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ABSTRACT

In many countries, taxes on businesses are less progressive than labor income taxes. This paper provides a justification for this pattern based on adverse selection that entrepreneurs face in credit markets. Individuals choose between becoming entrepreneurs or workers and differ in their skill in both of these occupations. I find that endogenous cross-subsidization in the credit market equilibrium results in excessive (insufficient) entry of low-skilled (high-skilled) agents into entrepreneurship. This gives rise to a corrective role for differential taxation of entrepreneurial profits and labor income. In particular, a profit tax that is regressive relative to taxes on labor income restores the efficient occupational choice.

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1 Introduction

In most countries, taxes on entrepreneurs and businesses, such as the corporate income tax, are less progressive than labor income taxes in the sense that they are typically characterized by flat rather than increasing marginal tax rates. This paper proposes a framework in which such a pattern arises as an optimal policy response to frictions that entrepreneurs face in credit markets. The argument is developed in a model in which individuals can choose between entrepreneurship and paid employment as workers and have private information about their ability in both of the two occupations. In order to set up a firm, entrepreneurs have to borrow funds in competitive credit markets that are affected by adverse selection.[1] Whenever there is cross-subsidization between high and low quality borrowers, this provides excessive incentives for low skilled individuals to enter entrepreneurship, but insufficient incentives for high ability agents. I show that this occupational misallocation can be removed by a profit tax that is regressive relative to labor income taxes, thus counteracting the cross-subsidization in the credit market equilibrium. Notably, this pattern of tax policy can be justified on efficiency grounds even without a redistributive or revenue motive for taxation.

The fact that adverse selection can induce the wrong *mix* of individuals in entrepreneurship and paid employment, rather than just an inefficient overall share of entrepreneurs in the economy, is driven by multidimensional heterogeneity. The existing literature, going back to the seminal papers by Stiglitz and Weiss (1976) and De Meza and Webb (1987), has instead focused on settings where a one-dimensional, privately known ability type drives occupational choice. In this case, credit market imperfections induce either a too low or a too high number of agents to become entrepreneurs, depending on whether ability affects the mean or the riskiness of entrepreneurial returns. This calls for either a lump-sum subsidy or tax on entrepreneurship (or bank profits) to restore efficiency, but is unable to explain why profit taxes should be less progressive than labor income taxes.

By contrast, I consider a more general setting in which individuals differ in both their ability as entrepreneurs and workers, and the two dimensions of private information are not necessarily perfectly correlated. In this case, adverse selection in credit markets can distort occupational choice even if the equilibrium level of overall entrepreneurial activity is at the efficient level. This is because the *composition* of agents in entrepreneurship is inefficient, with too many and too few entrepreneurs at the same time. Whereas lump-sum taxes or subsidies on entrepreneurship are unable to correct this misallocation, I

[1] See e.g. Evans and Leighton (1989), Hurst and Lusardi (2004) and De Nardi, Doctor, and Krane (2007) for evidence on the importance of borrowing frictions for entrepreneurship.

demonstrate that regressive profit taxes are a more flexible corrective instrument that not only affects the overall level but also the ability mix of agents in the two occupations.

Formally, private heterogeneity is captured in the model by a type vector (θ, ϕ), where θ denotes an individual's entrepreneurial skill and ϕ the skill as a worker. Entrepreneurial profits π are risky and distributed according to some cdf $H(\pi|\theta)$, where higher θ leads to better profit distributions. On the other hand, if an individual chooses to become a worker, her payoff is deterministic and proportional to her skill ϕ. This structure generates some frontier $\tilde{\phi}(\theta)$ that determines occupational choice, i.e. the set of types who are just indifferent between becoming entrepreneurs or workers. All types with $\phi \leq \tilde{\phi}(\theta)$ become entrepreneurs and all the others workers.

I start with characterizing credit market equilibria in this economy. Competitive banks offer the funds needed by entrepreneurs to set up a firm in exchange for repayment schedules $R_\theta(\pi)$. Theorem 1 shows that, under some conditions on the joint distribution of θ and ϕ and feasible repayment schemes, the equilibrium involves only a single debt contract $R(\pi) = \min\{\pi, z\}$ being offered to all types of entrepreneurial ability. This generalizes the results from the financial contracting literature in settings with moral hazard or one-dimensional heterogeneity (as reviewed in Proposition 1), in particular Innes (1990, 1993), to the present setting with multidimensional privately observed heterogeneity.

As a result of the cross-subsidization between high and low quality borrowers in the pooling equilibrium, occupational choice is distorted compared to the efficient allocation in the sense that the equilibrium frontier $\tilde{\phi}(\theta)$ is a rotation of the efficient one: there are too many low-θ and too few high-θ entrepreneurs in equilibrium, i.e. $\tilde{\phi}(\theta)$ is too flat. Since the credit market imperfection therefore does not discourage (or encourage) entry into entrepreneurship across the board, lump-sum policy instruments suggested in the existing literature (as summarized in Proposition 3) are unable to address it. Proposition 2 demonstrates, however, that a regressive profit tax, which in expectation subsidizes high-skilled entrepreneurs and taxes low-skilled ones, can be designed so as to counteract the effects of cross-subsidization in the credit market and restore the efficient occupational choice. This points out the role of profit taxation as a more targeted policy instrument that is able to control the composition of entrepreneurship rather than just its overall level.

I finally extend the model to allow for endogenous labor supply and demand and thus taxes on workers in addition to entrepreneurs. In this case, progressive taxation of labor income, together with a flat profit tax, is an alternative policy tool to implement the efficient occupational choice. Rather than directly counteracting cross-subsidization in credit markets, it introduces symmetric cross-subsidization among workers. In fact, Proposition 4 shows that there is a continuum of implementations, ranging from the one extreme of a regressive profit tax together with a flat tax on labor income, to the other extreme of a flat tax on profits and a progressive labor income tax. What matters in all of these implementations is that profit taxes are regressive *relative* to taxes on workers. As mentioned at the beginning, this describes a pattern that can be observed in practice, since business taxes are indeed less progressive than labor taxes in many countries.

Related literature. The present paper is related to an extensive literature on the role of government interventions in credit markets with adverse selection. This research has focused on models with one-dimensional heterogeneity and derived contrasting results depending on whether entrepreneurial ventures differ in terms of their risk profile or their expected returns. The most prominent example of the former case is Stiglitz and Weiss (1976), who point out the possibility of credit rationing and therefore an inefficiently low number of entrepreneurs in equilibrium when banks are restricted to offering debt contracts. However, De Meza and Webb (1987) have shown that, in fact, equity contracts are optimal in this setting, which implements the first best and thus eliminates the possibility of credit rationing. On the other hand, De Meza and Webb (1987) have developed a model corresponding to the second case, i.e. heterogeneity in expected returns. In this case, debt financing is optimal and excessive entry into entrepreneurship results if the outside option is a fixed safe investment. The appropriate policy is therefore to tax rather than subsidize entrepreneurship. Yet none of these papers addresses the role of multidimensional heterogeneity for equilibrium efficiency.

An important exception is the work by Hellman and Stiglitz (2000), who consider entrepreneurs that differ in both expected returns and risk. They demonstrate that the possibility of credit rationing, and thus an inefficiently small amount of entrepreneurship, can reemerge in this setting if there are specialized investors who only offer either debt or equity contracts and entrepreneurs can obtain financing from only one of these markets, but not both at the same time. However, the possibility of an inefficient mix of individuals entering entrepreneurship does not arise in their model, nor do they consider policy instruments to address the inefficiency, which is the focus of the present paper.

More closely related are the more recent contributions by Parker (2003) and Ghatak, Morelli, and Sjöström (2007). The present paper shares their approach of viewing the outside option of entrepreneurs as paid employment rather than a safe investment and therefore of exploring the role of tax policy as a means to affect occupational choice. However, the key difference is that both papers focus on settings with one-dimensional heterogeneity in privately observed ability. Ghatak, Morelli, and Sjöström (2007) consider a two-type model and assume that θ and ϕ are perfectly correlated (they also allow for heterogeneity in asset holdings, but this dimension is publicly observed). With pooling in credit markets, all high-θ types and an inefficiently high share of low-θ types become entrepreneurs, whereas the remaining low-θ types become workers. As in De Meza and Webb (1987), a lump-sum tax on entrepreneurs is therefore optimal.[2] I show how these results change when abilities for the two occupations are not perfectly correlated, so that an occupational misallocation with too many and too few entrepreneurs simultaneously emerges. The optimal policy then must discourage entry into entrepreneurship for some types, but encourage it for other types, as achieved by a non-linear profit tax.

Parker (2003) also considers an economy where ϕ is a function of θ, but allows for multiple crossings in the relationship so that it no longer necessarily is the case that all high ability types become entrepreneurs and the others workers. However, even if there are multiple intervals in the relationship between abilities and occupational choice, there always exists a one-to-one mapping in the sense that different occupations have income distributions with non-overlapping supports. Moreover, the tax policies proposed in his contribution crucially rely on this property. The present paper addresses the difficulties that arise in the absence of such a one-to-one mapping, which Parker (2003) speculates about. With two-dimensional heterogeneity, there are both entrepreneurs and workers at any ability and thus income level, which is an empirically more attractive feature than the perfect sorting of ability types into occupations under one-dimensional heterogeneity.[3] Despite the resulting overlapping income distributions, it turns out that it is possible to transparently characterize the occupational misallocation and tax policies that correct it. In particular, none of the above papers derive the (relative) regressivity of profit taxes as an optimal policy response to the distortions from credit market frictions.

This paper also contributes to the optimal taxation literature that has started to explicitly account for multidimensional heterogeneity recently, albeit typically in different contexts. For instance, Kleven, Kreiner, and Saez (2009) have considered an application to the optimal taxation of couples and Choné and Laroque (2010) have characterized optimal taxation with an extensive margin when individuals are characterized both by a skill type and an additive taste for labor. Relatedly, Scheuer (2012) has characterized the optimal taxation of labor income of workers and profits of entrepreneurs when productivity in both occupations is determined by a single skill type and there is an additive utility cost of entering entrepreneurship. However, in all these studies, the motivation for taxation

[2] Moreover, Ghatak, Morelli, and Sjöström (2007) emphasize the role of endogenous wages and output prices for occupational choice in their setting, giving rise to interesting general equilibrium effects and the possibility of multiple equilibria. I abstract from endogenous wages and prices in the main part of this paper, but briefly demonstrate how the model can be extended to account for them in Section 6.

[3] Parker (1997) provides evidence on a U-shaped relationship between income and the share of entrepreneurs, which is strictly between 0 and 1 everywhere. Generating such a pattern requires a model with multidimensional heterogeneity.

is very different from the current setting. There are no inefficiencies in these models: the no tax equilibrium is on the constrained Pareto frontier and the only reason for income taxes is therefore redistribution. Moreover, Scheuer (2012) considers a Mirrlees (1971) framework with an elastic intensive labor supply margin, so that optimal taxes are crucially shaped by the classic tradeoff between labor distortions and redistributive motives in addition to occupational choice.[4]

In contrast, the key role of taxes emphasized in the present paper is corrective: they are desirable for efficiency reasons even without a redistributive or revenue motive. This is because I explicitly account for the effect of entrepreneurial borrowing and adverse selection in credit markets on the equilibrium occupational choice, which is abstracted from in Scheuer (2012). Moreover, in order to transparently expose the role of an elastic occupational choice margin, I abstract from endogenous labor supply in the main part of the present paper (see Section 6.1 for an extension in this direction). As a result, the regressivity of optimal profit taxes is not driven by a desire to stimulate an intensive effort margin or to manipulate wages, but entirely by the inefficiency of occupational choice from endogenous cross-subsidization in the credit market equilibrium without taxes.

