimal from the point of view of the median voter. Both inefficiencies are the more severe, the fewer shares the median voter possesses, i.e. the more skewed the income distribution is. However, if $\bar{t} = 1 - \varepsilon$ and $\varepsilon \rightarrow 0$, then the inefficiencies generally become arbitrarily small, irrespective of the median voter's shareholdings.⁶⁵

The inefficiency also concerns basic research investments. Consider any choice of labor income and profit taxes, \hat{t}_L, \hat{t}_P with $\hat{L}_B = \tilde{L}_B(\hat{\tau}) > 0$, i.e. given this tax policy it is socially desirable to invest in basic research.⁶⁶ 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. In fact, the median voter will typically invest too little in basic research. Intuitively, via a reduction in the lump-sum transfer, the median voter pays the per-capita share of any increase in basic research investments. However, she benefits less than average from the associated increase in aggregate output due to the decrease in gross income.⁶⁷ Interestingly, with the median voter investing less than the social optimum in basic research, the political equilibrium can help explain the surprisingly high rates of return to public (basic) research typically found in empirical studies.⁶⁸

⁶⁴Cf. Persson and Tabellini (2002) for a discussion and Traxler (2012) for a more recent example from the related literature.

⁶⁵This is not necessarily the case if the median voter can earn more than the per-capita income in the output-maximizing entrepreneurial economy. Cf. footnote 88.

⁶⁶Recall that we limit our attention to growth-oriented entrepreneurial economies. For \hat{t}_L, \hat{t}_P with $\hat{L}_B = \tilde{L}_B(\hat{\tau}) = 0$ no such economy exists.

⁶⁷For $\hat{\tau} \geq 1$, this can be shown analytically. In particular, 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 $L_y(L'_B, \hat{\tau}) > L_y^S$. Then, by continuity of y in L_B and by the optimality of $\tilde{L}_B(\hat{\tau})$, there 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.

⁶⁸Cf. Salter and Martin (2001) and Toole (2012), for example.

Constitutional design

With bounds on taxation at center stage in our model, these results also have important implications for the design of tax rules in the constitution. Typically, decisions on tax bounds in the constitution are thought to be taken behind a veil of ignorance as in Brennan and Buchanan (1977). We perform the simplest exercise in our framework and suppose that the only uncertainty individuals face behind the veil of ignorance is the amount of shares of firms they will possess. As opposed to Brennan and Buchanan (1977), constitutional limits on taxation are not designed as an obstacle to a Leviathan-like government that maximizes revenue within these limits, but rather to curtail the policy space for the median voter, who, after the resolution of the uncertainty, will exhaust her possibilities for maximizing her income. It turns out that bounds on taxation are rejected under a veil of ignorance. This will resolve the conflict between efficiency and equality that is present for tighter constitutional tax bounds and will thus induce the median voter to opt for a more growth-oriented policy. In turn, this will increase the expected income of an individual before lifting the veil of ignorance.⁶⁹

Fiscal capacity

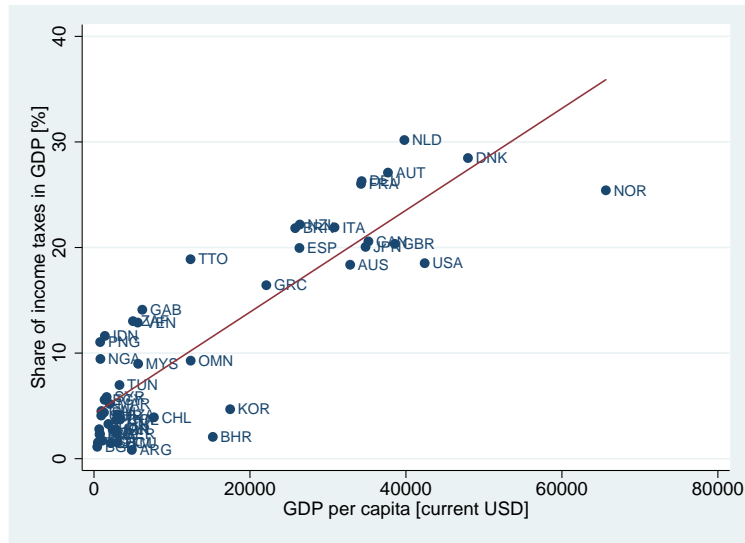
An alternative view on the upper bounds on taxation is to interpret them as a reduced form for fiscal capacity, as in Besley and Persson (2009) and Acemoglu (2005).⁷⁰ While, in the latter paper, fiscal capacity affects growth indirectly via its complementarity with other state capacities, in the former article, fiscal capacity directly influences growth as a determinant of the extent of distortionary taxation and productive investments by self-interested governments.

Figure 4 plots fiscal capacity against GDP per capita for a cross-section of countries, where, following Besley and Persson (2009), we have used income taxes over GDP as a proxy for fiscal capacity. This plot indicates a strong positive relationship between fiscal capacity and GDP per capita. Our model provides a new and intuitive political economy rationale for why strong fiscal capacity may have a positive effect on economic growth. In the absence of strong fiscal capacities, it may not be viable to sufficiently redistribute the gains from innovation for a majority of the population to support such

⁶⁹The detailed argument can be found in appendix A.4.

⁷⁰In some developed countries with very high fiscal capacity, the upper bound on taxation may be determined by the peak of the Laffer-curve (see e.g. Trabandt and Uhlig (2011)). However, the peak of the Laffer-curve also depends on how tax revenues are spent (Daniel and Gao (2015)). Productive public expenditure as in our model would make the peak of the Laffer-curve and hence the upper bound of taxation endogenous. We leave such considerations for future research.

