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# Endogenous Leverage and Advantageous Selection in Credit Markets*


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**Abstract**

I study asset price amplification in an asymmetric information model. Entrepreneurs issue debt to finance investments in a physical asset. They have private information about their success probabilities. For a given debt level, higher asset prices require entrepreneurs to invest more of their own funds. This makes bad entrepreneurs more reluctant to mimic good ones; as a result, good entrepreneurs *increase* their equilibrium leverage and invest more, and this amplifies the initial asset price increase. This model generates predictions about the credit market that are qualitatively consistent with existing evidence. (*JEL* E44, G32, E22)


The financial crisis of 2007–2009 was characterized by a significant contraction in credit and severe disruptions in new debt issuance across credit markets. This event was associated with a tightening of lending standards and large drops in output and asset prices. The pre-2007 credit boom followed the opposite pattern: An increase in aggregate credit, output, and asset prices, and a relaxation of lending standards was observed. This paper studies a model of the credit market that can shed


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light on this and a number of other facts. The model features a novel feedback between asset prices and equilibrium leverage that arises in the presence of asymmetric information in the credit market.

I consider an economy with productivity heterogeneity, a fixed supply of a physical asset (land), and no technological externalities. Land is traded in a competitive market and demanded by entrepreneurs with linear technologies who use it in production. In addition, land can be used by a neoclassical sector with decreasing returns to scale technology. Entrepreneurs face idiosyncratic uncertainty about their productivity: With some probability, an entrepreneur's investment is successful and delivers positive output, and with the complementary probability it is unsuccessful and delivers no output. An entrepreneur can borrow via standard debt contracts, which are backed by output from their technology. Debt contracts are described by their promised repayment or face value and are traded in Walrasian markets. The face value and price of debt determine the loan size and, consequently, the down payment per unit of land that entrepreneurs have to finance with their own funds.

Entrepreneurs have private information about their success probability and, hence, about the probability of debt repayment. Specifically, in the benchmark model, there are two entrepreneurial types: good entrepreneurs, with a high success probability who are creditworthy, and bad entrepreneurs, with a low success probability and who are never creditworthy in equilibrium. Given this asymmetric information problem, good entrepreneurs can separate from bad entrepreneurs via the debt contract that they issue in equilibrium. In particular, since bad entrepreneurs have a lower success probability, they are less willing to use their own funds to invest in land. Thus, by issuing debt with a sufficiently low face value and using more of their own funds, good entrepreneurs can ensure favorable debt valuations. The highest face value of debt that separates good entrepreneurs from bad ones, given the price of land, determines the leverage of good entrepreneurs.

In this separating equilibrium, I identify an important effect of the price of land on the incentives of bad entrepreneurs to pool with good entrepreneurs and, hence, on the leverage of good entrepreneurs. For a given debt level, a higher land price means that entrepreneurs must invest more of their own funds. This makes bad entrepreneurs more reluctant to mimic good ones; as a result, this allows good entrepreneurs to issue debt with a higher face value and to get a larger loan. Put differently, an increase in the price of land exerts a form of advantageous selection in the credit market, thereby expanding the set of debt contracts that only good entrepreneurs prefer to issue. I call this mechanism the *debt quality channel*.

The increase in the loan size arising from this advantageous selection is larger than the increase in the land price that induced it. Thus, the debt quality channel is sufficiently strong, so that even the *share* of the price that good entrepreneurs finance with their own funds – the down payment per unit of investment – decreases with the price of land. This strong effect has an explanation. First, whenever a bad entrepreneur chooses to pool with a good entrepreneur, he receives an implicit subsidy. However, that subsidy is only a fraction of the loan that the good entrepreneur obtains. Second, the highest face value of debt that ensures separation leaves a bad entrepreneur indifferent between pooling and separating. To maintain this indifference, the implicit subsidy must change one-for-one with the land price. However, for this to happen, there must be a more than one-for-one change in the loan that the good entrepreneur obtains. Hence, the land price positively affects not just the debt level but also the leverage *ratio* (the reciprocal of the down payment per unit of investment) of good entrepreneurs.