More generally, this paper is related to an extensive literature on multidimensional screening. Most of this literature has focused on monopolistic or duopolistic screening and the form of the optimal contract when agents differ not only in their valuation of the good provided by the principal but also in their outside option. Jullien (2000) has analyzed adverse selection with such type dependent participation constraints when the two dimensions are perfectly correlated. Rochet and Stole (2002) have generalized this setting to imperfect correlation and thus full two-dimensional heterogeneity.[5] The pooling result derived in the present paper can be viewed as an extreme form of the results about the prevalence of bunching in this line of research (see also Rochet and Choné, 1998), even though the setting considered here, with competition between many principals, is quite different and in the spirit of Rothschild and Stiglitz (1976).[6] None of these papers have considered the implications of the resulting cross-subsidization for occupational choice and optimal tax policy.

[4]Scheuer (2012) also considers the role of endogenous wages for nonlinear income taxation and is mainly interested in comparing optimal tax schedules under a uniform versus differential tax treatment of entrepreneurs and workers. See also Rothschild and Scheuer (2012a,b) for Mirrleesian optimal tax studies when individuals can choose between different sectors and are characterized by a fully two-dimensional skill type, one for each sector, rather than the additive second dimension of heterogeneity considered here.

[5]See Armstrong and Rochet (1999) and Rochet and Stole (2003) for overviews of this literature.

[6]Smart (2000) and Netzer and Scheuer (2010) have examined 4-type models with two-dimensional heterogeneity in the Rothschild-Stiglitz framework. These papers do not consider endogenous entry into insurance markets, however.

The structure of the paper is as follows. Section 2 introduces the baseline model with two-dimensional heterogeneity. Section 3 characterizes the credit market equilibrium without taxes. The main result of this section is Theorem 1, which implies cross-subsidization between borrowers of different qualities in equilibrium. Section 4 analyzes the effects of this cross-subsidization on the equilibrium occupational choice and constructs a regressive profit tax system that eliminates this occupational misallocation (Proposition 2). Section 5 provides a numerical example and Section 6 extends the baseline model to allow for labor income taxes. Proposition 4 shows that what matters in this more general framework is that profit taxes are regressive relative to labor income taxes. Finally, Section 7 concludes. The proof of Theorem 1 is relegated to the appendix.

2 The Model

I consider a unit mass of heterogeneous individuals who are characterized by a two-dimensional type vector $(\theta, \phi) \in \Theta \times \Phi \equiv [\underline{\theta}, \overline{\theta}] \times [\underline{\phi}, \overline{\phi}]$, where θ will be interpreted as an individual's skill as an entrepreneur and ϕ as an individual's skill as a worker, as explained in more detail below. θ and ϕ are assumed to be independently distributed, where $F(\theta)$ denotes the cumulative distribution function of θ and $G(\phi)$ the cumulative distribution function of ϕ, both assumed to allow for density functions $f(\theta)$ and $g(\phi)$. Both θ and ϕ are an individual's private information.

Agents can choose between two occupations: they can become a worker, in which case they obtain the payoff ϕ according to the second dimension of their skill type. Alternatively, an agent may select to become an entrepreneur. To set up a firm, each entrepreneur has to make a fixed investment I. Agents are born without wealth and hence have to borrow these funds from banks in a competitive credit market. Entrepreneurs produce stochastic profits π according to some cdf $H(\pi|\theta)$ that depends on their entrepreneurial skill θ. In particular, I assume that $H(\pi|\theta) \succeq_{MLRP} H(\pi|\theta')$ for $\theta > \theta'$, i.e. a higher skilled entrepreneur has a distribution of π that is better in the sense of the monotone likelihood ratio property (MLRP). $H(\pi|\theta)$ has support $\Pi \equiv [\underline{\pi}, \overline{\pi}]$ for all θ such that

$$\underline{\pi} < I < \overline{\pi} \text{ and } \underline{\phi} = 0, \ \overline{\phi} \geq \int_{\Pi} \pi dH(\pi|\overline{\theta}).$$

The first assumption rules out trivial credit market equilibria where entrepreneurs can always or never repay the investment outlays I, independent of their profit realization. The second ensures that, for each θ, there exist some ϕ-types who become entrepreneurs and others who choose to be workers in the credit market equilibrium (and this is also efficient). An entrepreneur's realized profits π are publicly observable.

There is a large number of risk-neutral banks, offering credit contracts that supply funding I in return for a repayment schedule $R_\theta(\pi)$.[7] The expected utility of an entrepreneur of ability type θ from such a contract is then $\int_\Pi [\pi - R_\theta(\pi)]\, dH(\pi|\theta)$. For a given credit contract, an individual of skill type (θ, ϕ) decides to enter entrepreneurship if and only if

$$\int_\Pi [\pi - R_\theta(\pi)]\, dH(\pi|\theta) \geq \phi$$

and becomes a worker otherwise. I can therefore characterize the occupational choice decision of all individuals by the critical values

$$\tilde{\phi}(\theta) \equiv \max\left\{\underline{\phi}, \min\left\{\overline{\phi}, \int_\Pi [\pi - R_\theta(\pi)]\, dH(\pi|\theta)\right\}\right\}$$

such that all (θ, ϕ) with $\phi \leq \tilde{\phi}(\theta)$ become entrepreneurs and all the others workers. This also makes clear that occupational choice depends on the (endogenous) credit market equilibrium $\{R_\theta(\pi)\}$, a key force underlying the results in the following. The above assumptions on the support $[\underline{\phi}, \overline{\phi}]$ make sure that the critical value for occupational choice $\tilde{\phi}(\theta)$ is always given by an interior value in $(\underline{\phi}, \overline{\phi})$ in equilibrium.

As a result of two-dimensional heterogeneity in both skill dimensions, there will not be a perfect ranking between occupational choice and (expected) payoffs: for any given θ, there are individuals who enter entrepreneurship and others who become workers due to their different ϕ-type. This is an empirically attractive implication of the present specification and in contrast to models where occupational choice is only based on one dimension of privately observed heterogeneity.[8] In that case, it is typically assumed that one occupation rewards ability relatively more than the other. Then there exists a critical skill level such that higher skilled agents select into the high-reward occupation, and lower-ability agents into the other. This would result in income distributions for the two occupations that somewhat unrealistically occupy non-overlapping intervals.

3 Equilibrium in the Credit Market

I next define and characterize credit market equilibria in the economy introduced in the preceding section.

[7] I introduce the index θ even though θ is private information since, in a separating equilibrium, banks may offer different credit contracts to entrepreneurs of different ability levels θ. Of course, any such assignment has to be incentive compatible, as specified below. Moreover, note that it is impossible to screen entrepreneurs based on their ϕ-type.

[8] A partial list of such models includes Stiglitz and Weiss (1976), De Meza and Webb (1987), Boadway, Marceau, and Pestieau (1991), Moresi (1997), Parker (1999, 2003) and Ghatak, Morelli, and Sjöström (2007).

Definition 1. *A credit market equilibrium is a set of contracts $\{R_\theta(\pi)\}$ such that*
(i)

$$\int_\Pi (\pi - R_\theta(\pi))\, dH(\pi|\theta) \geq \int_\Pi (\pi - R_{\theta'}(\pi))\, dH(\pi|\theta) \ \ \forall \theta, \theta' \in \Theta, \tag{1}$$

(ii)

$$\int_\Theta G(\tilde{\phi}(\theta)) \left[\int_\Pi R_\theta(\pi) dH(\pi|\theta) - I \right] dF(\theta) \geq 0 \tag{2}$$

with

$$\tilde{\phi}(\theta) = \int_\Pi (\pi - R_\theta(\pi))\, dH(\pi|\theta) \ \ \forall \theta \in \Theta, \ \ \textit{and}$$

(iii) there exists no other set of contracts $\{\tilde{R}_\theta(\pi)\}$ that earns strictly positive profits when offered in addition to $\{R_\theta(\pi)\}$ and all individuals select their preferred occupation and preferred contract from $\{\tilde{R}_\theta(\pi)\} \cup \{R_\theta(\pi)\}$.

Condition (1) is the set of incentive constraints, which require that each entrepreneur is willing to select the credit contract $R_\theta(\pi)$ intended for her. Constraint (2) makes sure that the set of equilibrium credit contracts make non-negative profits *in aggregate* when taken up by the agents who select into entrepreneurship, as given by the critical cost values $\tilde{\phi}(\theta)$ for all $\theta \in \Theta$. Finally, the last part of the definition rules out profitable sets of deviating contract offers. Note that, although the structure of this definition is similar to Rothschild and Stiglitz (1976), it is considerably more general by letting banks offer *sets* of contracts, thus allowing for cross-subsidization between different contracts in equilibrium.

Following Innes (1993), I restrict attention to contracts $R_\theta(\pi)$ that satisfy the following two properties: First, $0 \leq R_\theta(\pi) \leq \pi$ for all $\theta \in \Theta$ and $\pi \in \Pi$, which is a standard limited liability constraint. Second, $R_\theta(\pi)$ is non-decreasing in π so that, when the entrepreneur earns higher profits, the repayment received by the bank $R_\theta(\pi)$ is also higher. This monotonicity constraint has been a standard assumption in the financial contracting literature since Innes (1990) and Nachman and Noe (1994). It generates more realistic equilibrium contracts by smoothing sharp discontinuities in repayment schedules and can also be formally justified, e.g. based on the following hidden side trades (see e.g. chapters 3.6 and 6.6 in Tirole, 2006): if banks can only observe total cash flows, entrepreneurs would have incentives to increase their profits by costlessly borrowing $b > 0$ and reporting augmented profits $\tilde{\pi} \equiv \pi + b$ in any decreasing segment of the repayment schedule $\tilde{R}(\tilde{\pi})$. This would give rise to an effective repayment function $R(\pi) = \min_{\tilde{\pi} \geq \pi} \{\tilde{R}(\tilde{\pi})\}$ that automatically satisfies the monotonicity constraint. Moreover, whenever π has only two possible realizations, any repayment scheme that guarantees the bank non-negative profits in equilibrium must be weakly increasing in π. Note that both of these motivations for the monotonicity constraint work independently from whether the underlying heterogeneity of entrepreneurs is one- or multidimensional.