Figure 4: Fiscal capacity and GDP per capita



Source: The data on the share of income taxes in GDP is taken from Besley and Persson (2009) and refers to averages from 1975 onwards. The data on GDP per capita is taken from World Bank (2013) and refers to 5-year centered moving averages in 2005. Countries with a share of oil revenues in GDP of more than 50% have been excluded from the sample. The data was downloaded in July 2013.

policy changes.

Inclusive Growth

Our analysis in section 6 readily offers results on the feasibility of growth policies that satisfy normative prescriptions such as the desideratum that most or all social layers benefit from economic growth. This view is related to claims subsumed under the term 'inclusive growth'.⁷¹ In our analysis, the characterization of implementable policies is tied to the approval of a politically decisive individual whom we choose to be the median voter. However, we could easily take this individual to represent the workers with the smallest shareholdings, for example. Then, implementable policies have to benefit at least weakly the poorest individuals in society.⁷² Our results on the tax bounds then predict that with higher upper bounds on tax rates, more ambitious growth policies can be pursued which still ensure that the poorer parts of society will not lose out.

⁷¹Further information on different manifestations of 'inclusive growth' can be found e.g. on the website of the OECD.

⁷²Such normative requirements can be implemented via alternative social choice procedures such as super-majority rule or minority protection (cf. also the discussion in section 6).

8 Conclusions

We have outlined a rationale for a taxation pecking order to finance basic research investments, thus presenting a new perspective on the theory of optimal income taxation. We have subsequently assumed a political economy perspective and characterized the conditions under which the optimal policy scheme is politically viable. In particular, our political economy analysis suggests that entrepreneurial policies may harm workers with little in the way of shareholdings. We have shown that upper bounds on taxation – explicitly specified in the constitution or implicitly arising from fiscal capacity – 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 future income levels, the point being that the political process tends to result in inefficient policies vis-à-vis the social optimum. This inefficiency encompasses the amount of basic research investments, which tend 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 in constitutions are sometimes proposed as a means for protecting investors from excessive indirect expropriation, the mechanisms considered here suggest that such measures may only be efficient if growth policies are *given*. If, by contrast, growth policies are subject to the political process, they may actually harm the firm-owners they are meant to protect.

Future work may set out to integrate our analysis of the optimal financing of basic research investments into the theory on optimal taxation in the tradition of Mirrlees (1971). With concave utilities and the traditional supply-side effects of labor income taxation, optimal policies would account for losses in aggregate utility from income inequality and for potentially adverse effects on labor supply. These additional efficiency-equality trade-offs might push optimal tax policies towards a more egalitarian economy. In the presence of incomplete markets, concave utilities might also allow additional beneficial effects of basic research on entrepreneurship and thus innovation in the economy, as basic research can reduce idiosyncratic risks. Another interesting avenue for future research is to extend the model to an open economy set-up where entrepreneurs are mobile between countries and may choose location depending on the tax codes (see Akcigit et al. (2015)). This adds an interesting perspective on tax com-

petition between countries and would yield endogenous bounds on taxation.⁷³ While some of these extensions may 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.

⁷³The key forces will be the tax differentials between countries on the one hand and the entrepreneurs' propensity to leave on the other hand. The latter could be connected to preferences or to differences in the quality of the public infrastructure or bureaucracy, for example. A low propensity to leave will grant freedom to governments to increase the profit tax for redistributive purposes. However, *ceteris paribus*, the higher the level of the domestic profit tax, the more entrepreneurs will want to move to countries with lower profit taxes. Including such trade-offs would keep our logic intact, but would moderate the results quantitatively.

Appendix

A Details on political economy analysis

A.1 Applicability of median voter theorem

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

Consider policy space \mathcal{P} with policies $p = (t_L, t_P, t_H, L_B)$ that either reflect a stagnant economy with $L_B = 0$ or growth-oriented entrepreneurial policies with $L_B > 0$. We order the policies according to their implied net final-good profit, $(1-t_P)\pi_y$, i.e. $p_2 > p_1 \Leftrightarrow (1-t_P^2)\pi_y^2 > (1-t_P^1)\pi_y^1$. We further order the voters according to their shareholdings. The single-crossing condition requires that if $p > p'$ and $s < s'$, or if $p < p'$ and $s > s'$, then from $EU_s(p) > EU_s(p')$ it follows that $EU_{s'}(p) > EU_{s'}(p')$. In this 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:

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

We immediately observe that the single-crossing condition holds for the preferences of all individuals with $k \geq 1$, i.e. when we exclude all potential entrepreneurs. Consider two policies p_1 and p_2 with $p_2 > p_1$. 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 to p_2 , so will the individual with shares s_1 . Intuitively, the labor income and the lump-sum transfers are always the same for both workers, 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 1

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 agents (i.e. including the set of potential entrepreneurs), the single-crossing condition does not hold. This can be illustrated by

restricting the vote to one between a stagnant and an entrepreneurial policy, for instance by assuming that the stagnant economy is the status quo 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 (A.1) and Lemma 1 that the first statement, which we recall in the next lemma, is satisfied but the statement in parentheses is not.

Lemma 2

Suppose a worker with shareholdings \hat{s} prefers a growth-oriented entrepreneurial economy to the stagnant economy. Then so will all voters with shareholdings $s \geq \hat{s}$.