Turning to the equilibrium determination of the land price, higher leverage means that good entrepreneurs can borrow more per unit of land and increase their demand for land. Combining this demand effect with the debt quality channel leads to positive feedback between the land price and entrepreneurial leverage; this leads to land price amplification. Specifically, a shock that increases the land price induces an increase in the leverage of good entrepreneurs via the debt quality channel. Higher leverage means that the entrepreneurial demand for land increases as well. However, a higher demand for land by good entrepreneurs increases the price of land further. This additionally increases good entrepreneurs' leverage, leading to a further increase in their demand for land, and so on.

The interaction between asset prices and entrepreneurial leverage amplifies different shocks. For example, a positive shock to the productivity of the neoclassical sector increases the price of land, and this triggers the positive feedback described above. Since a higher land price increases the demand for land by good entrepreneurs, this shock also induces reallocation of land from neoclassical firms and to the entrepreneurial sector. This counterintuitive reallocation effect, in turn, implies that aggregate output increases by more than the direct effect arising from the higher productivity of the neoclassical sector.

Next, I extend the model to include more heterogeneity among the types of entrepreneurs that are creditworthy in equilibrium. This extension allows the model to be consistent with several stylized facts about the credit market, including countercyclical lending standards and more severe credit fluctuations for lower quality borrowers. I consider the case with three types: a good type with high repayment probability, a mediocre type with lower repayment probability, and a bad type that is not creditworthy. Both the good and mediocre types are creditworthy in equilibrium. As in the benchmark two-type case, I consider equilibria in which, given the price of land, good and mediocre entrepreneurs use the lowest possible down payments that separate them from bad entrepreneurs and from each other.

I show that the debt quality channel continues to operate in this environment as well. Furthermore, as in the two-type case, it can lead to asset price amplification. However, a change in the asset price also exerts a new type of compositional effect among creditworthy entrepreneurs, since the debt quality channel is stronger for creditworthy entrepreneurs with *lower* repayment probability. There is an intuitive explanation for this. The asymmetric information problem is more severe for the good type than for the mediocre type, since a bad entrepreneur obtains a larger implicit subsidy when pooling with a good type than with a mediocre type. Thus, mediocre entrepreneurs have higher leverage in equilibrium. This makes them more dependent on external financing than good types. Since the debt quality channel influences the availability of external financing to creditworthy entrepreneurs, it must have a larger effect on the borrowing of the mediocre types.

Finally, I examine the empirical relevance of the debt quality channel. The model is broadly consistent with a number of facts about the cyclical behavior of credit markets. First, the model generates a positive comovement between aggregate credit volume, asset prices, and output that is a key characteristic of credit cycles. It also generates a positive comovement between these variables and individual leverage ratios. Furthermore, a stronger debt quality channel for creditworthy types with lower quality implies that credit volume to lower quality borrowers should be more sensitive to aggregate shocks. This differential sensitivity also implies that increases in aggregate credit volume are associated with a relaxation in lending standards, in the sense that the share of credit to lower quality borrowers increases and the average probability of repayment of loans decreases.

# 1 Related Literature

This paper is related to the seminal work of Kiyotaki and Moore (1997) and the large literature on financial frictions and credit cycles that originates from it (Krishnamurthy 2003; Cordoba and Ripoll 2004; Lorenzoni 2008; Korinek 2012; Jeanne and Korinek 2012; Liu, Wang, and Zha 2013; Justiniano, Primiceri, and Tambalotti 2015, among others). This work is also related to models with "cash-in-the-market-pricing" effects (Shleifer and Vishny 1992; Allen and Gale 1994).[1] However, the debt quality channel in my model is distinct to, and complementary of the collateral channel made familiar by this literature. In those models, asset prices directly affect borrowing constraints and entrepreneurial net worth, while in my model with asymmetric information, asset prices affect equilibrium borrowing through the quality of the borrower pool and have no influence on net worth. This indirect effect of asset prices on the credit market induces a response in equilibrium down payments and in individual leverage ratios. In contrast, minimum down payments in models with a collateral channel are exogenous, and fluctuations in leverage ratios are modeled via "leveraging"/"deleveraging" or "collateral" shocks (e.g., Midrigan and Philippon 2011; Liu, Wang, and Zha 2013; Justiniano, Primiceri, and Tambalotti 2015). Applying the terminology of Davila (2011), the debt quality channel is a form of a "margin channel," and therefore, it is more closely related to mechanisms explored by Geanakoplos (2006) and Simsek (2013) or to the "value-at-risk" channel of Brunnermeier and Pedersen (2009) or Adrian and Shin (2014). In addition, my simple model makes a distinct set of empirical predictions about the behavior of credit markets.