3.1 One-dimensional Heterogeneity

De Meza and Webb (1987) and Innes (1990, 1993) have characterized credit market equilibria under such assumptions in models with moral hazard or one-dimensional private heterogeneity, as captured by θ. Before demonstrating how their analysis generalizes to the present setting with two-dimensional private heterogeneity in θ and ϕ, let me briefly review their main results by considering the case where only θ is private information but ϕ is observable. In this case, there is a credit market for each value of ϕ, and within each such market, borrowers differ only in their privately known quality θ. I can therefore just look at one such market, for a given value of ϕ, and the equilibrium takes the following form (see e.g. Innes (1993), Proposition 1):

Proposition 1. *When ϕ is observable, the credit market equilibrium for a given ϕ is such that only the single debt contract $R_{z_\phi^*}(\pi) = \min\{\pi, z_\phi^*\}$ is offered. There is a critical value θ_ϕ^* such that all types with $\theta \geq \theta_\phi^*$ become entrepreneurs and all the others workers, where θ_ϕ^* solves*

$$\int_\Pi (\pi - \min\{\pi, z_\phi^*\}) dH(\pi|\theta_\phi^*) = \phi \tag{3}$$

and z_ϕ^* solves

$$\int_{\theta_\phi^*}^{\overline{\theta}} \left[\int_\Pi \min\{\pi, z_\phi^*\} dH(\pi|\theta) - I \right] dF(\theta) = 0. \tag{4}$$

The proposition, which is proven in Innes (1993), shows that an equilibrium always exists and is given by a pooling contract that takes the simple form of a debt contract: It specifies a fixed repayment level z_ϕ^*, which the entrepreneur has to return to the bank whenever she can, i.e. whenever $\pi \geq z_\phi^*$. Otherwise, the firm goes bankrupt, and the entire amount of profits goes to the bank, with the entrepreneur hitting her liability limit and thus being left with zero consumption. This results in the contract $R_{z_\phi^*}(\pi) = \min\{\pi, z_\phi^*\}$, where z_ϕ^* is such that the banks' expected profit is zero given the set of agents who enter the credit market for ϕ when anticipating the equilibrium contract $R_{z_\phi^*}(\pi)$. This set is determined by the threshold θ_ϕ^* and all individuals with ability higher than that become entrepreneurs and all the low ability agents become workers.

The intuition for this debt contracting result is the following: By the monotone likelihood ratio property, low-skill entrepreneurs have a larger probability weight in low-profit states. Among all contracts satisfying the monotonicity constraint, debt contracts in turn are the ones that put the maximal repayment weight in these low-profit states. As a result, debt contracts are least attractive to low-skill borrowers, and hence any set of deviation contracts that do not take the debt contract form would attract a lower quality borrower pool and generate lower profits for banks.

It is worth stressing that the assumption of return distributions ordered by MLRP, which implies FOSD and hence differences in expected returns, plays an important role for this result. In contrast, Stiglitz and Weiss (1976) have considered a setting where entrepreneurs have private information about the risk of their investment, ranked by SOSD, but they all have the same expected return. While Stiglitz and Weiss (1976) have confined attention to debt financing and demonstrated that it can generate credit rationing in equilibrium, De Meza and Webb (1987) have shown that equity contracts are in fact optimal in such a model, and they even implement the first best. On the other hand, De Meza and Webb (1987) have developed an alternative model where entrepreneurs differ in expected returns, as ranked by FOSD, and shown that debt contracts are optimal in this case. Proposition 1, going back to Innes (1993), is a more general result, allowing for a continuum of possible profit realizations rather than just two and demonstrating that debt financing endogenously arises as an equilibrium outcome when entrepreneurs differ in expected profits. In particular, while banks could offer equity contracts (or any other contracts that satisfy the constraints) here, it is not profitable for them to do so.

The result is also different from the canonical Rothschild and Stiglitz (1976) model, in which a pooling equilibrium is impossible and an equilibrium may fail to exist altogether. This is because there exist "cream-skimming" deviations that attract profitable types (i.e. low risk types in the Rothschild-Stiglitz framework) without attracting unprofitable (high risk) ones in their model. However, this is not possible in the present framework: any deviation set of contracts will in fact be more attractive to low quality borrowers than the equilibrium debt contract, and hence "cream-skimming" attempts only attract unprofitable rather than profitable types. In this sense, "cream-skimming" only works in the wrong direction in the present framework.

3.2 Two-dimensional Heterogeneity

Let me now demonstrate how the debt contracting result generalizes to the present framework withheterogeneity in both θ and ϕ and both are private information. As the next theorem shows, a debt contracting equilibrium still obtains under the following assumption on the distribution of ϕ.

Assumption 1. *$g(\phi)$ is non-increasing.*

I already assumed that θ and ϕ are independently distributed from the beginning. This together with Assumption 1 ensures that the two-dimensional screening problem that banks face when offering credit contracts remains tractable and the equilibrium takes the following form.

Theorem 1. *Under Assumption 1, the credit market equilibrium with unobservable θ and ϕ is such that only the single contract $R_{z^*}(\pi) = \min\{\pi, z^*\}$ is offered and z^* solves*

$$\int_{\Theta} G(\tilde{\phi}_{z^*}(\theta)) \left[\int_{\Pi} \min\{\pi, z^*\} dH(\pi|\theta) - I \right] dF(\theta) = 0 \tag{5}$$

with

$$\tilde{\phi}_{z^*}(\theta) = \int_{\Pi} (\pi - \min\{\pi, z^*\}) \, dH(\pi|\theta) \;\; \forall \theta \in \Theta. \tag{6}$$

Proof. See Appendix A. □

When both θ and ϕ are unobservable, there is only a single credit market for the entire economy and thus pooling occurs over all (θ, ϕ)-types that become entrepreneurs, as captured by the zero-profit constraint (5). Moreover, the equilibrium no longer takes the threshold form in terms of θ as under one-dimensional private heterogeneity: For any level of entrepreneurial ability θ, there are individuals who enter entrepreneurship and others who become workers, as determined by the critical cost values $\tilde{\phi}_{z^*}(\theta)$. Formally, the share of entrepreneurs conditional on a skill θ who demand a credit contract, given by $G(\tilde{\phi}_{z^*}(\theta))$, is now a smooth function of θ valued between zero and one, in contrast to the models with one-dimensional heterogeneity. Indeed, when ϕ was the same for all individuals in a credit market, then there was some critical value θ^*_ϕ such that $G(\tilde{\phi}_{z^*}(\theta)) = 0 \; \forall \, \theta < \theta^*_\phi$ and $G(\tilde{\phi}_{z^*}(\theta)) = 1$ otherwise. It is a key advantage of the present setting with two-dimensional heterogeneity that it can explain the existence of both workers and entrepreneurs in all parts of the skill distribution, including entrepreneurs of low skill and workers of high skill, rather than the (somewhat stark) perfect sorting of ability types into occupations in the threshold equilibrium, conditional on observables.[9]

[9] See e.g. Parker (1997) for evidence documenting that entrepreneurs are represented both at the high and low end of the income distribution in the UK. In addition, there is another empirical difference between the one- and two-dimensional models: consider a bank that offers a debt contract $\min\{\pi, z\}$ and increases z by a small amount. If ϕ is the same for all entrepreneurs in the credit market, the demand reaction to this change will occur only at the lower end of entrepreneurial abilities who demand credit, since the only marginal entrepreneur is at the threshold skill θ^*_ϕ, which will drop out of the credit market in response to the increase in z. In contrast, with private heterogeneity in ϕ, all critical values $\tilde{\phi}(\theta)$ will decrease when z increases. Hence, there will be a reduction in demand for *all* entrepreneurial skill levels θ because there are marginal borrowers at each quality level. Two-dimensional heterogeneity is therefore key to generate such smoother demand reactions to price changes.

The result in Theorem 1, showing that the equilibrium still involves a debt contract, as in Proposition 1, goes through even with two-dimensional heterogeneity for two reasons. First, the second dimension of the skill type ϕ does not affect preferences over different credit contracts. In other words, an individual's skill as a worker ϕ only affects her occupational choice, but not which credit contract she finds attractive given that she chooses to be an entrepreneur. The intuition from Innes (1993) about the higher attractiveness of a debt contract to high-θ types compared to low-θ types, conditional on being entrepreneurs, therefore extends to the present setting. However, the *distribution* $G(\phi)$ now matters for bank profits, since it determines *how many* agents of entrepreneurial skill θ choose to become entrepreneurs, and also how many of them are attracted into credit markets by a deviating contract.

The proof of Theorem 1 therefore involves demonstrating that, under the distributional assumptions of independence between θ and ϕ and Assumption 1, there still does not exist a profitable deviation for any bank from the pooling debt contract even though the number of entrepreneurs of skill θ who demand credit contracts, $G(\tilde{\phi}_{z^*}(\theta))f(\theta)$, is now endogenous and smooth. Independence and Assumption 1 ensure that any deviating contract still attracts relatively more low-θ agents into the credit market than high-θ agents (see Lemmas 3 and 4 in Appendix A). In particular, to prove the theorem, I consider any set of deviation contracts $\{R^d_\theta(\pi)\}$ and the resulting critical cost values for occupational choice

$$\tilde{\phi}_d(\theta) \equiv \max\left\{\int_\Pi [\pi - R_{z^*}(\pi)]\, dH(\pi|\theta), \int_\Pi \left[\pi - R^d_\theta(\pi)\right] dH(\pi|\theta)\right\}.$$

Then Lemma 3 in the appendix first shows that the change in critical cost values due to the deviation $\Delta\tilde{\phi}(\theta) = \tilde{\phi}_d(\theta) - \tilde{\phi}_{z^*}(\theta)$ is decreasing in θ. This means that low-θ types have a stronger reaction to any deviation set of contracts in terms of how they are attracted into the credit market in addition to those already attracted by the original debt contract. This holds without distributional assumptions. However, to make sure that it translates into a less favorable pool of borrower qualities for the deviating contract compared to the posited equilibrium debt contract, the reaction as measured by G, given by $\Delta G(\tilde{\phi}(\theta)) = G(\tilde{\phi}_d(\theta)) - G(\tilde{\phi}_{z^*}(\theta))$, must also be decreasing in θ. Since $\tilde{\phi}_{z^*}(\theta)$ is increasing by MLRP, Lemma 4 shows that independence of θ and ϕ and concavity of $G(\phi)$ are sufficient, even though not necessary, for this result.[10] Using this, the proof proceeds by showing that

[10]If $G(\phi)$ were not concave or depended on θ, it could be that, even though the response of high-θ types in terms of $\Delta\tilde{\phi}(\theta)$ is smaller, their response as measured by $\Delta G(\tilde{\phi}(\theta))$ is larger since $g(\phi)$ puts little density at low ϕ values (where the low-θ types react strongly in terms of $\Delta\tilde{\phi}(\theta)$) but much density at high ϕ values (where high-θ types react little). See Rochet and Stole (2002) for similar conditions to keep tractability in

any deviation must therefore attract a borrower pool that is tilted towards lower qualities than the zero profit pooling debt contract, and therefore cannot be profitable.

