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The effects of redistributive taxation in credit markets with adverse selection

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Abstract

This paper studies the effects of redistributive taxation in credit markets with adverse selection and shows that there exists a range of taxes that creates Pareto improvement relative to the (zero-tax) market allocation by increasing aggregate investment. For sufficiently high taxes, an increase in the safe interest rate can be accompanied by an increase in investment.

Keywords: Credit Market, Adverse Selection, Taxation, Redistribution, Welfare

JEL: D82, D86, H82, H25

1. Introduction

It is well known that adverse selection causes inefficiencies in markets that frequently justify public policy. For instance, loan government-backed guarantee programmes are frequently implemented to facilitate access to credit for small enterprises and start-ups. These programmes encourage banks to lend to entrepreneurs with no collateral or other pledgeable assets by guaranteeing (partial) loan repayment even if an entrepreneur is unable to meet her obligations. The rationale underlying such schemes is that potential credit market

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frictions confine entrepreneurs with good ideas to enter the marketplace.¹ This
10 paper studies the effectiveness of a simple tax-subsidy scheme that resembles a
loan government-backed guarantee programme to boost investment and improve
welfare in credit markets with adverse selection.

The market consists of a continuum of entrepreneurs with projects that suc-
ceed or fail. A project (or, equivalently, an entrepreneur) can be either high
15 risk or low risk: low-risk projects yield a higher expected return than high-risk
projects for the same amount of investment, although high-risk projects yield a
higher ex post return in the case of success. The market also consists of competi-
tive banks that inelastically raise funds at an exogenously given safe interest rate
and offer loan contracts that specify the level of the loan and the payments of
20 an entrepreneur to the bank in every possible contingency. I examine the effect
of a simple budget-balanced, tax-subsidy scheme on equilibrium investment and
welfare. The tax-subsidy system is similar to that analysed in Wilson (1977),
Dahlby (1981) and Crocker and Snow (1985a,b) in the stylised insurance market
of Rothschild and Stiglitz (1976), and, more recently, in Ghatak et al. (2007)
25 and Scheuer (2013) in a credit market.² Every entrepreneur pays a specific tax
if she succeeds; this tax is redistributed as a lump-sum subsidy, which can be
pledged as collateral if an entrepreneur fails. I argue that an alternative inter-
pretation of the tax-subsidy scheme is that of an entirely budget-balanced, loan
government-backed guarantee programme. I establish that taxes can lead to
30 Pareto improvement relative to the zero-tax allocation by increasing aggregate

¹See, for instance, OECD (2018) or the report of the OECD <http://www.oecd.org/global-relations/45324327.pdf> for more details.

²Ghatak et al. (2007) and Scheuer (2013) consider a model in which an individual selects between becoming a worker, receiving the labour market wage, or becoming an entrepreneur, and borrowing from the credit market. The tax system aims to discourage individuals with low-quality projects from becoming entrepreneurs to “correct” for occupational choice by reducing adverse selection and hence improving efficiency. In this paper, I allow for variable investment projects as opposed to fixed-investment projects, which allows for the separation of types. Moreover, the subsidy received by the government plays a fundamental role in this paper because it is necessary for entrepreneurs to pledge it as collateral.

investment.

Regarding the literature, related papers are Innes (1991) and Martin (2011), which study different types of policies in models similar to the model studied in the present paper. Innes (1991) shows how the government can increase
35 welfare by offering subsidised debt contracts. Martin (2011) shows that the government can attain Pareto efficiency by establishing a new market in which entrepreneurs can borrow without conditioning their loans. Unlike the present paper, these authors do not consider the effect of taxes on aggregate investment or the combination of interest rate changes and taxation on investment and
40 welfare.

The remainder of the paper is organised as follows. In Section 2, I describe the economy and the tax system; in Section 3, I study the effect of taxation. In Section 4, I provide policy implications.

2. The economy

45 2.1. *Entrepreneurs and banks*

A continuum of entrepreneurs of mass one are each endowed with a project. There are two possible projects: high-risk and low-risk, $i = H, L$ and a set of measures λ of entrepreneurs is endowed with low-risk projects.³ By investing x in the project, an entrepreneur can realise $z_i f(x)$ with probability π_i or zero with probability $1 - \pi_i$, where $z_i > 0$ for every i , $f(0) = 0$, $f'(x) > 0$, $f''(x) < 0$, $\lim_{x \rightarrow 0} f'(x) = \infty$, $\lim_{x \rightarrow \infty} f'(x) = 0$, and $\pi_L > \pi_H$.⁴ Uncertainty is purely idiosyncratic. I further assume that

$$z_H > z_L \quad \text{and} \quad \pi_H z_H \leq \pi_L z_L$$

Notably, when the two projects have the same expected return, the high-risk project is a mean-preserving spread of the low-risk project; when the expected

³For simplicity, I refer to an entrepreneur with a low-risk (high-risk) project as a “low-risk” (“high-risk”) type.