Intuitively, the higher a worker's shareholdings, the more he can benefit from the increase in final-good producers' profits associated with a growth-oriented entrepreneurial economy. (This is implied by Lemma 1.) The result extends to potential entrepreneurs with shareholdings $s \geq \hat{s}$, 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 to being workers and the result follows accordingly. Note that for agents with $0 \leq k \leq 1$ the decision whether to become an entrepreneur is captured by the maximum term in equation (A.1).

The reverse of Lemma 2 is not true. In particular, 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. This follows immediately from the fact, incorporated in equation (A.1), that the utility gain from being an entrepreneur must be weakly positive.

Hence, the single-crossing condition regarding a stagnant policy and an entrepreneurial policy does not hold for the entire set of individuals. Moreover, note that the single-crossing condition does not necessarily hold when we consider the voting on two different entrepreneurial policies. The reason is the expected gain from being an entrepreneur, as described in (A.1). To illustrate the argument, consider two policies $p_1 > p_2$. Suppose that a worker with \hat{s} shares prefers policy p_2 to policy p_1 . Now consider an entrepreneur with \hat{s} shares as well. Note that her absolute expected gain from being an entrepreneur as described in (A.1) may be larger for policy p_1 than for

policy p_2 . So, she may prefer policy p_1 .

The type of preferences of potential entrepreneurs can imply that the amount of shares of the median voter may be different across different binary collective decisions. This inhibits the direct application of the median voter theorem. However, when we order individuals from 1 to \bar{L} according to the amount of shares they own, starting with the lowest amount at $k = 1$, and if $\bar{L} > 2$, we will observe that the median voter on any collective decision between p_1 and p_2 is in $\left[\frac{\bar{L}}{2}, \frac{\bar{L}}{2} + 1\right]$. The preferences of potential entrepreneurs can affect the location of the median voter on some binary decisions in the interval $\left[\frac{\bar{L}}{2}, \frac{\bar{L}}{2} + 1\right]$.⁷⁴ All our results apply, as long as the shareholdings s of workers $\left[\frac{\bar{L}}{2}, \frac{\bar{L}}{2} + 1\right]$ fulfill the conditions required in section 6.⁷⁵

To simplify the presentation, we assume that all workers in $\left[\frac{\bar{L}}{2}, \frac{\bar{L}}{2} + 1\right]$ have the same amount of shares s . Accordingly, if these workers prefer policy p_1 to p_2 , at least half of the electorate will have the same preference ordering. The single-crossing property of the preferences of individuals $[1, \bar{L}]$ then implies the median voter theorem. The votes of potential entrepreneurs in $[0, 1]$ will not affect the outcome of any binary collective decision p_1 against p_2 .

A.2 Most-preferred policy of the median voter

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

With τ given, we can replace t_L by $1 - (1 - t_P)/\tau$ in expression (15) for the net transfers. Then taking the derivative of the net transfers with respect to t_P yields:

$$DNT := \frac{\partial NNT}{\partial t_P} \Big|_{\tau} = w \left[\left(\frac{\alpha}{1 - \alpha} l_y - m_l \right) (1 - s) + \chi(L_B) l_E - \frac{l_E}{\tau} \right], \quad (\text{A.2})$$

where we use $l_y := \frac{L_y}{L}$, $m_l := \frac{m}{L}$, and $l_E := \frac{L_E}{L}$ to denote per-capita variables. Note that with lump-sum transfers, a marginal increase in profit tax constitutes a redistribution of profits (from entrepreneurs and the final-good firm) to workers, while an increase

⁷⁴Note that if the worker with $k = \frac{\bar{L}}{2}$ prefers an entrepreneurial to a stagnant policy, all individuals in $\left[\frac{\bar{L}}{2}, \bar{L}\right]$ will support the former.

⁷⁵Even if collective decisions displayed cycles, these would remain in the set of most-preferred policies for workers in $\left[\frac{\bar{L}}{2}, \frac{\bar{L}}{2} + 1\right]$.

in the labor tax redistributes from workers to entrepreneurs.⁷⁶ The redistribution of profits is captured by the first two summands in (A.2). The first summand reflects the additional redistribution of the final-good firm's profits, the second represents the additional redistribution of entrepreneurial profits. As the median voter is a worker, she will prefer redistribution of entrepreneurial profits. Factor $1 - s$ indicates that the redistribution of the final-good firm's profits is only favorable if she owns less than the per-capita shares in the final-good firm. Finally, keeping τ 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 .

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) will depend on the particular value of τ . Table 2 shows the optimal levels of t_P and t_L depending on DNT and τ . Note that since profits of the final-good firm are non-negative (as $w \left(\frac{\alpha}{1-\alpha} l_y - m_l \right) \geq 0$), the case where $DNT < 0$ and $\tau \geq 1$ can only occur if entrepreneurship is inefficient (i.e. $\chi(L_B) < 1$) and/or $s > 1$.

Table 2: Median voter's preferred labor and profit tax rates, given τ and L_B

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

We use $\tilde{t}_L(\tau, L_B)$ and $\tilde{t}_P(\tau, L_B)$ to refer to the optimal labor and profit tax rates for given τ 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 τ and L_B .

Lemma 3

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

The proof is given in appendix B.6. Note that the median voter's income is not differentiable at the values of τ and L_B where $DNT = 0$. With these results, we now

⁷⁶The increase in labor tax does not per se constitute a redistribution towards the owners of the shares of the final-good firm, as these are also either workers or entrepreneurs.

move on to the second part of the median voter's maximization problem concerning the level of τ and the amount of basic research investments. Using Lemma 3, the median voter will seek the maximum of a continuous function over a compact set. Hence, by the Weierstrass extreme value theorem, the maximum will be attained in $[\underline{\tau}, \bar{\tau}] \times [0, \bar{L}]$. However, the set of maximizers may not be single-valued. For this purpose, 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 main text.