My paper contributes to the large literature on financial frictions arising from information asymmetries (Jaffee and Thomas 1976; Leland and Pyle 1977; Stiglitz and Weiss 1981; Myers and Majluf 1984; Bester 1985; Williamson 1987; more recently, Eisfeldt 2004; Plantin 2009; Hennessy and Zechner 2011; Tirole 2012; Daley and Green 2012; Kurlat 2013; Malherbe 2014; Bigio 2015, among others).

There are several important distinctions relative to that literature. First, relative to the recent macroeconomic literature that studies the effect of adverse selection in asset markets, asymmetric information in my model is about the production technology and future output realizations from it

[1] Apart from financial frictions, credit cycles can also arise as the result of coordination problems (Bebchuk and Goldstein 2011).

rather than about the quality of assets that agents own and try to sell or borrow against to finance profitable investment possibilities (Kurlat 2013; Bigio 2015) or for insurance motives (Plantin 2009; Daley and Green 2012; Malherbe 2014). Therefore, in my model there is private information on the expected return on equity of entrepreneurs or on the shadow value of entrepreneurial net worth, rather than on net worth itself.

Second, in models of adverse selection, in which trade is exogenously restricted to a single market, there is a well-known "pool quality", or "lemons" effect (Akerlof 1970), where a *higher* price of the single traded contract *strengthens* the incentives of *good* borrowers to pool with bad borrowers. In contrast, in my model, a *higher* asset price *weakens* the incentives of *bad* borrowers to pool with good borrowers on issuing debt with a higher face value. Put differently, a higher asset price expands the set of debt contracts, for which good borrowers separate from bad borrowers. To provide a starker contrast with the well-known effect of prices in adverse selection models, I refer to this effect of the asset price in my model as *advantageous* selection (de Meza and Webb 2001).

Third, in its focus on separation by different quality borrowers, the paper is related to a large finance literature beginning with Leland and Pyle (1977) and Ross (1977). In these models, agents with higher quality projects can credibly convey their private information by engaging in some privately costly action (a signal as in Spence 1973), which is more costly for low-quality types, thus ensuring "fair" valuations by outside investors. For example, in Leland and Pyle (1977), risk-averse agents with high-quality firms separate by retaining some fraction of their firm's equity, thus incurring the utility cost of an under-diversified portfolio. More recently, DeMarzo and Duffie (1999) study a model of optimal security design under asymmetric information, in which firms signal the quality of the underlying security by retaining a higher fraction of it. Chemla and Hennessy (2014) also study a securitization model whereby originators may signal the underlying security's quality by retaining the junior tranche, but they also face a moral hazard problem ex ante.[2]

Similar to those authors, I also study a model in which higher-quality borrowers separate in equilibrium by keeping some "skin in the game" when selling financial claims to outside investors. However, I contribute to that literature by studying the equilibrium interaction between the price of a physical asset used in production and individual leverage and the amplification effects, which

[2]See also Hennessy, Livdan, and Miranda (2010) and Morellec and Schürhoff (2011) for dynamic models of debt and equity issuance with repeated signaling.

are a result of that interaction.