⁴Inada’s conditions are sufficient to guarantee interior solutions and, hence, considerably simplify the analysis but are not necessary for any of the results.

return of the low-risk project is strictly higher than that of the high-risk project, the low-risk project second-order stochastically dominates the high-risk project. Although this assumption is very common in the credit rationing literature, none of the results rely on it.⁵ Let

$$\pi^P = \lambda\pi_L + (1 - \lambda)\pi_H$$

denote the population’s “average probability of success”. I assume that only the individual state is observable by outsiders and verifiable by a court of law. This assumption rules out equity as a feasible loan contract. Equivalently, it rules out linear or non-linear taxes (see below for more details). Last, I assume that

50 entrepreneurs have no wealth, are risk neutral and do not discount the future.

There are at least two profit-maximising banks in the economy that inelastically raise deposits at a (net) risk-free interest rate equal to r . Entrepreneurs apply for a loan contract $(x, c) \in \mathbb{R}_+^2$ to banks, where x denotes the amount of the loan (henceforth, the loan) and c denotes the transfer from the entrepreneur

55 to the bank if the project fails (henceforth, the collateral). I assume that entrepreneurs are protected by limited liability. Following an application, banks compete in the interest rate they charge, denoted by ρ . The market takes the form of a signalling game, as is extensively analysed in Dosis (2019).

2.1.1. The tax system

Let t denote the net specific tax (tax minus subsidy) an entrepreneur pays if her project succeeds and T denote the subsidy she receives. The tax system is *ex post* budget balanced, which means that the government simply redistributes wealth. Moreover, the tax system is non-discriminatory (or anonymous) in the sense that every type pays the same specific tax and receives the same lump-sum subsidy regardless of her contract choice. This assumption fits well in environments in which the government is unable to observe the entrepreneurs’ contract

⁵The assumption of mean-preserving spreads was first imposed in the seminal work of Stiglitz and Weiss (1981).

choices. Suppose that the tax-subsidy scheme is given by (t, T) ; following the discussion above, this situation satisfies the following condition:

$$T = \frac{\pi^p}{1 - \pi^p} t$$

60 Because T is uniquely identified for every t , it suffices to solely specify t .⁶

An alternative, perhaps interesting, interpretation of the tax system is to consider it as a budget-balanced loan government-backed guarantee programme. According to this interpretation, entrepreneurs voluntarily decide to participate in a scheme in which the government guarantees part of the losses of a loan
65 undertaken if the entrepreneur is unable to fulfil her obligations. In return, an entrepreneur pays a fixed fee, which is equivalent to the specific tax specified above. Loan government-backed guarantee programmes constitute one of the most widespread public policies to encourage entrepreneurship. The objective of these programmes is to encourage banks to lend to small firms that might
70 lack collateral or other pledgeable assets. Variations in loan government-backed guarantee programmes are implemented in the US, the UK, France, Germany and many other countries. The basic principles of loan government-backed guarantee programmes are similar in all countries: the government undertakes any losses that cannot be met by borrowers; borrowers pay an arrangement fee plus a
75 small premium over the market rate. The main discrepancy between the policy studied in this paper and the loan government-backed guarantee programmes that are implemented in practice is that the policy studied in this paper is entirely budget balanced whilst loan government-backed guarantee programmes are mainly publicly funded.

⁶Evidently, the tax system specified above is unrealistic in many respects. Most notably, in reality, entrepreneurs do not pay specific taxes, i.e., regardless of their income, but likely linear or non-linear taxes. Note, however, that given that the only observable and contractible variable is the individual state (i.e., success or failure), the government faces the constraints that banks face; given that equity is not feasible, taxes that condition payments on earned profits are not feasible, either.

80 **3. Equilibria**

3.1. Symmetric information

It is perhaps more convenient to study the equilibria of the game by defining allocations. An *allocation* is a pair of contracts, $((x_i, \rho_i, c_i))_i$, one for each type of entrepreneur.