Consider the optimization of the median voter's income (13) with respect to τ for given basic research investments L_B :

$$\max_{\tau \in [\underline{\tau}, \bar{\tau}]} I(\tau, L_B) = w(\tau, L_B) \left[1 + s \left(\frac{\alpha}{1 - \alpha} l_y(\tau, L_B) - m_l \right) \right] + NT(\tau, L_B). \quad (\text{A.3})$$

Regarding a marginal increase in τ at values of τ (and L_B), where $DNT \neq 0$, the median voter's income is affected as follows:⁷⁷

$$\frac{dI(\tau, L_B)}{d\tau} = \frac{\partial NT}{\partial \tilde{t}_P} \frac{\partial \tilde{t}_P(\tau, L_B)}{\partial \tau} + \frac{\partial NT}{\partial \tilde{t}_L} \frac{\partial \tilde{t}_L(\tau, L_B)}{\partial \tau} + \frac{\partial I(\tau, L_B)}{\partial l_E} \frac{\partial l_E}{\partial \tau}. \quad (\text{A.4})$$

Note that for an interior solution τ of the problem displayed in (A.3) $\frac{dI(\tau, L_B)}{d\tau}$ must be zero, if it is not equal to the critical values of τ associated with $DNT = 0$. An increase in τ has two effects: it increases the relation between labor and profit taxes and it (weakly) increases the number of entrepreneurs. The first two summands in (A.4) reflect the decline of redistribution from profits to labor income due to the comparatively lower profit taxes. Note that one of the summands is zero, as either \tilde{t}_P or \tilde{t}_L remains at the boundary of the feasible set $[\underline{t}, \bar{t}]$. The last term in (A.4) captures the effect of an increase in the number of entrepreneurs on the median voter's income.⁷⁸ 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 τ : On the one hand, a marginally higher level of τ via a decline of t_P will lower her gross income (as the wage payments are the major income source) and lower the share of profits redistributed.⁷⁹ On the other, a larger τ will increase total output and with it

⁷⁷Note that the terms $\frac{\partial \tilde{t}_P(\tau, L_B)}{\partial \tau}$ and $\frac{\partial \tilde{t}_L(\tau, L_B)}{\partial \tau}$ differ according to the different cases in Table 2. At the critical values τ_c , as defined in the proof of Lemma 3, and $\tau = 1$, equation (A.4) can still be used when we refer to the right-sided derivatives.

⁷⁸Note that for small values of L_B and τ , L_E will remain at zero in response to a marginal increase in τ .

⁷⁹Obviously, if τ 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.

the tax base for profit tax. This reflects a standard Laffer-curve trade-off.

As the set of maximizers may contain several values for τ , we cannot proceed as in section 5.2 by defining a function $\tau(L_B)$, inserting it back into the objective function, and then solving for the optimal value of L_B . Instead, we have to derive the correspondence $L_B(\tau)$ that maximizes the median voter's income with respect to basic research investments for a given level of τ . Optimal policy candidates for the median voter will lie in the intersection between the two correspondences $\tau(L_B)$ and $L_B(\tau)$. Those with the highest income level will then constitute the median voter's preferred policies.

A.3 Details on the numerical illustration

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 $\eta(L_B)$: $\eta(L_B) = (L_B/\bar{L})^\beta$. For a complete numerical specification, five parameter values need to be specified: α , β , γ , b , and m . We calibrate these parameters such that an entrepreneurial economy with positive basic research and entrepreneurship 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 in OECD member states.⁸⁰ This yields the following condition:

$$(1 - \alpha) \frac{L_B}{L_y} = 0.0033 . \quad (\text{A.5})$$

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

$$L_E = 0.0425\bar{L} , \quad (\text{A.6})$$

where 4.25% is the average share of the labor force engaged in opportunity-driven entrepreneurial activities.⁸¹ We combine these requirements with information 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

⁸⁰*Source:* own calculations based on OECD (2012). The data refers to centered 5-year moving averages in 2005 and was downloaded in June 2013.

⁸¹*Source:* own calculations based on Global Entrepreneurship Monitor (2013). The data refers to centered 5-year moving averages in 2006. The definition by GEM: 'improvement-driven opportunity entrepreneurial activity'. The data was downloaded in July 2013.

that in our entrepreneurial economy the output share of intermediates be 0.5. With all intermediates selling at price $p(i) = mw$, this corresponds to the following condition:

$$(1 - \alpha) \frac{m}{L_y} = 0.5 . \quad (\text{A.7})$$

Concerning labor income shares, we refer to data provided by the EU KLEMS project and require that:^{82,83}

$$(1 - \alpha) \frac{L_y + L_x + L_B}{L_y + (1 - \alpha)L_B} = 0.628 . \quad (\text{A.8})$$

From the labor market clearing condition we obtain:

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

Combining this result with equations (A.5) to (A.8) and solving for m , yields:

$$m \approx 15.2 .$$

Next we require that output in the entrepreneurial economy be 5.7% larger than in the stagnant economy:⁸⁴

$$\left[\frac{L_y}{\bar{L} - m} \right]^{1-\alpha} = 1.057 . \quad (\text{A.9})$$

From equation (A.7) we can replace 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 α to obtain:

$$\alpha \approx 0.79 .$$

We now turn to b , β , and γ , the parameters characterizing entrepreneurship and innovation in our economy. We need three conditions to calibrate these parameters. An

⁸²*Source*: own calculations based on EU KLEMS (2011). The value of 0.628 is the average labor income share in 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 $\frac{\text{labor compensation}}{\text{labor compensation} + \text{capital compensation}}$. The data was downloaded in July 2013.