Modeling financial claims as traded in Walrasian markets in fully diversified pools brings the paper close to the recent literature on collateral equilibria, competitive pooling, and models with endogenous incomplete markets and equilibrium default (Geanakoplos 2006, 2010; Dubey and Geanakoplos 2002; Dubey, Geanakoplos, and Shubik 2005; Fostel and Geanakoplos 2008, 2012; Geanakoplos and Zame 2009; Simsek 2013). These papers examine endogenous fluctuations in down payments (or margins) and asset prices that are the result of belief heterogeneity. My paper contributes to this literature by applying the concepts of collateral equilibrium and competitive pooling to an environment with asymmetric information on firm productivity and by uncovering important feedback between the price of a physical asset and equilibrium leverage.[3]

In addition to collateral equilibrium and competitive pooling, there are other related approaches to modeling contracting under asymmetric information with Walrasian markets (Gale 1992; Bisin and Gottardi 1999, 2006; DeMarzo and Duffie 1999; Azevedo and Gottlieb 2014). Finally, the focus on financing decisions of agents with profitable investment opportunities in a Walrasian market environment relates the paper to recent literature on corporate finance and financial contracting in general equilibrium (Zame 2006; Bisin, Gottardi, and Ruta 2009).

# 2 Model

## 2.1 Preferences and technology

I consider a two-period economy, with $t = 0, 1$. The economy is populated by a measure 2 of risk-neutral agents with utility function given by $U(c_0, c_1) = c_0 + c_1$, where $c_t$ is the time $t$ consumption of a perishable good. For simplicity, I assume that the discount factor of agents equals 1, so that the risk-free interest rate in this economy equals 0.

All agents have access to a production technology, but there is heterogeneity in the technology that each agent is endowed with. Each technology uses a durable good – productive land (or "land" for short) – to produce $t = 1$ consumption. Land cannot be consumed at either $t = 0$ or $t = 1$. I

[3] Taddei (2011) is a recent paper that also studies asymmetric information about entrepreneur productivity in a collateral equilibrium. However, he considers an environment with switches between an "illiquid" pooling equilibrium and a "liquid" separating equilibrium. In contrast, in my paper I consider only separating equilibria and the impact asset prices have on the separating equilibrium contract.

normalize the aggregate stock of land in the economy to unity. Agents can trade land at $t = 0$ in a competitive market with a price of $q$.

A measure one of agents – the entrepreneurs – have access to a linear production technology

$$f(a, l) = al, \tag{1}$$

where $l$ is the land that an entrepreneur uses in production and $a$ is an idiosyncratic productivity state that is realized at $t = 1$. Even though $a$ is realized at $t = 1$, so that there is ex post heterogeneity among entrepreneurs, there is also ex ante heterogeneity at $t = 0$. Specifically, at $t = 0$, entrepreneurs can be of type $\theta \in \Theta = \{\theta_0, \theta_1, \theta_2, ..., \theta_N\}$, for $N \geq 1$, with a distribution in the population given by $\Pr\{\theta = \theta_j\} = \phi_j$, for $j \in \{0, 1, 2, ..., N\}$, where $\sum_{j=0}^{N} \phi_j = 1$.

Ex post productivity $a = a(\theta)$ is distributed as

$$a(\theta) = \begin{cases} S & , \, with \quad pr. \, \eta_\theta \\ 0 & , \, o.w. \end{cases}, \tag{2}$$

so $\eta_\theta$ is the probability that the entrepreneur's investment is successful, in which case it delivers $S$ units of the $t = 1$ consumption good per unit of land used. Otherwise, the technology delivers 0.

$$A_\theta \equiv E[a|\theta] = \eta_\theta S \tag{3}$$

denotes the expected productivity for an entrepreneur of type $\theta$. I assume that $A_{\theta_0} < A_{\theta_j}$, for $j \in \{1, 2, ..., N\}$, so that in terms of production efficiency, entrepreneurs of type $\theta_0$ are strictly dominated by entrepreneurs of any other type. Entrepreneurs' types $(\theta)$ are private information at $t = 0$.