4 Occupational Choice and Entrepreneurial Tax Policy

4.1 Inefficiency of Occupational Choice

I now ask whether the no tax equilibrium in this economy involves the efficient occupational choice. In fact, efficiency would require that a type (θ, ϕ) becomes an entrepreneur if and only if

$$\int_{\Pi} \pi dH(\pi|\theta) - I \geq \phi,$$

i.e. her expected profits minus the investment outlays exceed the payoff from being a worker ϕ. This can be solved for the efficient critical cost value

$$\tilde{\phi}_e(\theta) \equiv \int_{\Pi} \pi dH(\pi|\theta) - I \tag{7}$$

for any $\theta \in \Theta$. Then the following result is a corollary of Theorem 1:

Corollary 1. *When θ and ϕ are both unobservable, there exists a unique skill-type $\tilde{\theta}$ such that $\int_{\Pi} \min\{\pi, z^*\} dH(\pi|\tilde{\theta}) = I$ and*

$$\tilde{\phi}_{z^*}(\theta) > \tilde{\phi}_e(\theta) \;\; \forall \theta < \tilde{\theta} \quad \text{and} \quad \tilde{\phi}_{z^*}(\theta) < \tilde{\phi}_e(\theta) \;\; \forall \theta > \tilde{\theta}.$$

Proof. First, $\int_{\Pi} \min\{\pi, z^*\} dH(\pi|\theta)$ is increasing in θ by the monotone likelihood ratio property. Second, $\tilde{\theta}$ exists by the aggregate zero profit constraint (5). Third, by (6) and (7), $\tilde{\phi}_e(\theta) \gtreqless \tilde{\phi}_{z^*}(\theta)$ if and only if $\int_{\Pi} \min\{\pi, z^*\} dH(\pi|\theta) \gtreqless I$. □

Since the credit market equilibrium is a pooling equilibrium, it involves cross-subsidization across entrepreneurs of different qualities θ. In particular, by the monotone likelihood ratio property, banks make higher profits with higher ability entrepreneurs, and thus by the zero profit condition (5), there exists some critical skill level $\tilde{\theta}$ such that banks make profits with all higher quality entrepreneurs and negative profits with all the others. But this cross-subsidization implies that, compared to the efficient occupational choice defined in (7), low skilled agents have too strong incentives to set up a firm, and too many

a two-dimensional monopolistic screening problem where the second dimension of private information also enters preferences additively. They partially characterize the optimal contract, such as no distortion at the boundaries of the type space, assuming independence between the two dimensions and a log-concave distribution for the additive dimension and a uniform distribution for the other.

high skill agents stay in the workforce. In other words, the credit market equilibrium generates occupational misallocation such that there is excessive entry of low ability types into entrepreneurship, but insufficient entry of high-skilled types. This can be seen most easily by substituting the equilibrium zero profit condition (5) into equation (7), solving the former for I:

$$\tilde{\phi}_e(\theta) = \int_\Pi \pi dH(\pi|\theta) - \frac{\int_\Theta G(\tilde{\phi}_{z^*}(\theta)) \int_\Pi \min\{\pi, z^*\} \, dH(\pi|\theta) dF(\theta)}{\int_\Theta G(\tilde{\phi}_{z^*}(\theta)) dF(\theta)}$$

and comparing it with the equilibrium critical values for occupational choice in (6):

$$\tilde{\phi}_{z^*}(\theta) = \int_\Pi \pi dH(\pi|\theta) - \int_\Pi \min\{\pi, z^*\} dH(\pi|\theta).$$

Notably, this comparison clearly identifies the importance of cross-subsidization as the source of the inefficiency: If Θ is singleton, for instance, then $\tilde{\phi}_{z^*}(\theta) = \tilde{\phi}_e(\theta)$.

It is again useful to compare this misallocation to the case when ϕ is the same for all agents, so that there only remains one-dimensional heterogeneity in ability. One way to generate this case is by assuming that ϕ is observable, so that there is a separate credit market for each given ϕ. Then the following corollary of Proposition 1 shows that the equilibrium only involves excessive entry into entrepreneurship, with too many low-skill types receiving funding in the credit market.

Corollary 2. *Suppose ϕ is observable and denote the critical skill level for the efficient occupational choice by θ^e_ϕ such that, given ϕ,*

$$\int_\Pi \pi dH(\pi|\theta^e_\phi) - I = \phi. \tag{8}$$

Then $\theta^e_\phi > \theta^*_\phi$ for any given ϕ.

Proof. Suppose, to obtain a contradiction, that $\theta^*_\phi \geq \theta^e_\phi$ for some given ϕ. Recall from (3) that θ^*_ϕ is such that

$$\int_\Pi \pi dH(\pi|\theta^*_\phi) - \int_\Pi \min\{\pi, z^*_\phi\} dH(\pi|\theta^*_\phi) = \phi.$$

Subtracting this from (8) yields

$$\int_\Pi \min\{\pi, z^*_\phi\} dH(\pi|\theta^*_\phi) - I = \int_\Pi \pi dH(\pi|\theta^*_\phi) - \int_\Pi \pi dH(\pi|\theta^e_\phi) \geq 0,$$

where the last inequality follows from the assumption that $\theta^*_\phi \geq \theta^e_\phi$ and MLRP. Moreover,

$$\int_\Pi \min\{\pi, z^*_\phi\} dH(\pi|\theta) - I \geq \int_\Pi \min\{\pi, z^*_\phi\} dH(\pi|\theta^*_\phi) - I \geq 0$$

for all $\theta \geq \theta^*_\phi$, where the first inequality is strict for all $\theta > \theta^*_\phi$ by MLRP. Hence, banks would make strictly positive profits with all entrepreneurs of skill $\theta > \theta^*_\phi$ and weakly positive profits with the marginal type θ^*_ϕ, resulting in overall strictly positive profits. This contradicts the zero profit condition (4). □

With one-dimensional heterogeneity, there is unambiguously too much entry into entrepreneurship, since in each credit market conditional on ϕ, the marginal entrepreneur who still receives funding in equilibrium, with skill θ^*_ϕ, is of lower quality than the efficient level θ^e_ϕ. This observation has been made first by De Meza and Webb (1987) in a model where agents choose between a safe investment and a risky project (entrepreneurship) with binary output, and extended to an occupational choice setting by Ghatak, Morelli, and Sjöström (2007).[11] This extreme case is quite in contrast to the seminal analysis by Stiglitz and Weiss (1976), who emphasized credit rationing and thus insufficient entry into entrepreneurship in a model where entrepreneurs differ in the riskiness of their projects rather than expected returns.

The present model demonstrates that, with two-dimensional heterogeneity, the occupational inefficiency can take both forms simultaneously, as there are too many and too few entrepreneurs of different skill types. In fact, the overall *level* of entrepreneurship can no longer be considered to evaluate the efficiency or inefficiency of the equilibrium. The total share of entrepreneurs in equilibrium may be equal to the efficient level, i.e.

$$\int_\Theta G(\tilde{\phi}_{z^*}(\theta))dF(\theta) = \int_\Theta G(\tilde{\phi}_e(\theta))dF(\theta),$$

but the equilibrium occupational choice would still be inefficient because the wrong mix of individuals are in the two occupations. This will be further illustrated in the numerical example in Section 5. It also demonstrates that, most generally, if different occupations are affected by different degrees of cross-subsidization, this makes the equilibrium occupational choice decisions inefficient.

4.2 Regressive Profit Taxation

In the following, I show that there is a simple entrepreneurial tax policy that eliminates this occupational misallocation. Suppose the government introduces a (possibly nonlinear) entrepreneurial profit tax $T(\pi)$, so that an entrepreneur's after-tax profits are given by $\hat{\pi} \equiv \pi - T(\pi)$. Banks and entrepreneurs, taking the tax schedule $T(\pi)$ as given,

[11] The latter in fact consider a two type model with $\theta \in \{\theta_L, \theta_H\}$ and assume that the skill as an entrepreneur and a worker are perfectly correlated with $\phi(\theta_H) < \phi(\theta_L)$. This effectively reduces private heterogeneity to one dimension as well with the result that, in the relevant equilibria, all θ_H-types and an inefficiently high share of the θ_L-types become entrepreneurs.

then write contracts contingent on these after-tax profits $\hat{\pi}$, and I can define the resulting credit market equilibrium for any given tax policy just as in Definition 1, replacing π by $\hat{\pi}$. Moreover, I keep assuming that contracts $R_\theta(\hat{\pi})$ must satisfy the limited liability constraint $0 \leq R_\theta(\hat{\pi}) \leq \hat{\pi}$ and the monotonicity constraint that $R_\theta(\hat{\pi})$ is non-decreasing in $\hat{\pi}$.[12] Under these conditions, it is known from Theorem 1 that the credit market equilibrium is a pooling equilibrium with only a debt contract being offered if the after-tax profits $\hat{\pi}$ satisfy the monotone likelihood ratio property with respect to θ, so that $\hat{H}(\hat{\pi}|\theta) \succeq_{MLRP} \hat{H}(\hat{\pi}|\theta')$ for $\theta > \theta'$, where $\hat{H}(\hat{\pi}|\theta)$ is the cdf of after-tax profits for type θ. The following lemma provides a condition on the tax schedule $T(\pi)$ for this to hold.

Lemma 1. *Suppose $H(\pi|\theta) \succeq_{MLRP} H(\pi|\theta')$ for $\theta > \theta'$, $\theta, \theta' \in \Theta$, and $T(\pi)$ is such that $\hat{\pi} = \pi - T(\pi)$ is increasing. Then $\hat{H}(\hat{\pi}|\theta) \succeq_{MLRP} \hat{H}(\hat{\pi}|\theta')$.*

Proof. Since $\hat{\pi} \equiv \Gamma(\pi) \equiv \pi - T(\pi)$ and $\Gamma(\pi)$ is increasing, the following relation between $\hat{H}(\hat{\pi}|\theta)$ and $H(\pi|\theta)$ is true:

$$\hat{H}(\Gamma(\pi)|\theta) = H(\pi|\theta) \;\; \forall \pi \in \Pi, \theta \in \Theta$$

and equivalently

$$\hat{H}(\hat{\pi}|\theta) = H(\Gamma^{-1}(\hat{\pi})|\theta) \;\; \forall \hat{\pi} \in \hat{\Pi}, \theta \in \Theta.$$

Differentiating with respect to $\hat{\pi}$, I therefore obtain

$$\hat{h}(\hat{\pi}|\theta) = \frac{h(\Gamma^{-1}(\hat{\pi})|\theta)}{\Gamma'(\Gamma^{-1}(\hat{\pi}))} \;\; \forall \pi \in \hat{\Pi}, \theta \in \Theta. \tag{9}$$

By assumption, $H(\pi|\theta)$ satisfies MLRP, which means that $h(\pi|\theta)/h(\pi|\theta')$ is increasing in π for $\theta > \theta'$. Equation (9) yields

$$\frac{\hat{h}(\hat{\pi}|\theta)}{\hat{h}(\hat{\pi}|\theta')} = \frac{h(\Gamma^{-1}(\hat{\pi})|\theta)/\Gamma'(\Gamma^{-1}(\hat{\pi}))}{h(\Gamma^{-1}(\hat{\pi})|\theta')/\Gamma'(\Gamma^{-1}(\hat{\pi}))} = \frac{h(\Gamma^{-1}(\hat{\pi})|\theta)}{h(\Gamma^{-1}(\hat{\pi})|\theta')},$$

which is increasing in $\Gamma^{-1}(\hat{\pi})$ by the assumption that $H(\pi|\theta)$ satisfies MLRP. Then the result follows from the fact that $\Gamma^{-1}(\hat{\pi})$ is an increasing function since $\hat{\pi} = \Gamma(\pi) = \pi - T(\pi)$ is increasing. □

Lemma 1 considers entrepreneurial profit tax schedules that involve marginal tax rates uniformly less than one, so that after-tax profits are increasing in before-tax profits. This is a weak restriction on tax policy that I assume to be satisfied in the following. The

[12] The idea behind this is that the government has no superior ability to extract tax payments from a firm in case of bankruptcy compared to banks, so that is must always hold that $\pi - T(\pi) - R(\pi) \geq 0$, where $R(\pi)$ is the repayment to the bank. In addition, when $T(\pi)$ is negative, it is assumed that banks can capture this transfer from the government in case of bankruptcy, so that $R(\pi) \leq \pi - T(\pi)$. In other words, tax payments are fully pledgeable.

lemma shows that, under this condition, the fact that higher θ-types have better before-tax profit distributions in the sense of the monotone likelihood ratio property translates into the same ordering of after-tax profit distributions. This is intuitive since such a profit tax preserves the ranking of before-tax profit levels and applies to all θ-types equally. Combined with Theorem 1, Lemma 1 then implies that, whenever the government imposes a tax on entrepreneurial profits $T(\pi)$ that involves marginal tax rates less than one, the resulting credit market equilibrium with this tax will be a single debt contract $R_{z_T^*}(\hat{\pi}) = \min\{\hat{\pi}, z_T^*\}$, where z_T^* is such that banks make zero profits in aggregate:

$$\int_{\Theta} G(\tilde{\phi}_{z_T^*,T}(\theta)) \left[\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I \right] dF(\theta) = 0. \tag{10}$$

Here,

$$\tilde{\phi}_{z_T^*,T}(\theta) = \int_{\Pi} (\pi - T(\pi) - \min\{\pi - T(\pi), z_T^*\})\, dH(\pi|\theta) \tag{11}$$

denotes the critical ϕ-value for entry into entrepreneurship at θ when the tax policy $T(\pi)$ is in place.