Under symmetric information, competition in the banking sector ensures that entrepreneurs pay actuarially fair interest rates and, therefore, banks earn zero profits in equilibrium. It is only straightforward that in the unique equilibrium under symmetric information, the equilibrium allocation is given by $((x_L^*, \rho_L^*, 0), (x_H^*, \rho_H^*, 0))$, where for every i , $\pi_i \rho_i^* = x_i^*$, and

$$f'(x_i^*) = \frac{1+r}{\pi_i z_i} \quad (1)$$

The equilibrium (expected) payoff of type i is

$$U_i^* = \pi_i z_i f(x_i^*) - x_i^*(1+r) \quad (2)$$

Consider now a strictly positive tax. Evidently, because the tax is specific, it does not distort the equilibrium levels of investment. The equilibrium payoff of type i as a function of the tax is

$$U_i^*(t) = \pi_i z_i f(x_i^*) - x_i^*(1+r) + \left((1-\pi_i) \frac{\pi^P}{1-\pi^P} - \pi_i \right) t \quad (3)$$

85 Given that $\pi_H < \pi^P < \pi_H$, the payoff of the high-risk type is strictly increasing in t , while the payoff of the low-risk type is strictly decreasing in t ; the high-risk is simply cross-subsidised by the low-risk type through the tax-subsidy scheme.

3.1.1. Asymmetric information

As shown in Dosis (2019), the equilibrium allocation is the *least-cost separating* (LCS) allocation. As is well known, in the LCS allocation, high-risk types face no distortion relative to the symmetric information equilibrium; low-risk types' loans are distorted such that they are no longer desired by high-risk

types. The low-risk type's level of investment \bar{x}_L in the LCS allocation is the [low-risk type's] payoff-maximising solution to the following equation:

$$z_H f(x_H^*) - \frac{x_H^*(1+r)}{\pi_H} = z_H f(x) - \frac{x(1+r)}{\pi_L}, \quad (4)$$

90 which represents the binding incentive constraint of the high-risk type. Dosis (2019) shows that this equation has two solutions, and the solution that maximises the payoff of the low-risk type is such that $\bar{x}_L < x_H^*$: in the LCS allocation, the low-risk type is restricted by the incentive constraint and unable to raise as much capital as she would raise under symmetric information.

95 The following proposition characterises the effect of taxation on the LCS allocation.

Proposition 1. *For a sufficiently low t , the equilibrium allocation is given by*

$$((\bar{x}_L(t), \bar{\rho}_L(t), \frac{\pi^P}{1-\pi^P}t), (x_H^*, \bar{\rho}_H(t), \bar{c}_H(t))),$$

where

$$\begin{aligned} \pi_H \bar{\rho}_H(t) + (1 - \pi_H) \bar{c}_H(t) &= x_H^*(1+r) \\ \pi_L \bar{\rho}_L(t) + (1 - \pi_L) \frac{\pi^P}{1 - \pi^P} t &= \bar{x}_L(t)(1+r) \end{aligned}$$

$$z_H f(\bar{x}_L(t)) - \frac{\bar{x}_L(t)(1+r)}{\pi_L} = \left(z_H f(x_H^*) - \frac{x_H^*(1+r)}{\pi_H} \right) + \left(\frac{(1-\pi_H)}{\pi_H} - \frac{(1-\pi_L)}{\pi_L} \right) \frac{\pi^P}{1-\pi^P} t \quad (5)$$

and

$$\bar{c}_H(t) \leq \frac{\pi^P}{1-\pi^P} t$$

The low-risk type uses the entire subsidy as collateral, although this does not necessarily imply that her payoff is higher after taxation than before taxation. All Proposition 1 states is that in a specified interval of taxes, the low-risk type strictly prefers using the subsidy as collateral to borrow more rather than consuming it. By implicitly differentiating (5) with respect to t , one obtains the following:

$$\frac{d\bar{x}_L}{dt} = \frac{\left(\frac{(1-\pi_H)}{\pi_H} - \frac{(1-\pi_L)}{\pi_L} \right) \frac{\pi^P}{1-\pi^P} t}{z_H f'(\bar{x}_L(t)) - \frac{(1+r)}{\pi_L}}$$

which is strictly positive. Therefore, investment is strictly increasing in the tax because the subsidy relaxes the high-risk type's incentive constraint and allows the low-risk type to borrow more. The payoff of the low-risk type in the equilibrium allocation as a function of the tax is written, for notational convenience, as

$$\bar{U}_L(t) = \pi_L z_L f(x_L(t)) - x_L(t)(1+r) + \left((1-\pi_L) \frac{\pi^p}{1-\pi^p} - \pi_L \right) t \quad (6)$$

Given that the production function is strictly concave, $\bar{U}_L(t)$ is also strictly concave in t ; this is the first part proven in Proposition 2. The question of interest then boils down to whether $\bar{U}_L(t)$ has an interior maximum. Proposition 2 states that there is indeed a threshold in the average probability of success $\pi_{L \min}^p$, such that, for any $\pi^p \geq \pi_{L \min}^p$, $U_L(t)$ has an interior maximum. The strict concavity of $\bar{U}_L(t)$ implies that there is a closed interval of taxes that increase the payoff of the low-risk type after taxation. Proposition 2 formalises the discussion above.