The rest of the agents – the consumers – have access to a standard backyard neoclassical production technology with diminishing returns of the form

$$H(Z, l) = Zh(l), \tag{4}$$

with $h'(l) > 0$ and $h''(l) < 0$, where $l$ is the quantity of land used in production, and $Z \in \mathcal{Z} \subset \mathbb{R}_+$

is a productivity shifter common to all consumers. Additionally, I assume that $Zh'(1) > A_{\theta_0}$ and $Zh'(0) < \min_{j\in\{1,2,\dots,N\}}\{A_{\theta_j}\}$, $\forall Z \in \mathcal{Z}$. Thus, the neoclassical sector's marginal productivity lies between the expected productivities of a type $\theta_0$ entrepreneur and any other entrepreneur type. Given these assumptions, $N \geq 1$ will denote the number of creditworthy types in any equilibrium in which consumers also hold land.

Consumers are endowed with $l^C$ units of land and $e^C$ units of the $t = 0$ consumption good. Entrepreneurs are endowed with $e^E$ units of the $t = 0$ consumption good. I assume that entrepreneurs have no land endowments, so $l^E = 0$.[4]

## 2.2 Credit market

Entrepreneurs can invest in land by using their endowments and by raising financing from outside investors via claims on their $t = 1$ output. The claims take the form of standard debt contracts.[5] Also, entrepreneurs have limited commitment, so they are free to default ex post on any promises that are not backed by the output from the production technology. Therefore, each debt contract can be described by a face value or promised repayment $\beta \geq 0$, and land units $w \geq 0$, whose output backs this promise. Given limited commitment, each debt contract $(\beta, w)$ can equivalently be represented by a pair $(d_S, w)$, where $d_S$ denotes the repayment in case of success $(a = S)$ and satisfies

$$d_S(\beta, w) = \min\{\beta, Sw\}. \tag{5}$$

Linearity of the production technology implies that Equation (5) can be written equivalently as

$$d_S(\beta, w) = w \min\left\{\frac{\beta}{w}, S\right\}. \tag{6}$$

Therefore, the payoff structure of a debt contract $(\beta, w)$ is equivalent to that of $w$ units of debt contract $\left(\frac{\beta}{w}, 1\right)$. I exploit this feature of the linear technology of entrepreneurs and restrict attention to the one-dimensional space of contracts $\{(\gamma, 1)\}$ for $\gamma \in [0, S]$.[6] For notational convenience, I also

[4] The assumption of no initial land holdings by entrepreneurs is for tractability, since it removes the dependence of entrepreneurial net worth on the asset price $q$.

[5] Given the binary output structure, the restriction to standard debt contracts is without loss of generality, since entrepreneurs essentially issue claims on output in case the technology delivers a positive payoff.

[6] Although this restriction is not without loss of generality, it essentially implies that I will be considering equilibria, in which the investment scale of entrepreneurs is not a signal of their type. This restriction removes a large set of

drop the reference to a single unit of land. $\{\gamma\}_{\gamma\in[0,S]}$ denotes the space of debt contracts by their face value, and similarly for the debt repayment $d_S(\gamma) \equiv d_S(\gamma, 1)$.

I consider a Walrasian credit market setup as in Geanakoplos (2006), Geanakoplos and Zame (2009), and Simsek (2013). In particular, each debt contract with face value $\gamma$ (or $\gamma$-debt for short) trades in an anonymous competitive market with price given by $D(\gamma)$. Anonymity implies that entrepreneurs of any type can sell claims in the same debt market. As in Dubey and Geanakoplos (2002) and Dubey, Geanakoplos, and Shubik (2005), I assume competitive pooling for each $\gamma$-debt (by a set of competitive intermediaries not explicitly modeled), so that outside investors that buy these debt contracts hold a fully diversified pool across idiosyncratic entrepreneur productivity risk and entrepreneur types. $\tilde{D}(\gamma)$ denotes the expected payoff for the pool of $\gamma$-debt. I assume that all outside investors hold the same beliefs about the composition of entrepreneurs that issue a debt contract. Therefore,

$$\tilde{D}(\gamma) = E_\mu [d_S(\gamma)], \tag{7}$$

where $\mu \in \triangle\Theta$ denotes outside investors' (lenders) beliefs about the types of entrepreneurs that issue that debt.