Now suppose the government sets the profit tax schedule $T(\pi)$ such that, for all $\theta \in \Theta$,

$$\int_{\Pi} T(\pi) dH(\pi|\theta) = - \left(\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I \right). \tag{12}$$

Substituting equation (12) into (11) yields $\tilde{\phi}_{z_T^*,T}(\theta) = \tilde{\phi}_e(\theta)$ for all θ, so that the policy is exactly counteracting the cross-subsidization in the credit market, providing the efficient incentives for entry into entrepreneurship to all agents.[13] Note that equation (12) is a fixed point condition, since for any given profit tax schedule $T(\pi)$, we can compute the equilibrium debt contract z_T^* from solving equations (10) and (11), and given z_T^*, the tax policy must satisfy equation (12). Total revenue from the profit tax is then given by

$$\begin{aligned} & \int_{\Theta} G(\tilde{\phi}_{z_T^*,T}(\theta)) \int_{\Pi} T(\pi) dH(\pi|\theta) dF(\theta) \\ = & -\int_{\Theta} G(\tilde{\phi}_{z_T^*,T}(\theta)) \left(\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I \right) dF(\theta) = 0, \end{aligned}$$

where the first equality follows from equation (12) and the second from the zero profit condition (10). Hence, the government budget constraint is automatically satisfied with

[13] From a bank's perspective, of course, there is still cross-subsidization since net profits $\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I$ vary with θ, and hence banks still make profits with high-θ and losses with low-θ types in the pooling equilibrium with taxes. However, $T(\pi)$ is such that there is no cross-subsidization from the perspective of *entrepreneurs* any longer, which is what determines occupational choice.

equality and the tax policy $T(\pi)$ is feasible. The following proposition summarizes these results:

Proposition 2. *Suppose that both θ and ϕ are unobservable and an entrepreneurial tax policy $T(\pi)$ is introduced that is such that $\pi - T(\pi)$ is increasing and equation (12) is satisfied for all $\theta \in \Theta$. Then*
(i) the resulting credit market equilibrium is such that $\tilde{\phi}_{z_T^*,T}(\theta) = \tilde{\phi}_e(\theta)$ for all $\theta \in \Theta$, where $\tilde{\phi}_{z_T^*,T}(\theta)$ and $\tilde{\phi}_e(\theta)$ are given by (11) and (7), respectively, and
(ii) the government budget is balanced.

By (12), the efficient entrepreneurial tax policy is regressive in the sense that higher ability entrepreneurs face a lower expected tax payment. In fact, for all $\theta > \tilde{\theta}_T$ with $\tilde{\theta}_T$ such that $\int_\Pi \min\{\pi - T(\pi), z_T^*\}\, dH(\pi|\tilde{\theta}_T) = I$, the expected tax payment is negative. This is because the profit tax has to counteract the equilibrium cross-subsidization in the credit market, which is decreasing in θ as argued above. By the monotone likelihood ratio property of $H(\pi|\theta)$, this pushes towards a tax schedule $T(\pi)$ that is itself decreasing in π and in that sense regressive as well. This makes the assumption in Lemma 1 that $\pi - T(\pi)$ is increasing even less restrictive, and will be further illustrated in the next section.

It is worth emphasizing that the entrepreneurial tax policy in Proposition 2 is quite different from the general subsidization of entrepreneurship that one may think of at first glance in view of credit market frictions. As shown by Ghatak, Morelli, and Sjöström (2007), even if there is only one-dimensional heterogeneity in entrepreneurial abilities, the resulting excessive entry into entrepreneurship in this case would in fact require a lump sum tax on entrepreneurial profits, rather than a subsidy. This can be seen in the present framework by again considering the case where ϕ is observable. Then for each given ϕ, I can set a lump sum tax T_ϕ on all entrepreneurs that restores the efficient occupational choice as follows. Note first that any such tax T_ϕ induces a credit market equilibrium as before, with the only difference that the marginal entrepreneur is now of quality $\theta_\phi^*(T_\phi)$ such that

$$\int_\Pi (\pi - \min\{\pi, z_\phi^*(T_\phi)\}) dH(\pi|\theta_\phi^*(T_\phi)) - T_\phi = \phi \tag{13}$$

and the repayment amount $z_\phi^*(T_\phi)$ specified in the equilibrium debt contract solves the zero profit condition

$$\int_{\theta_\phi^*(T_\phi)}^{\bar{\theta}} \left(\int_\Pi \min\{\pi, z_\phi^*(T_\phi)\} dH(\pi|\theta) - I \right) dF(\theta) = 0. \tag{14}$$

In order to obtain efficiency of occupational choice, the lump sum tax T_ϕ is set so as to achieve $\theta^*_\phi(T_\phi) = \theta^e_\phi$ and hence (comparing (8) and (13))

$$T_\phi = -\left(\int_\Pi \min\{\pi, z^*_\phi(T_\phi)\}dH(\pi|\theta^*_\phi(T_\phi)) - I\right). \tag{15}$$

Note that equation (15) is again a fixed point condition, since for any given lump-sum tax T_ϕ, we can derive the resulting credit market equilibrium as characterized by $\theta^*_\phi(T_\phi)$ and $z^*_\phi(T_\phi)$ solving equations (13) and (14), and given this, T_ϕ has to satisfy equation (15). I summarize these insights in the following proposition:

Proposition 3. *Suppose that ϕ is observable and a lump-sum tax T_ϕ is imposed on all entrepreneurs in the credit market for ϕ. If T_ϕ satisfies (15), then*
(i) the resulting credit market equilibrium is such that $\theta^*_\phi(T_\phi) = \theta^e_\phi$ as given by (8) and (13), and
(ii) $T_\phi > 0$.

Proof. Part (i) immediately follows from substituting (15) into (13). To prove part (ii), suppose that $T_\phi \leq 0$ and hence, by (15),

$$\int_\Pi \min\{\pi, z^*_\phi(T_\phi)\}dH(\pi|\theta^*_\phi(T_\phi)) - I \geq 0.$$

Then

$$\int_\Pi \min\{\pi, z^*_\phi(T_\phi)\}dH(\pi|\theta) - I \geq 0$$

for all $\theta \geq \theta^*_\phi(T_\phi)$ by MLRP, with strict inequality for all $\theta > \theta^*_\phi(T_\phi)$. Thus, banks would make profits with all entrepreneurs in the market for ϕ, and strictly so with almost all of them. This would contradict the overall zero profit condition (14). □

With one-dimensional private heterogeneity, a strictly positive lump-sum tax T_ϕ on all entrepreneurs would be able to restore the efficient occupational choice. Clearly, the resulting positive tax revenue $(1 - F(\theta^*_\phi(T_\phi)))T_\phi$ could be rebated lump-sum to all agents of type ϕ, entrepreneurs and workers, without changing any of the results. In contrast, the occupational inefficiency with two-dimensional heterogeneity does not just involve excessive entry into entrepreneurship, so such a uniform tax on entrepreneurs turns out not to be optimal in general.

The optimal policy $T(\pi)$ also differs from the tax on bank profits that De Meza and Webb (1987) propose in order to deal with the excessive entry into entrepreneurship that they find in their model with one-dimensional heterogeneity. As can be seen from the zero profit condition (14), a tax on bank profits and a lump-sum tax on entrepreneurship have equivalent effects. Thus, a tax on bank profits is not able (nor necessary) to restore occupational efficiency in the present setting. Instead, Proposition 2 points out the importance of entrepreneurial profit taxation as a more targeted corrective instrument. In particular, in contrast to the policies suggested in the literature, it is able to affect the composition of agents who become entrepreneurs rather than just the overall level of entrepreneurship in the economy, which is crucial in the present framework.

5 A Numerical Illustration

In this section, I provide a numerical example that illustrates the computation and properties of the corrective profit tax schedule. I consider $\theta \in [0,1]$ where $F(\theta)$ is uniform. The entrepreneurial profit distributions are such that

$$h(\pi|\theta) = 2\frac{(1-\theta)\overline{\pi} - \theta\underline{\pi} - (1-2\theta)\pi}{(\overline{\pi}-\underline{\pi})^2},\ \forall\theta \in [0,1],\ \pi \in [\underline{\pi}, \overline{\pi}],$$

which satisfies the MLRP property. The left panel in Figure 1 depicts the corresponding cdfs for a selection of four θ-values. ϕ is assumed to follow an exponential distribution with support $[0,\infty)$. I set $\Pi = [10,20]$ and $I = 13$. Note that the conditions from the previous sections, including Assumption 1, are satisfied by this parametrization.

I start with computing the no tax equilibrium characterized in Theorem 1. This is done by finding the repayment level z^* such that overall bank profits are zero, as required by equation (5), taking into account the endogenous occupational choice defined in equation (6). The right panel in Figure 1 plots aggregate profits as a function of $z \in [\underline{\pi}, \overline{\pi}]$. As can be seen from the graph, aggregate bank profits are increasing in z and there is a unique value $z^* = 13.63$ such that they are zero.

I next compare the equilibrium occupational choice, described by the critical values $\tilde{\phi}_{z^*}(\theta)$, with the efficient occupational choice $\tilde{\phi}_e(\theta)$. Both functions are shown in the left panel of Figure 2. As shown in Corollary 1, the frontier for the equilibrium occupational choice is a clockwise rotation of the efficient frontier, i.e. the equilibrium involves too many low-skilled but too few high-skilled entrepreneurs, and vice versa for workers. This misallocation, however, is not reflected in the overall shares of entrepreneurs in the economy: They are given by 63.2% in the equilibrium and by 62.4% under the efficient occupational choice, and thus very close together in the two situations. This demonstrates how misguiding it can be to look at the overall level of entrepreneurial activity as a measure of efficiency, rather than its composition as emphasized in this paper.