⁸³To mimic labor shares observed from the data, we add basic research investments to both labor income and final-good production when computing the labor share in our model, as basic research represents government expenditures. We note that using the labor share in the private sector alone, $\frac{w[L_y + L_x]}{y}$, would yield a very similar calibration.

⁸⁴A 5.7% increase corresponds to the average total factor productivity growth for the OECD members included in the EU KLEMS database for the period 1996 to 2006. *Source*: own calculations based on EU KLEMS 2011. The data was downloaded in July 2013.

initial condition follows directly from the use of our previously derived results in the labor market clearing condition:

$$L_y = \bar{L} - L_B - m + L_E [\chi(L_B) - 1] . \quad (\text{A.10})$$

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,⁸⁵ we obtain the value for $b \approx 2.31$ from the equilibrium condition for L_E :⁸⁶

$$L_E = 1 - \frac{1}{\tau \chi(L_B) b} . \quad (\text{A.11})$$

Finally, we have to specify β and γ . Those parameter values are calculated to match both the value of $\chi(L_B)$ derived previously and empirical evidence on mark-ups presented by Roeger (1995) and Martins et al. (1996). In line with this evidence, we require intermediate-good producers to charge on average a mark-up of 1.2, i.e. we require:

$$\frac{1}{\gamma} L_E \eta(L_B) = 1.2 .$$

This gives us the values $\gamma \approx 0.16$ and $\beta \approx 0.28$.

A.4 Constitutional design

In this part of the appendix, we discuss constitutional design behind the veil of ignorance. Specifically, suppose that households decide on \bar{t} without knowing their individual shareholdings but only the distribution from which these shareholdings will be drawn. This distribution is the same for all households, i.e. households own the per-capita shares in expectation. For simplicity, suppose further that they are aware of their immaterial utilities from being an entrepreneur. Let $\bar{L} > 2$, i.e. let the majority of the population be workers. Then workers will choose \bar{t} to maximize their expected income under the policy preferred by the median voter.⁸⁷ As before, let $s < 1$, i.e. after the veil of ignorance has been resolved the median voter owns less than the per-capita shares. Then ex-ante workers will not care about the distribution of final-good

⁸⁵Source: own calculations based on Djankov et al. (2010). The data was downloaded in April 2014.

⁸⁶Note that this value for b implies that the aggregate immaterial utility from being an entrepreneur is positive, i.e. that, on average, entrepreneurs like being entrepreneurs, although some entrepreneurs dislike being entrepreneurs, in line with empirical evidence previously cited (cf. footnote 17).

⁸⁷Recall that households are risk-neutral.

producer's profits, only about aggregate income and the distribution thereof between workers and entrepreneurs. By contrast, the ex-post median voter will also care about distribution of final-good producer's profits. In essence, agents with (expected) $s = 1$ set \bar{t} to guide the subsequent policy choice by a median voter with $s < 1$. In principle, we have to distinguish two cases, depending on whether or not the median voter with $s \leq 1$ can earn \bar{y}_{opt} , the per-capita income in the output-maximizing entrepreneurial economy, or even more. We limit our attention to the more realistic case where this is not feasible.⁸⁸

Suppose \bar{t} is chosen arbitrarily close to 1 at the constitutional stage, i.e. $\bar{t} = 1 - \varepsilon$ for some arbitrarily small $\varepsilon > 0$. Then, by choosing t_L, t_P arbitrarily close to 1 with $t_L > t_P$, the ex-post median voter can earn an income that is arbitrarily close to \bar{y}_{opt} . Given that it is not possible for her to earn \bar{y}_{opt} , she will implement this policy. This is ex-ante desired by the worker as it maximizes the cake and fully redistributes entrepreneurial profits. We conclude that in the constitutional design phase workers will choose $\bar{t} = 1 - \varepsilon$, the largest possible upper bound on taxation. As in Proposition 4, choosing $\bar{t} = 1 - \varepsilon$ helps resolve the conflict between efficiency and equality. For $\bar{t} = 1 - \varepsilon$, the higher redistribution incentive for a voter with $s < 1$ will not compromise efficiency.⁸⁹ The optimality of maximal constitutional freedom for tax policies adds a new perspective to the literature, which has hitherto emphasized constitutional tax constraints.⁹⁰

⁸⁸If the median voter owns less than the per-capita shares of the final-good producer, she can only receive an income of \bar{y}_{opt} or more if entrepreneurs receive less income than workers on average (she can never have an income exceeding the average worker's income). Formally, we must have $(1 - t_P)\chi(L_B)w < (1 - t_L)w$, i.e. entrepreneurs are taxed sufficiently more heavily than workers such that net income is redistributed from entrepreneurs to workers. With $\chi(L_B) > 1$ in any growth-oriented entrepreneurial economy, this requires $\tau < 1$, i.e. tax policies dis-incentivize entrepreneurship, so this economy is inefficient when compared to the output-maximizing economy yielding \bar{y}_{opt} . Hence, for the median voter to receive income larger than \bar{y}_{opt} , the redistribution of net income from entrepreneurs to workers must be large enough to overcompensate for the loss in efficiency arising from the decrease in productive entrepreneurship due to $\tau < 1$. If b is very large, this is possible in principle, as then the decrease in τ has only a small negative effect on entrepreneurship. However, this may not be the most realistic scenario, and we therefore ignore it here.