### 2.3 Agents' problems

Consumers in the model have a secondary role, so a formal statement of their problem is given in the Online Appendix. Consumers use their endowments to buy debt issued by entrepreneurs and invest in the backyard technology. Additionally, I consider economies, in which the consumers' endowment of the $t = 0$ consumption good is sufficiently large (consumers have "deep pockets"), so that debt prices, $D(\gamma)$, are never below agents' expected debt payoffs, $\tilde{D}(\gamma)$, or $D(\gamma) \geq \tilde{D}(\gamma)$, $\forall\gamma$.[7] Given these prices, consumers are indifferent between consuming at $t = 0$ and $t = 1$.

From the characterization of the consumer's problem, it follows that his demand for land, $L^C$, is implicitly given by

$$Zh'\left(L^C\right) = q, \tag{8}$$

equilibria, in which the investment scale of entrepreneurs is pinned down by arbitrary outside investor beliefs about the types of entrepreneurs who issue debt with a particular asset backing $w$.

[7] $e^C \geq A_{\theta_N}$ will be sufficient to guarantee this. The Online Appendix includes an extension of the model which implicitly relaxes this assumption and allows for lenders to obtain positive profits in equilibrium.

for $q \leq Zh'(0)$ and $L^C = 0$ for $q \geq Zh'(0)$.

I now turn to the problem of an entrepreneur.[8] For simplicity, I assume that entrepreneurs do not buy debt issued by other entrepreneurs, but, instead, immediately consume the fraction of their endowments that is not used to finance their own investment in land. An entrepreneur solves

$$V_\theta^E = \max_{c_{\theta,0}^E, \{l_\theta^E(\gamma)\}_\gamma} c_{\theta,0}^E + E\left[c_{\theta,1}^E(a)|\theta\right] \tag{9}$$

$$s.t.\ \ c_{\theta,0}^E + \int_0^S (q - D(\gamma)) l_\theta^E(\gamma) d\gamma = e^E,$$

$$c_{\theta,0}^E \geq 0,\ l_\theta^E(\gamma) \geq 0,\ \gamma \in [0, S],$$

$$E\left[c_{\theta,1}^E(a)|\theta\right] \equiv \eta_\theta \int_0^S (S - \gamma) l_\theta^E(\gamma) d\gamma,$$

where $l_\theta^E(\gamma)$ denotes the quantity of land that collateralizes debt with face value $\gamma$. Note that $l_\theta^E(\gamma)$ is also the quantity of $\gamma$-debt issued by the entrepreneur.[9] The entrepreneur's problem consists of two decisions: (1) what debt to use for financing (the leverage decision), and (2) how much land to invest in (the scale decision).

I define an object that will be important for all analysis below:

$$R_\theta(\gamma; q, D(\gamma)) \equiv \frac{A_\theta - \eta_\theta \gamma}{q - D(\gamma)}. \tag{10}$$

$R_\theta(\gamma, q, D(\gamma))$ is the expected leveraged return (or expected return on equity) of an entrepreneur of type $\theta$ from producing by investing in land and simultaneously issuing $\gamma$-debt with price $D(\gamma)$.[10] The following result describes an entrepreneur's joint investment and financing decision:

[8] Given the information asymmetry, the Modigliani-Miller theorem (Modigliani and Miller 1958) need not apply, and instead an entrepreneur's investment decision will depend on his financing decision. Therefore, an entrepreneur's net worth will matter for his investment decision.

[9] $l_\theta^E(\gamma)$ is assumed to be a Lebesgue-measurable function. Note that there is a technical issue in defining $l_\theta^E(\gamma)$ in this way as it can have a mass point in equilibrium when agents issue only a single type of debt contract. In this case, for notational convenience, I will use $l_\theta^E(\gamma)$ to denote the mass of debt contracts as well.

[10] In equilibrium, this function is bounded, as otherwise an entrepreneur would be able to derive an unbounded payoff by issuing unlimited amounts of debt with some face value $\gamma \leq S$, which would violate market clearing.