To compute the profit tax schedule that corrects this occupational misallocation, I follow an iterative procedure starting from the no tax equilibrium from Theorem 1. In particular, I start with $z_0 = z^*$ computed above and the initial tax schedule $T_0(\pi) = 0\ \forall\pi \in \Pi$ and compute the right-hand side of equation (12). Then I find a new tax schedule $T_1(\pi)$

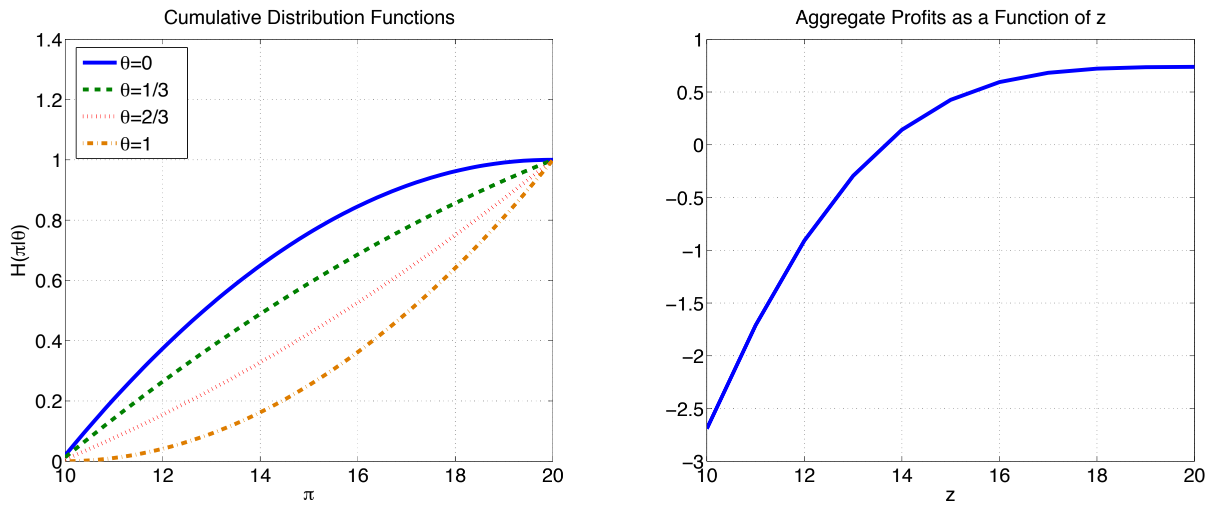

Figure 1: Profit distributions $H(\pi|\theta)$ and credit market equilibrium z^* without taxes.

that satisfies condition (12), i.e.[14]

$$\int_{\Pi} T_1(\pi) dH(\pi|\theta) = -\left(\int_{\Pi} \min\{\pi - T_0(\pi), z_0\} dH(\pi|\theta) - I \right) \ \forall \theta \in \Theta. \qquad (16)$$

Given this new tax schedule $T_1(\pi)$, I find the new credit market equilibrium, as summarized by z_1 satisfying equations (10) and (11). Once z_1 has been found, it is used together with $T_1(\pi)$ to compute an updated value of the right-hand side of equation (16), and to find an updated tax schedule $T_2(\pi)$ that satisfies (16). These steps are repeated until a fixed point is reached. The constraint $T(\pi) \leq \pi$ is imposed in all steps.

The right panel of Figure 2 shows the resulting profit tax schedule $T(\pi)$, as well as before tax profits π and after tax profits $\pi - T(\pi)$. By construction, the equilibrium with profit taxes $T(\pi)$ implements the efficient occupational choice $\tilde{\phi}_e(\theta)$ $\forall \theta \in \Theta$ and generates zero tax revenues. Moreover, the graph demonstrates that $T(\pi)$ is regressive and decreasing over most of the range of possible profit realizations. It taxes away almost all profits if they turn out to be very low, but on the other hand subsidizes high profit realizations. Clearly, after tax profits $\hat{\pi} = \pi - T(\pi)$ are increasing as a result and therefore the tax schedule is consistent with the assumption underlying Lemma 1. They now range from 0 to 49.97, and new equilibrium repayment level consequently increases to $z_T^* = 20.73$. This illustrates that the credit market equilibrium, not just the occupational choice, is significantly affected by the entrepreneurial tax policy.

Finally, I compare the results to the case with one-dimensional private heterogeneity,

[14]This substep is computed by discretizing Θ and Π in $n = 1000$ possible realizations and finding a solution of the system of n linear equations in n unknowns given by condition (12).

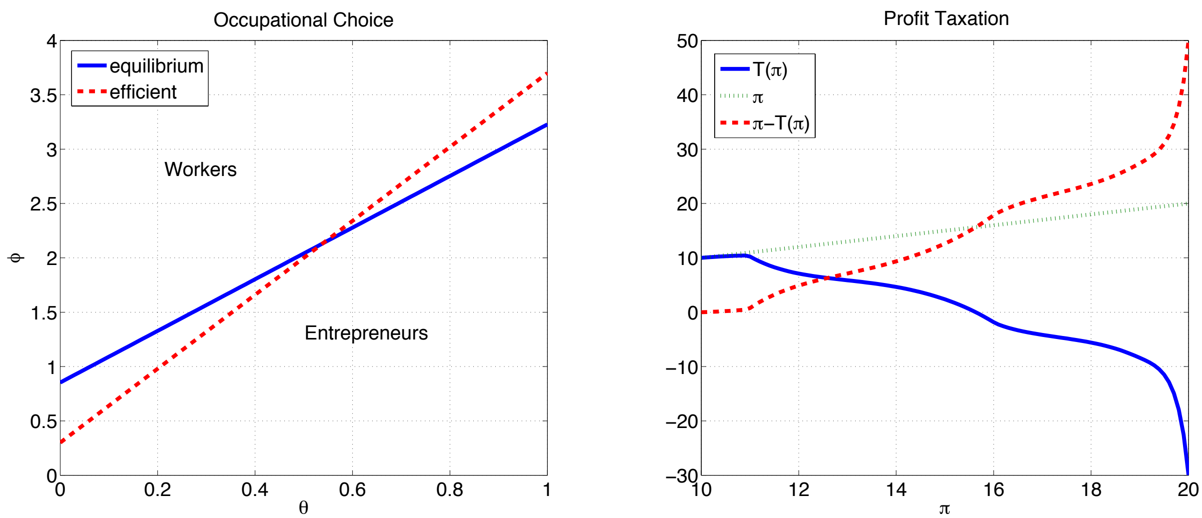

Figure 2: Occupational choice $\tilde{\phi}_{z^*}(\theta)$ vs. $\tilde{\phi}_e(\theta)$ and regressive profit taxes $T(\pi)$.

when ϕ is observable. The left panel in Figure 3 illustrates the very different nature of occupational misallocation in this case: There is excessive entry into entrepreneurship in this case since $\theta^*_\phi < \theta^e_\phi$ for all ϕ as demonstrated in Corollary 2. The right panel depicts the optimal lump sum taxes T_ϕ that are sufficient to implement the efficient occupational choice in this case, characterized in Proposition 3. They are computed using a similar iterative procedure as used for the optimal profit tax: for each ϕ, I start with the no tax equilibrium from Proposition 1, so that $T_{\phi,0} = 0$. Then I find the new lump sum tax $T_{\phi,1}$ by setting it equal to the right-hand side of equation (15). For this new tax, I then compute the new credit market equilibrium $\theta^*_\phi(T_{\phi,1})$, $z^*_\phi(T_{\phi,1})$ as determined by equations (13) and (14), and so on. As can be seen from the figure, all these lump sum taxes are positive, illustrating the result in Proposition 3. For the chosen parameters and distributions, they turn out to be decreasing in ϕ since the excessive entry into entrepreneurship is more pronounced for types with lower values of ϕ.

6 Extensions

The purpose of this section is to demonstrate how the results derived so far are affected in a richer environment that allows for redistributive taxes on the labor income of workers. I therefore explicitly include endogenous labor supply and labor markets into the model considered so far and demonstrate that the results are unchanged by this generalization. I then use this extension to discuss the effect of redistribution among workers on profit taxation and point out that what matters for implementing the efficient occupational choice

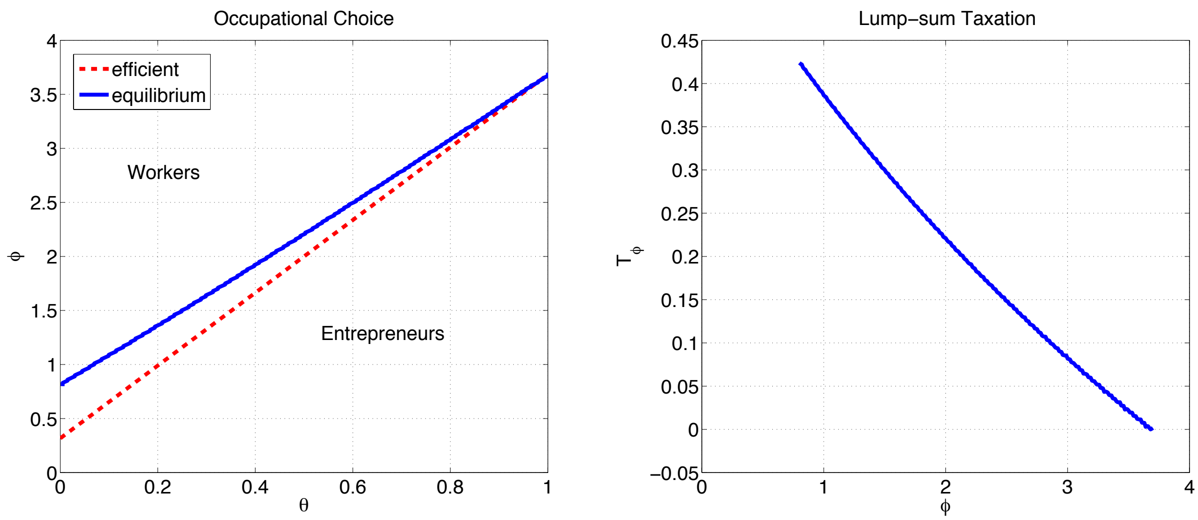

Figure 3: Occupational choice θ^*_ϕ vs. θ^e_ϕ and lump sum taxes T_ϕ.

is that the profit tax is regressive *relative* to redistributive taxes on labor income. I finally briefly discuss how the results extend to the case where entrepreneurs can offer collateral in case of default or save on their own to finance part of the investment.

6.1 Labor Market Equilibrium

I briefly demonstrate how to include labor markets into the present framework. This extension is necessary in order to address taxes on labor income since, in the model so far, a worker's payoff ϕ was assumed to be private information, ruling out incentive compatible redistribution among workers. I show in the following that the model equivalently applies to the standard optimal taxation framework where ϕ is a worker's unobservable skill, but labor income is observable.

Formally, suppose that workers supply labor l and obtain utility $w\phi l - h(l)$, where w is the wage and thus $w\phi$ is the effective wage of a worker of skill ϕ, and $h(l)$ is some increasing and convex disutility of labor. For any given wage w, workers then supply labor $l_w(\phi)$ optimally and obtain indirect utility $V_w(\phi)$, which is strictly increasing in ϕ. Entrepreneurs, on the other hand, hire an amount of labor L and, after having made the fixed investment I, produce output using some concave technology $Y(L)$. Their profits are given by $\pi = Y(L) - wL + \varepsilon$, where ε is some stochastic profit component distributed according to the cdf $H_\varepsilon(\varepsilon|\theta)$. Observe that this implies that, for any given set of credit contracts $\{R_\theta(\pi)\}$, all entrepreneurs hire the same amount of labor such that $Y'(L) = w$. Hence, if H_ε satisfies the monotone likelihood ratio property, for any wage w I can work directly with the resulting distribution of profits $\pi \sim H_w(\pi|\theta)$, with the only difference that it is now a function of w.