⁸⁹Note that this rationale also implies that in the constitutional design phase workers will choose $\bar{t} = 1 - \varepsilon$, the largest possible upper bound on taxation. The lower \bar{t} is, the more the median voter will compromise efficiency for more redistribution of the (final-good producer's) profits in her optimal policy choice.

⁹⁰Cf. Brennan and Buchanan (1977) and Gradstein (1999) and the discussion in section 2. Note, however, that in our model $\bar{t} = 1 - \varepsilon$ is no longer optimal in general if the ex-post median voter can receive income larger than \bar{y}_{opt} or if she holds s shares with $s > 1$. Then the median voter's ex-post interest in the redistribution of final-good producers' profits is different from the optimal solution for a worker with $s = 1$. Similarly, additional effects have to be taken into account if entrepreneurial talent is also behind the veil of ignorance in the constitutional stage. In this case, households care about

B Proofs

B.1 Proof of Proposition 1

We proceed in three steps: We first derive two preliminary results and then prove Proposition 1.

First, considering the equilibrium in the market for intermediate goods for the case of positive production in the final-good sector, we can state:

Lemma 4

- (i) *In any equilibrium with positive production in the final-good sector, intermediate-good producers supplying their product will charge $p(i) = mw$.⁹¹*
- (ii) *In any equilibrium with positive production in the final-good sector, the final-good producer will use all varieties of intermediate goods.*

Proof: We prove each part of Lemma 4 separately.

(i) We consider innovative and non-innovative intermediate-good producers 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 marginal cost in equilibrium, i.e. non-innovative intermediate-good producers will offer their goods at price $p(i) = mw$.

The production costs of innovative intermediate-good producers are reduced to γmw . 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 show by contradiction that $\delta_i \in [\gamma, 1)$ cannot be optimal. In particular, we show that no symmetric equilibria exist in which all innovative intermediate-good producers charge the common price $p(i) = \delta mw$, with $\delta \in [\gamma, 1)$.⁹²

maximizing aggregate welfare including the immaterial costs and benefits of being an entrepreneur (cf. appendix A.2 of Gersbach et al. (2014) and the discussion in section 7.) when choosing \bar{t} . Depending on parameter values, $\bar{t} = 1 - \varepsilon$ may or may not be optimal in this case.

⁹¹To avoid needing to discretize the strategy space in order to obtain the 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.

⁹²It is straightforward to verify that no non-symmetric equilibrium exists with $\delta_i < 1$ for any value of 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 enables us to write the maximization problem of the final-good producer as:

$$\begin{aligned} \max_{L_y, \{x(i)\}_{i=0}^1} \pi_y &= L_y^{1-\alpha}(\tilde{X} + \hat{X}) - wL_y - \delta mw\tilde{X} - mw\hat{X} \\ &= \tilde{X}(L_y^{1-\alpha} - \delta mw) + \hat{X}(L_y^{1-\alpha} - mw) - wL_y. \end{aligned} \quad (\text{B.1})$$

As $\delta < 1$, $L_y^{1-\alpha} - \delta mw > 0$ is a necessary condition for non-negative profits for the final-good producer with positive output. $L_y^{1-\alpha} - \delta mw$ 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 will always demand $x(i) = 1$ 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:

$$\max_{L_y, X} \pi_y = L_y^{1-\alpha} X - wL_y - mwX = X(L_y^{1-\alpha} - mw) - wL_y. \quad (\text{B.2})$$

Hence the profit function is linear in X . A necessary condition for non-negative profits is $L_y^{1-\alpha} - mw > 0$. Hence $X = 1$ is profit-maximizing if the final-good producer is operating. □

Second, the indivisibility of intermediates implies that the final-good producer will not always be able to break even:

Lemma 5

The final good producer will be able to break even with strictly positive production if and only if governmental policy (τ, L_B) satisfies the following Positive Profit Condition

(PPC):

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

Proof: We can use the equilibrium number of entrepreneurs (6) and labor in intermediate-good production (8) together with the market clearing condition in the labor market:

$$\bar{L} = L_E^e + L_B + L_y^e + L_x^e \quad (\text{B.3})$$

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

$$L_y^e = \bar{L} - L_B - L_E^e - L_x^e. \quad (\text{B.4})$$

Equation (3) yields the corresponding equilibrium wage rate as:

$$w^e = (1 - \alpha)(\bar{L} - L_B - L_E^e - L_x^e)^{-\alpha}. \quad (\text{B.5})$$

Using the profit function (2) and Lemma 4, we obtain equilibrium profits in the final-good sector:

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

Inserting the equilibrium wage rate (B.5) yields:

$$\pi_y^e = \alpha(L_y^e)^{1-\alpha} - (1 - \alpha)m(L_y^e)^{-\alpha}. \quad (\text{B.6})$$

We observe that the final-good firm's profit strictly increases in the amount of labor it employs in equilibrium.⁹³ Consequently, according to (B.6), the final-good firm's profits will be positive if the amount of labor employed in final-good production exceeds the critical level, $L_y^c := m\frac{1-\alpha}{\alpha}$. Combining this result with (6), (8), and (B.4) yields condition (PPC).

□

Now we can prove Proposition 1. From Lemmas 4 and 5 we know that, if condition (PPC) is satisfied, the final-good producer is operating and using all varieties of the intermediate goods in production. Conversely, if condition (PPC) is not satisfied, he is

⁹³This 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 the inputs labor and intermediate goods are lower.

not operating. From this follows $L_E^e = L_x^e = L_y^e = 0$ and zero profits. We now need to show that in case (i) the other variables take on the unique equilibrium values stated in the Proposition.