**Lemma 1.** *Let*

$$\overline{R}_\theta \equiv \max_\gamma R_\theta\left(\gamma, q, D\left(\gamma\right)\right).$$

- *An entrepreneur never issues* $\gamma$*-debt, such that* $R_\theta\left(\gamma, q, D\left(\gamma\right)\right) < \overline{R}_\theta$*.*

- *If* $\overline{R}_\theta < 1$*, then the entrepreneur does not issue debt of any face value and does not invest in land.*

- *If* $\overline{R}_\theta > 1$*, then the entrepreneur uses all of his* $t = 0$ *endowment to invest in land.*

- *If* $\overline{R}_\theta = 1$*, then the entrepreneur is indifferent between investing and not investing.*

- *An entrepreneur's maximized payoff is given by* $V_\theta^E = v_\theta e^E$*, where*

  $$v_\theta \equiv \max\left\{1, \overline{R}_\theta\right\}$$

  *denotes the shadow value of entrepreneurial net worth.*

- *An entrepreneur never issues* $\gamma$*-debt, such that* $R_\theta\left(\gamma, q, D\left(\gamma\right)\right) < v_\theta$*.*

*Proof.* See Appendix. ■

Lemma 1 shows that an entrepreneur's leverage decision determines the shadow value of net worth, $v_\theta$. The scale decision depends on $v_\theta$ and is either determined in equilibrium, when an entrepreneur is indifferent between investing and not, or at a corner, when an entrepreneur uses all net worth to invest in land or does not invest.

### 2.4 Equilibrium concept

There are three important equilibrium objects: the price of land, $q$, the debt contracts that entrepreneurs issue, and the expected debt payoffs, $\tilde{D}\left(\gamma\right)$. Given prices and expected debt payoffs, agents in the economy optimally choose their consumption and asset holdings. Expected debt payoffs for debt traded in equilibrium, in turn, reflect the equilibrium decisions of entrepreneurs of different types. Finally, the land and debt markets clear.[11] Below is a formal definition of the

[11]Note that there can be price indeterminacy for untraded debt. The indeterminacy of prices of debt contracts not traded in equilibrium is characteristic of collateral equilibria (Simsek 2013) and is not an artifact of asymmetric

equilibrium. Allocations with superscript $E$ refer to entrepreneurs and allocations with superscript $C$ refer to consumers. Also, I use the individual agent allocation and aggregate allocation for that group interchangeably.

**Definition 1.** An equilibrium of this economy consists of $t = 0$ asset holdings and $t = 0$ and $t = 1$ consumption allocations $\left\{c_0^C,\, c_1^C,\, L^C,\, \left\{b^C(\gamma)\right\}_\gamma\right\}$, $\left\{c_{\theta,0}^E,\, c_{\theta,1}^E(S),\, c_{\theta,1}^E(0),\, \left\{l_\theta^E(\gamma)\right\}_\gamma\right\}_{\theta\in\Theta}$, prices of land $q$, and of debt contracts $\{D(\gamma)\}_\gamma$, a set $\Gamma$ of debt contracts traded in equilibrium, and expected debt payoffs $\left\{\tilde{D}(\gamma)\right\}_\gamma$ such that:

1. Consumption allocations and asset holdings solve the agents' optimization problems given prices and expected debt payoffs.

2. Expected debt payoffs, $\left\{\tilde{D}(\gamma)\right\}_\gamma$, are consistent with entrepreneurs' debt issuance decisions for debt contracts traded in equilibrium, or

$$\tilde{D}(\gamma) = \left(\sum_{j=0}^{N} \frac{\phi_j l_{\theta_j}^E(\gamma)}{\sum_{i=0}^{N} \phi_i l_{\theta_i}^E(\gamma)} \eta_{\theta_j}\right)\gamma,$$

   for any $\gamma \in \Gamma$.

3. The land market clears:

$$L^C + \sum_{j=0}^{N} \phi_j \int l_{\theta_j}^E(\gamma) d\gamma = 1,$$

   where $L^C$ satisfies (8).