For any given wage w, the model therefore works exactly as before when replacing $H(\pi|\theta)$ by $H_w(\pi|\theta)$ and ϕ by $V_w(\phi)$. In particular, for a given w, the credit market equilibrium is defined as in Definition 1, where the critical value for occupational choice $\tilde{\phi}_w(\theta)$ now solves

$$V_w(\phi) = \int_\pi (\pi - R_\theta(\pi))\, dH_w(\pi|\theta) \tag{17}$$

for all $\theta \in \Theta$. Given the cross-subsidization in the credit market equilibrium, there is thus the same occupational misallocation and the same structure of corrective profit taxation as discussed in Section 4 for any given wage. To see this, observe that the equilibrium occupational choice under the tax schedule $T(\pi)$ and given the wage w will now be determined by the critical value

$$\tilde{\phi}_{z_T^*,T,w}(\theta) = V_w^{-1}\left(\int_\Pi (\pi - T(\pi) - \min\{\pi - T(\pi), z_T^*\})\, dH_w(\pi|\theta)\right)$$

whereas the efficient critical value would be

$$\tilde{\phi}_{e,w}(\theta) = V_w^{-1}\left(\int_\Pi \pi dH_w(\pi|\theta) - I\right), \tag{18}$$

so that setting $T(\pi)$ as required by (12) still implements $\tilde{\phi}_{z_T^*,T,w}(\theta) = \tilde{\phi}_{e,w}(\theta)$ for all $\theta \in \Theta$. In particular, this also holds for the equilibrium wage w^*, which is such that the labor market clears, i.e.

$$\int_\Theta G(\tilde{\phi}_{w^*}(\theta))L(w^*)dF(\theta) = \int_\Theta \int_{\tilde{\phi}_{w^*}(\theta)}^{\overline{\phi}} g(\phi)l_{w^*}(\phi)dF(\theta),$$

where $L(w^*)$ solves $Y'(L) = w^*$. This demonstrates that the previous results can be extended to this more general framework with endogenous labor supply in a straightforward way.[15] Notably, since the analysis can be performed for any given wage w, let me suppress dependence on w in the following to simplify notation.

6.2 Relative Degrees of Cross-Subsidization and Regressivity

Let me now consider the case of progressive redistribution among workers, as for instance implemented by some progressive income tax $T_y(y)$ with $y \equiv w\phi l$, so that workers no

[15] See Ghatak, Morelli, and Sjöström (2007) and Scheuer (2012) for an analysis of entrepreneurial taxation in view of general equilibrium effects through wages.

longer obtain utility $V(\phi)$ as in the preceding subsection but instead some increasing but concave transformation $\Psi(V(\phi))$ of it, where Ψ is such that there is some V^* with

$$\Psi(V) \geq V \;\text{ for all }\; V \leq V^* \;\text{ and }\; \Psi(V) \leq V \;\text{ otherwise.} \tag{19}$$

Condition (19), which is assumed for the sake of clarity, captures the notion of progressive redistribution in the sense that low ability workers, with low $V(\phi)$ in the no tax equilibrium, benefit from an increase in utility and vice versa for high ability workers. By equation (17), the equilibrium occupational choice is now determined by the critical value

$$\tilde{\phi}_{z_T^*,T}(\theta) = V^{-1}\left(\Psi^{-1}\left(\int_{\Pi}(\pi - T(\pi) - \min\{\pi - T(\pi), z_T^*\})\, dH(\pi|\theta)\right)\right), \tag{20}$$

whereas the efficient one is still given by (18). The following proposition provides a decomposition of the corrective profit tax in this case.

Proposition 4. *Suppose workers obtain utility $\Psi(V(\phi))$, where both $\Psi(V)$ and $V(\phi)$ are increasing. If the entrepreneurial profit tax $T(\pi)$ is such that*
(i) $\pi - T(\pi)$ is increasing in π and
(ii)

$$\int_{\Pi} T(\pi) dH(\pi|\theta) = -\left(\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I\right) + \left(V(\tilde{\phi}_e(\theta)) - \Psi(V(\tilde{\phi}_e(\theta)))\right) \tag{21}$$

for all $\theta \in \Theta$, then it implements the efficient occupational choice with $\tilde{\phi}_{z^*,T}(\theta) = \tilde{\phi}_e(\theta)$ for all $\theta \in \Theta$.

Proof. Equalizing the left-hand sides of equations (18) and (20) yields, after applying first $V(\phi)$ and then $\Psi(V)$ on both sides of the equation and rearranging,

$$\begin{aligned}\int_{\Pi} T(\pi) dH(\pi|\theta) \;\; = \;\; & -\left(\int_{\Pi} \min\{\pi - T(\pi), z_T^*\} dH(\pi|\theta) - I\right) \\ & + \int_{\Pi} \pi dH(\pi|\theta) - I - \Psi\left(\int_{\Pi} \pi dH(\pi|\theta) - I\right).\end{aligned}$$

Next, using equation (18), the second line above can be rewritten as

$$V(\tilde{\phi}_e(\theta)) - \Psi(V(\tilde{\phi}_e(\theta))),$$

which leads to (21). □

The first term in (21) is familiar from equation (12) in Section 4, requiring the profit tax to counteract cross-subsidization in the credit market. The second term, however, is new and captures the effects of redistribution among workers on occupational choice. In particular, it is negative for all $\theta \leq \theta^*$ and positive otherwise under condition (19), with θ^* such that $V(\tilde{\phi}_e(\theta^*)) = V^*$. This new component of the profit tax therefore goes in the opposite direction than the first and familiar component and makes the profit tax *less* regressive than if there were no redistribution among workers. The reason is that progressive redistribution among workers by itself induces an occupational choice with too many low-skilled and too few high-skilled workers (in terms of ϕ). This may partly undo or even cancel out the opposite occupational misallocation resulting from cross-subsidization in the credit market.

Proposition 4 gives rise to the following two key insights from this model extension. First, progressive redistribution among workers is an alternative policy tool to deal with occupational choice distortions from cross-subsidization in credit markets. Rather than counteracting this cross-subsidization directly through profit taxes, it introduces a symmetric cross-subsidization among workers to restore the efficient occupational choice. In fact, one may construct a progressive labor income tax $T_y(y)$, inducing a transformation $\Psi(V)$, such that the first and second term on the right-hand side of equation (21) just cancel when $T(\pi) = 0$ for all $\pi \in \Pi$.

Second, it demonstrates that the efficient occupational choice can be implemented by a continuum of tax policies, ranging from a regressive profit tax together with a flat tax on labor income, to the other extreme of a progressive labor income tax and a flat profit tax. What matters in all of those implementations is that the profit tax is always regressive *relative* to the labor income tax schedule (or equivalently, that it is *less progressive* than redistribution among workers). This is particularly evident from the decomposition in equation (21), where the second term matches the progressivity of redistribution among workers, whereas the first term captures the additional regressive component in profit taxes that was studied in isolation in Section 4. It also describes a pattern that can frequently be observed in practice. Indeed, entrepreneurial or business taxes are less progressive than labor income taxes in most countries. The present paper points at the role of adverse selection in credit markets as a novel justification for this structure of policy. At the most general level, the above results indicate that, in an economy with different occupations that are affected by cross-subsidization to different degrees, occupations for which there is more cross-subsidization should face relatively more regressive, or less progressive, tax schedules.

6.3 Collateral and Savings

Finally, I briefly discuss how the main results extend to the case where entrepreneurs can offer collateral for their credit contracts or are able to accumulate part of the required investment outlays through saving.Let me begin with the case of collateral and assume, as in Ghatak, Morelli, and Sjöström (2007), that individuals have wealth a, with distribution $\Gamma(a)$, which is illiquid, i.e. it cannot be used to directly finance part of the investment I, but can be offered as collateral to a bank in case of default. If an entrepreneur offers collateral of amount c, it is worth ξc to the bank if it collects it, with $\xi < 1$.

Since wealth is observable, there will be a credit market for each wealth class a and I can consider one such class, in which individuals only differ in θ and ϕ as before. In this class, banks can ask for collateral up to a in case of default, which is worth ξa to them. By the same logic as in Section 3, the equilibrium contract involves putting the maximal repayment weight in low profit states in order to attract high quality borrowers. Hence, banks will ask for the maximal collateral and the equilibrium debt contract takes the form $R(\pi) = \min\{\pi + a, z_a^*\}$ in terms of what entrepreneurs have to pay (banks obtain $\min\{\pi + \xi a, z_a^*\}$), where z_a^* solves

$$\int_\Theta G(\tilde{\phi}(\theta)) \left(\int_\Pi \min\{\pi + \xi a, z_a^*\} dH(\pi|\theta) - I \right) dF(\theta) = 0$$

with

$$\tilde{\phi}(\theta) = \int_\Pi (\pi - \min\{\pi + a, z_a^*\})\, dH(\pi|\theta) - V_w \;\; \forall \theta \in \Theta.$$

Hence, up to these modifications, the equilibrium takes the same form as before and the efficiency and tax policy implications remain unchanged as well. Of course, the risk of losing the wealth a in case of default makes entrepreneurship less attractive than before, so there will be less entry into entrepreneurship, especially for low-θ types.[16]

In order to consider the case where individuals can save to partly finance I, in addition to borrowing in frictional credit markets, a dynamic setting as in Ghatak, Morelli, and Sjöström (2001) would be required. However, it is worth emphasizing that the key force underlying the results here is the existence of *some* cross-subsidization among entrepreneurs. As long as some agents are unable to accumulate I through saving (or it is

[16]This effect is emphasized in Ghatak, Morelli, and Sjöström (2007): in their two-type model, the risk of losing collateral may induce the low-θ types to completely drop out of entrepreneurship (which generates a separating equilibrium, because only high-θ types remain in the credit market). With a continuum of types, even if there were no private heterogeneity in ϕ, collateral leads to an increase in the critical ability type θ^*_ϕ, but there is still a pooling equilibrium for all types $\theta \geq \theta^*_\phi$ who remain in the credit market. The "separating" case would be knife-edge where only the highest types $\overline{\theta}$ remain entrepreneurs.

inefficient for them to delay investment that long) and therefore have to borrow the remaining funds in credit markets with adverse selection, the qualitative results are therefore expected to go through, even though saving can certainly mitigate the inefficiencies discussed here.

7 Conclusion

This paper has analyzed the non-linear taxation of profits in a private information economy with endogenous firm formation. I have pointed out that a differential tax treatment of profits can be justified based on corrective arguments, mitigating occupational misallocation that results from credit market frictions. More generally, the role of tax policies that are able to affect the mix of individuals entering into entrepreneurship, rather than only the aggregate number of entrepreneurs, has been emphasized. This is because in a setting with multidimensional heterogeneity, the overall level of entrepreneurial activity is no longer a sufficient statistic for the efficiency of occupational choice.

Even though the proposed framework provides an efficiency based justification for the observed pattern that business taxes are typically less progressive than labor income taxes, the analysis has abstracted from several potentially important aspects of entrepreneurship and its implications for tax policy. Notably, income effects and risk aversion, capital accumulation and additional choices available to entrepreneurs, such as the decision whether to incorporate or not, have been neglected. An exploration of how some of these issues may affect the properties of optimal policy is left for future research.

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A Proof of Theorem 1

By construction, the proposed equilibrium contract $R_{z^*}(\pi)$ satisfies conditions (i) and (ii) of Definition 1, and thus only requirement (iii) remains to be checked. I will do so by proving a series of lemmas, starting with the following result due to Innes (1993).