(i) Conditions (1) and (2) 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, and condition (4) from equation (B.5) above. 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. Condition (7) has been derived above. Finally, condition (8) follows from using w^e in the expression for profits of a monopolistic intermediate-good producer.

□

B.2 Proof of Corollary 1

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

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

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

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

is increasing in m , b , and $\bar{\tau}$ and decreasing in γ as $\chi(\tilde{L}_B(\bar{\tau})) = m(1 - \gamma)\eta(\tilde{L}_B(\bar{\tau}))$.

□

B.3 Proof of Proposition 4

By using (3), (4), and (6) from Proposition 1(i), income per capita can be written as:

$$\bar{y} := \frac{y}{L} = w \left[1 + \frac{\alpha}{1-\alpha} l_y - m_l + l_E(\chi(L_B) - 1) - l_B \right], \quad (\text{B.7})$$

where we use $l_y := \frac{L_y}{L}$, $m_l := \frac{m}{L}$, and $l_E := \frac{L_E}{L}$ to denote per-capita variables. In the stagnant economy, this reduces to:

$$\bar{y}^S = \frac{y^S}{L} = w^S \left[1 + \frac{\alpha}{1-\alpha} l_y^S - m_l \right], \quad (\text{B.8})$$

where we use a superscript S to denote variable values in the stagnant economy. Substituting (15) in (13), the value of the median voter's income is:

$$I = w \left[1 + \left(\frac{\alpha}{1-\alpha} l_y - m_l \right) (s + t_P(1-s)) + l_E(t_P \chi(L_B) - t_L) - l_B \right],$$

which reduces to:

$$I^S = w^S \left[1 + \left(\frac{\alpha}{1-\alpha} l_y^S - m_l \right) (s + t_P^S(1-s)) \right]$$

in the stagnant economy. Due to the assumption $s < 1$, the median voter maximally redistributes profits $t_P^S = \bar{t}$ in the stagnant economy.⁹⁴

Consider any policy $(\hat{\tau}, \hat{L}_B)$ for which $\hat{y} > \bar{y}^S$ (such a policy necessarily implies $\hat{L}_B > 0$ and $\hat{L}_E > 0$). With $s < 1$, we have a condition where $I^S \leq \bar{y}^S$. Hence it suffices to show that for $(\hat{\tau}, \hat{L}_B)$ we can find a \bar{t} such that $\hat{I} > \bar{y}^S$. Note that $\lim_{t_P \rightarrow 1, t_L \rightarrow 1} \hat{I} = \hat{y}$. Since $\hat{y} > \bar{y}^S$, the assertion of Proposition 4 follows from the fact that for any $\delta > 0$ we can find a pair $(t_P, t_L) \ll (1, 1)$ yielding $\hat{\tau}$ and satisfying $\hat{y} - \hat{I} \leq \delta$.

□

B.4 Proof of Proposition 5

To show the result, note first that the restriction $s \leq \frac{\bar{L}}{L+(1-\gamma)m}$ is a sufficient condition for the derivative of the median voter's gross income with respect to L_y to be negative. In particular, this will be the case for all L_y s.t. $s \left[\frac{L_y+m}{L} \right] < 1$, and the restriction on

⁹⁴Note that 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 their shareholdings in the final-good firm.

s follows from rearranging terms and from observing that L_y is strictly bounded from above by $\bar{L} - \gamma m$.

Now suppose that $\bar{t} = 0$. Then the median voter's income corresponds to her gross income minus her share of the cost involved in providing basic research. In such circumstances, she will strictly prefer the stagnant economy over the entrepreneurial economy.⁹⁵ The result then follows from the continuity of the median voter's income, implying that she will also prefer the stagnant economy for sufficiently small $\bar{t} > 0$.

□

B.5 Proof of Proposition 6

Fix any entrepreneurial policy $(\hat{\tau}, \hat{L}_B)$ with $\hat{L}_y > L_y^S$. From Proposition 4 we know that for $\bar{t} = 1 - \varepsilon$, 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. Accordingly, it remains to be shown 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 $\bar{t} \geq \bar{t}_c$.

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 our attention to $\bar{t} \geq \bar{t}_c^1$, and the result follows if we can show that $\hat{I} - I^S$ is monotonic in \bar{t} .⁹⁶ 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. Thus we can limit our 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:⁹⁷

$$\frac{\partial NT^S}{\partial \bar{t}} = w^S \left[\left(\frac{\alpha}{1-\alpha} l_y^S - m_l \right) (1-s) \right] \geq 0 .$$

⁹⁵Note that in the entrepreneurial economy $L_y \geq L_y^S$ and $L_B > 0$.

⁹⁶As we show below, $\hat{I} - I^S$ can be monotonically increasing or decreasing. Obviously, if it is monotonically decreasing then we must have $\bar{t}_c = \bar{t}_c^1$.

⁹⁷Note that we always have $1 \in [\underline{\tau}, \bar{\tau}]$. Hence, by Assumption 2, the stagnant economy is always feasible, irrespective of \bar{t} .

Note that $\frac{\partial NT^S}{\partial \bar{t}}$ is constant. The monotonicity of $\hat{I} - I^S$ then follows from $\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}$ being constant as well. We will show that this holds for each of the four cases outlined in Table 2 of appendix A.2.