Proposition 2. $\bar{U}_L(t)$ is concave in t , and every $\pi^p \in [\pi_{L \min}^p, \pi_L]$ attains a unique interior maximum.

Taxation entails two countervailing effects for low-risk types. The negative effect is a consequence of cross-subsidisation; the positive effect is due to the relaxation of the incentive constraint of high-risk types that allows low-risk types to approach their symmetric information investment level. When the share of low-risk types is sufficiently high, the latter effect dominates and, consequently, low-risk types benefit from the tax system.

One interesting question is to examine the effect of interest rate changes on investment and welfare for a given tax. One can find the impact of an interest rate change on investment by implicitly differentiating (5)

$$\frac{d\bar{x}_L(t)}{dr} = \frac{\bar{x}_L(t)/\pi_L - x_H^*/\pi_H}{z_H f'(\bar{x}_L(t)) - (1+r)/\pi_L}, \quad (7)$$

Because the low-risk type might invest more than the high-risk type—contrary to the separating equilibrium under zero tax—an increase in the interest rate

115 might be accompanied by an increase in the investment of the low-risk type. Because $\bar{x}_L(t)$ is strictly increasing in t , this phenomenon is more prevalent for high taxes. This result is formally stated below.

Proposition 3. *Suppose that $\bar{x}_L(t) > \pi_L x_H^*/\pi_H$; then, an increase in the interest rate will cause an increase in investment by low-risk types. If the increase*
 120 *in investment by low-risk types offsets the decrease in investment by high-risk types, then an increase in the interest rate will cause an increase in aggregate investment.*

Consider now the impact of an interest rate change on the payoff of the low-risk type. For a given tax, differentiating (6) with respect to r , one obtains

$$d\bar{U}_L(t)/dr = \underbrace{(\pi_L z_L f'(\bar{x}_L(t)) - (1+r)d\bar{x}_L(t)/dr)}_{\text{Indirect effect}} - \underbrace{\bar{x}_L(t)}_{\text{Direct effect}}, \quad (8)$$

125 The direct effect is negative for every tax; the indirect effect is positive if $\bar{x}_L(t) > \pi_L x_H^*/\pi_H$ and negative otherwise, as explained above. Nonetheless, because $\bar{x}_L(t)$ is strictly increasing in t , it is rather unclear whether the positive indirect effect can ever offset the negative direct effect.

4. Concluding remarks

130 At least two policy implications emerge from the analysis. First, taxes create Pareto improvement if and only if the share of high-quality projects in the market is relatively high. If one accepts that during booms, high-quality projects outnumber low-quality projects, an implication of the model is that Pareto improvement might be possible only during booms. During busts, the government
 135 might be unable to increase welfare, and hence, it might be optimal to decrease taxes. Second, Pareto improvement is feasible only if entrepreneurs can pledge government subsidies as collateral. An implication of this finding is that when collateral is scarce, the government can stimulate the economy by redistributing wealth.

Proof of Proposition 1. To specify the LCS allocation for pair of contracts for a sufficiently small t , one needs to solve the following recursive programme:

$$\begin{aligned} \max_{(x,\rho,c) \in \mathbb{R}_+^3} \quad & \pi_H(z_H f(x) - \rho - t) + (1 - \pi_H)(T - c) \text{ s.t.} \\ & \pi_H \rho + (1 - \pi_H)c \geq x(1 + r) \\ & \rho \leq z_H f(x) - t \\ & c \leq T \end{aligned}$$

which has a solution $(x^*, \bar{\rho}_H(t), \bar{c}_H(t))$ as defined in Eq. (1), and,

$$\begin{aligned} \max_{(x,\rho,c) \in \mathbb{R}_+^3} \quad & \pi_L(z_L f(x) - \rho - t) + (1 - \pi_L)(T - c) \text{ s.t.} \\ & \pi_L \rho + (1 - \pi_L)c \geq x(1 + r) \end{aligned}$$

$$\pi_H(z_H f(x^*) - \bar{\rho}_H - t) + (1 - \pi_H)(T - \bar{c}_H) \geq \pi_H(z_H f(x) - \rho - t) + (1 - \pi_H)(T - c)$$

$$\begin{aligned} \rho & \leq z_L f(x) - t \\ c & \leq T \end{aligned}$$

The first and the second constraints are each binding at the optimum; combining these two constraints, one obtains

$$z_H f(x) - \frac{x(1+r)}{\pi_L} - \left(z_H f(x^*) - \frac{x^*(1+r)}{\pi_H} \right) - \left(\frac{1-\pi_H}{\pi_H} - \frac{1-\pi_L}{\pi_L} \right) c = 0 \quad (9)$$