Lemma 2. *Consider an arbitrary non-debt contract $R(\pi)$ that satisfies the limited liability and monotonicity constraints, and let $R_{z_\theta}(\pi) \equiv \min\{\pi, z_\theta\}$ denote the debt contract such that*

$$\int_\Pi R(\pi)dH(\pi|\theta) = \int_\Pi R_{z_\theta}(\pi)dH(\pi|\theta)$$

for some $\theta \in \Theta$. Then

$$\int_\Pi R(\pi)dH(\pi|\theta') \leq \int_\Pi R_{z_\theta}(\pi)dH(\pi|\theta') \ \ \forall\theta' \leq \theta.$$

In words, whenever banks offer a debt contract $R_{z_\theta}(\pi)$ that involves the same expected repayment for entrepreneurs of ability θ as the non-debt contract $R(\pi)$, then the expected repayment from the debt contract $R_{z_\theta}(\pi)$ is at least as high as from the non-debt contract $R(\pi)$ for all entrepreneurs of a lower skill $\theta' \leq \theta$. This result immediately follows from the fact that the entrepreneurs' profit distributions are ranked by MLRP and that, among the contracts that satisfy the limited liability and monotonicity constraints, debt contracts put the maximal repayment in low profit states. Note that Lemma 2 also immediately implies

$$\int_\Pi [\pi - R(\pi)]\, dH(\pi|\theta') \geq \int_\Pi [\pi - R_{z_\theta}(\pi)]\, dH(\pi|\theta') \ \ \forall\theta' \leq \theta,$$

i.e. all entrepreneurs of quality less than θ prefer the non-debt contract $R(\pi)$ to the debt contract $R_{z_\theta}(\pi)$. Clearly, this is independent of the type dimension ϕ.

Suppose that, in the presence of the equilibrium contract $R_{z^*}(\pi)$, a bank offers an arbitrary, incentive compatible set of deviation contracts $\{R^d_\theta(\pi)\}$. Let me denote the resulting critical cost values for occupational choice by $\tilde{\phi}_d(\theta)$, i.e. for all $\theta \in \Theta$,

$$\tilde{\phi}_d(\theta) \equiv \max\left\{\int_\Pi [\pi - R_{z^*}(\pi)]\, dH(\pi|\theta), \int_\Pi \left[\pi - R^d_\theta(\pi)\right] dH(\pi|\theta)\right\}. \tag{22}$$

Next, the following auxiliary result is useful.

Lemma 3. *For all $\theta \in \Theta$, let $\Delta\tilde{\phi}(\theta) \equiv \tilde{\phi}_d(\theta) - \tilde{\phi}_{z^*}(\theta)$ denote the change in critical cost values for occupational choice due to the deviation. Then $\Delta\tilde{\phi}(\theta)$ is decreasing in θ.*

Proof. Showing that $\Delta\tilde{\phi}(\theta) \equiv \tilde{\phi}_d(\theta) - \tilde{\phi}_{z^*}(\theta)$ is decreasing in θ is, by (6) and (22), equivalent to showing that

$$\int_\Pi R^d_\theta(\pi)dH(\pi|\theta) - \int_\Pi R_{z^*}(\pi)dH(\pi|\theta)$$

is increasing in θ. To see this, note that, by Lemma 2, if $\int_\Pi R^d_\theta(\pi)dH(\pi|\theta) = \int_\Pi R_{z^*}(\pi)dH(\pi|\theta)$ for some θ, then $\int_\Pi R^d_\theta(\pi)dH(\pi|\theta') \leq \int_\Pi R_{z^*}(\pi)dH(\pi|\theta')$ for all $\theta' \leq \theta$, which implies that

$$\int_\Pi R^d_\theta(\pi)dH(\pi|\theta) - \int_\Pi R_{z^*}(\pi)dH(\pi|\theta) \geq \int_\Pi R^d_\theta(\pi)dH(\pi|\theta') - \int_\Pi R_{z^*}(\pi)dH(\pi|\theta') \tag{23}$$

whenever $\theta \geq \theta'$. Moreover, by incentive compatibility of $\{R^d_\theta(\pi)\}$,

$$\int_\Pi \left[\pi - R^d_{\theta'}(\pi)\right] dH(\pi|\theta') \geq \int_\Pi \left[\pi - R^d_\theta(\pi)\right] dH(\pi|\theta')$$

and hence $\int_\Pi R^d_{\theta'}(\pi)dH(\pi|\theta') \leq \int_\Pi R^d_\theta(\pi)dH(\pi|\theta')$, which, when combined with (23), completes the argument. □

This allows me to prove the following lemma:

Lemma 4. *Let $\Delta G(\theta) \equiv G(\tilde\phi_d(\theta)) - G(\tilde\phi_{z^*}(\theta))$ for all $\theta \in \Theta$. Under Assumption 1, $\Delta G(\theta)$ is decreasing in θ.*

Proof. First, observe that $\tilde\phi_{z^*}(\theta)$ is increasing in θ by MLRP. Moreover, $G(\phi)$ is concave by Assumption 1. Therefore, the result from Lemma 3 that $\Delta\tilde\phi(\theta) \equiv \tilde\phi_d(\theta) - \tilde\phi_{z^*}(\theta)$ is decreasing in θ implies that

$$\Delta G(\theta) \equiv G(\tilde\phi_d(\theta)) - G(\tilde\phi_{z^*}(\theta))$$

is also decreasing in θ, proving the lemma. □

The deviating bank's expected profits from offering $\{R^d_\theta(\pi)\}$ are given by

$$\begin{aligned}\Pi^d &= \int_\Theta \mathbb{1}_{\{\tilde\phi_d(\theta) > \tilde\phi_{z^*}(\theta)\}}(\theta) G(\tilde\phi_d(\theta)) \int_\Pi (R^d_\theta(\pi) - I)dH(\pi|\theta)dF(\theta) \\ &< \int_\Theta \mathbb{1}_{\{\tilde\phi_d(\theta) > \tilde\phi_{z^*}(\theta)\}}(\theta) G(\tilde\phi_d(\theta)) \int_\Pi (R_{z^*}(\pi) - I)dH(\pi|\theta)dF(\theta) \end{aligned} \tag{24}$$

since $\int_\Pi R^d_\theta(\pi)dH(\pi|\theta) < \int_\Pi R_{z^*}(\pi)dH(\pi|\theta)$ whenever $\tilde\phi_d(\theta) > \tilde\phi_{z^*}(\theta)$ by (22). Aggregate profits in the proposed equilibrium are

$$\Pi^* = \int_\Theta G(\tilde\phi_{z^*}(\theta)) \int_\Pi (R_{z^*}(\pi) - I)dH(\pi|\theta)dF(\theta) = 0 \tag{25}$$

by (5), and therefore, subtracting (25) from (24) yields

$$\begin{aligned}\Pi^d &< \int_\Theta \left(\mathbb{1}_{\{\tilde\phi_d(\theta) > \tilde\phi_{z^*}(\theta)\}}(\theta) G(\tilde\phi_d(\theta)) - G(\tilde\phi_{z^*}(\theta))\right) \int_\Pi (R_{z^*}(\pi) - I)dH(\pi|\theta)dF(\theta) \\ &= \int_\Theta \left(\Delta G(\theta) - \mathbb{1}_{\{\tilde\phi_d(\theta) = \tilde\phi_{z^*}(\theta)\}}(\theta) G(\tilde\phi_{z^*}(\theta))\right) \int_\Pi (R_{z^*}(\pi) - I)dH(\pi|\theta)dF(\theta) \end{aligned} \tag{26}$$

The following two lemmas establish that the RHS of (26) is non-positive.

Lemma 5. *In equation (26),*

$$\int_{\Theta} \Delta G(\theta) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) \leq 0. \tag{27}$$

Proof. Find $\tilde{\theta}$ such that $\int_{\Pi}(R_{z^*}(\pi) - I)dH(\pi|\tilde{\theta}) = 0$, which exists and is unique by (5) and MLRP. Also, find the constant δ such that $\delta G(\tilde{\phi}_{z^*}(\tilde{\theta})) = \Delta G(\tilde{\theta})$. Then since $\Delta G(\theta)$ is decreasing and $\delta G(\tilde{\phi}_{z^*}(\theta))$ is increasing by Lemma 4, $\delta G(\tilde{\phi}_{z^*}(\theta)) \leq \Delta G(\theta)$ for all $\theta \leq \tilde{\theta}$, and $\delta G(\tilde{\phi}_{z^*}(\theta)) \geq \Delta G(\theta)$ otherwise. Thus,

$$\begin{aligned}
& \int_{\underline{\theta}}^{\tilde{\theta}} \Delta G(\theta) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) + \int_{\tilde{\theta}}^{\overline{\theta}} \Delta G(\theta) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) \\
\leq & \int_{\underline{\theta}}^{\tilde{\theta}} \delta G(\tilde{\phi}_{z^*}(\theta)) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) + \int_{\tilde{\theta}}^{\overline{\theta}} \delta G(\tilde{\phi}_{z^*}(\theta)) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) \\
= & \ 0,
\end{aligned} \tag{28}$$

where the inequality follows from $\int_{\Pi}(R_{z^*}(\pi) - I)dH(\pi|\theta) < 0$ for $\theta \leq \tilde{\theta}$ and $\int_{\Pi}(R_{z^*}(\pi) - I)dH(\pi|\theta) \geq 0$ otherwise, and the equality from (5). □

Lemma 6. *In equation (26),*

$$\int_{\Theta} \mathbb{1}_{\{\tilde{\phi}_d(\theta) = \tilde{\phi}_{z^*}(\theta)\}}(\theta) G(\tilde{\phi}_{z^*}(\theta)) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) \geq 0. \tag{29}$$

Proof. There are 3 cases to be considered. If $\tilde{\phi}_d(\theta) = \tilde{\phi}_{z^*}(\theta)$ for all $\theta \in \Theta$, then (29) holds with equality due to (5). If there does not exist a $\theta \in \Theta$ such that $\tilde{\phi}_d(\theta) = \tilde{\phi}_{z^*}(\theta)$, then (29) also holds as an equality trivially. Finally, if $\tilde{\phi}_d(\theta) = \tilde{\phi}_{z^*}(\theta)$ holds for some but not all $\theta \in \Theta$, there must exist some threshold value $\hat{\theta} \in (\underline{\theta}, \overline{\theta})$ such that $\tilde{\phi}_d(\theta) > \tilde{\phi}_{z^*}(\theta)$ for all $\theta < \hat{\theta}$ and $\tilde{\phi}_d(\theta) = \tilde{\phi}_{z^*}(\theta)$ otherwise. This follows from Lemma 3, which has shown that $\Delta\tilde{\phi}(\theta)$ is decreasing in θ and, by the definition in (22), $\tilde{\phi}_d(\theta) \geq \tilde{\phi}_{z^*}(\theta)$. With this, (29) becomes

$$\int_{\hat{\theta}}^{\overline{\theta}} G(\tilde{\phi}_{z^*}(\theta)) \int_{\Pi} (R_{z^*}(\pi) - I) dH(\pi|\theta) dF(\theta) > 0$$

since $\hat{\theta} > \underline{\theta}$ and $\int_{\Pi}(R_{z^*}(\pi) - I)dH(\pi|\theta)$ is increasing in θ by MLRP. □

Lemmas 5 and 6 together with equation (26) show that $\Pi^d < 0$, and hence there does not exist a profitable deviation.