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

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

$$\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}^{\hat{\tau}} = 0 ,$$

so $\hat{I} - I^S$ is monotonically decreasing in \bar{t} .⁹⁸

$DNT \geq 0, \hat{\tau} \geq 1$ 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:

$$\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}^{\hat{\tau}} = \hat{w} \left[\hat{\tau} \left(\left(\frac{\alpha}{1-\alpha} \hat{l}_y - m_l \right) (1-s) + \chi(\hat{L}_B) \hat{l}_E \right) - \hat{l}_E \right] ,$$

which is constant, implying that $\hat{I} - I^S$ is monotonic in \bar{t} .⁹⁹

$DNT \geq 0, \hat{\tau} < 1$ 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:

$$\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}^{\hat{\tau}} = \hat{w} \left[\left(\frac{\alpha}{1-\alpha} \hat{l}_y - m_l \right) (1-s) + \chi(\hat{L}_B) \hat{l}_E - \frac{\hat{l}_E}{\hat{\tau}} \right] .$$

Again, $\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}^{\hat{\tau}}$ is constant, implying that $\hat{I} - I^S$ is monotonic in \bar{t} . □

B.6 Proof of Lemma 3

We first show the continuity of the median voter's income I with respect to τ , for given L_B , and then the continuity of I with respect to L_B , for given τ .

⁹⁸Note that $\frac{\partial NT}{\partial \bar{t}} \Big|_{\substack{\hat{L}_B \\ \bar{t} \geq \bar{t}_c^1}}^{\hat{\tau}} = 0$, $\frac{\partial NT^S}{\partial \bar{t}} \geq 0$ and Proposition 4 imply that in the case considered here the median voter will prefer the entrepreneurial economy over the stagnant economy whenever both are feasible, i.e. we have $\bar{t}_c = \bar{t}_c^1 = 1 - \hat{\tau}$.

⁹⁹In fact, we have $\bar{t}_c > \bar{t}_c^1$. This follows from $t_P = 0$ and hence $NT < 0$ for $\hat{\tau} = \bar{\tau}$. Note that this also implies that $\hat{I} - I^S$ is monotonically increasing.

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

(2) We use Table 2, which describes optimal labor and profit taxes for given (τ, L_B) . We observe that the net transfers are continuous within each of the different subsets of (τ, L_B) defined by the four different cases. Potential discontinuities may exist at the transitions 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 a given L_B in the feasible set and by $DNT(\tau, L_B^c) = 0$ for a given τ , respectively.

(3) As can be observed from Table 2, there are two critical values of τ 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 by our assumptions in section 4 the latter will always be in the feasible set. Now consider any two sequences $\{\tau_m\}$ and $\{\tau_n\}$ with $\lim_{m \rightarrow \infty} \tau_m = \tau^c$, $\tau_m \leq \tau^c$, and $\lim_{n \rightarrow \infty} \tau_n = \tau^c$, $\tau_n \geq \tau^c$. 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 τ^c remains unchanged, we must obtain $\lim_{m \rightarrow \infty} NT(\tau_m, L_B) = \lim_{n \rightarrow \infty} NT(\tau_n, L_B)$. Hence, $NT(\tau, L_B)$ is continuous at τ^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 $\lim_{m \rightarrow \infty} \tau_m = 1$, $\tau_m \leq 1$, and $\lim_{n \rightarrow \infty} \tau_n = 1$, $\tau_n \geq 1$, we also obtain $\lim_{m \rightarrow \infty} NT(\tau_m, L_B) = \lim_{n \rightarrow \infty} NT(\tau_n, L_B) = NT(1, L_B)$. Thus, net transfers are continuous in τ at $\tau = 1$.

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

□

C Data Overview

In this section we provide the data for all the OECD countries. As mentioned in the main text we chose the year 2013 to give a recent account and for maximal data availability. If no data was available for 2013, we provide the last available data point. Unfortunately, some countries have not provided any data on basic research expenditures for more than 20 years or didn't provide any data on this measure at all.

Table 3: Data Overview^a

	Basic research exp. as perc. of GDP ^b	Corporate in- come tax rates ^c	Income tax rates at average wages ^c
Australia	0.45 ^d	30.0	23.1
Austria	0.56	25.0	34.4
Belgium	0.49	33.0	33.7
Canada	N/A	15.0	18.4
Chile	0.11	20.0	7.0
Czech Republic	0.66	19.0	14.6
Denmark	0.54	25.0	32.2
Estonia	0.37	21.0	16.4
Finland	N/A	24.5	30.1
France	0.54	38.0	22.7
Germany	N/A	15.8	31.4
Greece	0.28	26.0	26.9
Hungary	0.23	19.0	34.5
Iceland	0.46	20.0	20.3
Ireland	0.30	12.5	14.3
Israel	0.40	25.0	16.4
Italy	0.33	27.5	28.8
Japan	0.44	28.1	20.0
Korea	0.75	22.0	12.9
Latvia	0.15	15.0	N/A
Luxembourg	N/A	22.5	18.2
Mexico	0.14	30.0	9.8
Netherlands	0.55	25.0	28.4
New Zealand	0.29	28.0	16.9
Norway	0.29	28.0	26.7
Poland	0.23	19.0	20.8
Portugal	0.28	30.0	19.7
Slovak Republic	0.31	23.0	15.7
Slovenia	0.31	17.0	29.4
Spain	0.27	30.0	19.0
Sweden	N/A	22.0	25.1
Switzerland	0.90 ^e	8.5	14.0
Turkey	N/A	20.0	26.3
United Kingdom	0.20	21.0	24.0
United States	0.48	35.0	20.6
Average	0.37	23.5	22.1

^a All data is from the year 2013 if not noted otherwise.

^b *Source*: OECD (2016a).

^c *Source*: OECD (2016b).

^d Data from 2008.

^e Data from 2012.

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