Given that $z_H f(x) - \frac{x(1+r)}{\pi_L}$ is strictly increasing in $[0, x_L^*]$ and $\left(\frac{1-\pi_H}{\pi_H} - \frac{1-\pi_L}{\pi_L} \right) c \geq 0$ for every $c \geq 0$, the smallest solution of Eq. (9) is strictly increasing in c .

The payoff of the low-risk type is

$$U_L(x, \rho, c) = \pi_L \left(z_L f(x) - \frac{x(1+r)}{\pi_L} \right) + \frac{\pi^p - \pi_L}{1 - \pi^p} t$$

which is strictly increasing in $x \in [0, x^*]$; hence, at the optimum $c = T$. \square

Proof of Proposition 2. Because $f(x)$ is continuous and the first and second
145 derivatives exist and are continuous for any $x > 0$, $\bar{x}_L(t)$ is also continuous and
differentiable in $t \in [0, \bar{t}]$, and $\bar{U}_L(t)$ is also continuous and differentiable in $[0, \bar{t}]$,
then:

$$\begin{aligned}\bar{U}'_L(t) &= \left(z_L f'(\bar{x}_L(t)) - \frac{1+r}{\pi_L} \right) \times \bar{x}'_L(t) + \left(\frac{1-\pi_L}{\pi_L} \frac{\pi^p}{1-\pi^p} - 1 \right) \\ &= \frac{z_L f'(\bar{x}_L(t)) - \frac{1+r}{\pi_L}}{z_H f'(\bar{x}_L(t)) - \frac{1+r}{\pi_L}} \times \left(\frac{(1-\pi_H)}{\pi_H} - \frac{(1-\pi_L)}{\pi_L} \right) \frac{\pi^p}{1-\pi^p} t + \left(\frac{1-\pi_L}{\pi_L} \frac{\pi^p}{1-\pi^p} - 1 \right)\end{aligned}\tag{10}$$

I show that there exists $\pi^p_{L \min}$, such that $U'_L(\bar{t}_{Lopt}) = 0$, for some $\bar{t}_{Lopt} > 0$, for
every $\pi^p \in [\pi^p_{L \min}, \pi_L]$. Eq. (10) can be re-written as

$$\bar{U}'_L(t) = \left[(1 - \alpha(t)) \frac{1 - \pi_L}{\pi_L} + \alpha(t) \frac{1 - \pi_H}{\pi_H} \right] \frac{\pi^p}{1 - \pi^p} - 1$$

where

$$\alpha(t) = \frac{z_L f'(\bar{x}_L(t)) - \frac{1+r}{\pi_L}}{z_H f'(\bar{x}_L(t)) - \frac{1+r}{\pi_L}}$$

Note that

$$\bar{U}'_L(0) = \left(z_L f'(\bar{x}_L(0)) - \frac{1+r}{\pi_L} \right) \times \bar{x}'_L(0) + \left(\frac{1-\pi_L}{\pi_L} \frac{\pi^p}{1-\pi^p} - 1 \right)$$

where the first term is strictly positive and the second term is strictly negative,
given the maintained assumptions. Therefore, there exists $\pi^p_{L \min}$ such that
 $\bar{U}'_L(0) > 0$ for $\pi^p \in [\pi^p_{L \min}, \pi_L]$. Moreover,

$$\bar{U}'_L(t^*) = \left(\frac{1-\pi_L}{\pi_L} \frac{\pi^p}{1-\pi^p} - 1 \right) < 0$$

for every $\pi^p \in [\pi_H, \pi_L)$. By applying the intermediate value theorem for
 $\pi^p \in [\pi^p_{L \min}, \pi_L)$, there exists $\bar{t}_{Lopt} > 0$ such that $\bar{U}'_L(\bar{t}_{Lopt}) = 0$, which, given
150 that $\bar{U}'_L(t) > 0$ for every $t \in [0, \bar{t}_{Lopt})$ and $U'_L(t) < 0$ for every $t \in [\bar{t}_{Lopt}, t^*)$,
corresponds to a global maximum in $[0, t^*)$. Therefore, for $\pi^p \in [\pi^p_{L \min}, \pi_L]$,
there exists $\bar{t}_{Lopt} > 0$ that maximises the payoff of the low-risk type. \square

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