4. Debt markets clear:

$$b^C(\gamma) = \sum_{j=0}^{N} \phi_j l_{\theta_j}^E(\gamma)\ , \forall\gamma.$$

I will focus on separating equilibria in which entrepreneurs of different types issue different debt contracts or do not participate in the credit market.[12]

information. It arises from the inability of investors to short sell debt, as short selling is equivalent to borrowing and requires collateral. To circumvent these issues, which lead to trivially many equilibria with different prices for untraded debt but with the same equilibrium allocations and prices of land and of traded debt, I will consider only equilibria in which $D(\gamma) = \tilde{D}(\gamma)$, $\forall\gamma$.

[12] In the Online Appendix, I provide a formal definition of a separating equilibrium, which follows directly from Definition 1.

# 3 Equilibrium Analysis with Two Types

I start by characterizing separating equilibria for the case of two entrepreneurial types and one creditworthy type ($N = 1$). The environment with two types delivers the main insights from the model, the debt quality channel – the effect the land price exerts on the credit market – and the equilibrium feedback between the price of land and the credit market. For greater expositional clarity, I refer to the type $\theta_0$ entrepreneur as bad ($\theta_0 = B$) and the type $\theta_1$ entrepreneur as good ($\theta_1 = G$). Also, $\phi$ denotes the fraction of good entrepreneurs in the population.

In a separating equilibrium of this economy, good entrepreneurs use their financing decisions to signal their type. Specifically, by selling debt with a lower face value, and thus keeping more "skin in the game", good entrepreneurs can secure favorable financing. The amount of external financing that an entrepreneur obtains depends on the land price, $q$, making the model different from a standard signaling model of credit. Moreover, $q$ is determined in equilibrium and depends on the external financing that entrepreneurs can secure.

I characterize equilibria under the following refinement on lenders' beliefs about the expected payoffs from untraded debt:

**Belief Consistency (BC):** Let $v_\theta$ denote the equilibrium shadow value of net worth for a type $\theta$ entrepreneur, $\Gamma$ denote the set of debt contracts traded in equilibrium, and $q$ be the equilibrium price of land. For a debt contract with face value $\gamma' \notin \Gamma$, let $\mu_{\gamma'} \in \triangle\Theta$ denote the outside investors' belief about the types of entrepreneurs who issue debt with face value $\gamma'$. Define $\overline{D}(\gamma') \equiv \max_{\mu \in \triangle\Theta} E_\mu \left[d_S(\gamma')\right]$. Outside investors' debt valuations satisfy BC, iff, $\mu_{\gamma'}(\theta) = 0$, for any $\gamma' \notin \Gamma$ and $\theta \in \Theta$, s.t. $v_\theta > R_\theta\left(\gamma', q, \overline{D}(\gamma')\right)$.

This assumption is similar to (but stronger than) the Intuitive Criterion assumption in signaling games (Cho and Kreps 1987). The purpose of this belief condition is to reduce the set of separating equilibria to those in which, given the price of land, a good entrepreneur uses the lowest possible promised repayment that separates him from a bad entrepreneur.

## 3.1 Equilibrium down payments

Since bad entrepreneurs never invest in a separating equilibrium of this economy (by Lemma 2 in the Appendix), their equilibrium shadow value of net worth is $\nu_B = 1$. Define $\gamma_G(q)$ as the (unique) solution to

$$R_B(\gamma_G, q, D_{\eta_G}(\gamma_G)) = \frac{A_B - \eta_B \gamma_G}{q - \eta_G \gamma_G} = 1, \tag{11}$$

for $q \in (A_B, A_G)$, where I adopt the notation $D_{\tilde{\eta}}(\gamma) = \tilde{\eta}\gamma$ for the price of $\gamma$-debt given a fraction $\tilde{\eta}$ of successful investments. As the following result shows, $\gamma_G(q)$ is the promised repayment chosen by good entrepreneurs in a separating equilibrium with expected debt payoffs that satisfy (BC).

**Proposition 1.** *Let $\gamma_G(q)$ be given by condition (11). Then in any separating equilibrium of this economy with an equilibrium price of land of $q \in (A_B, A_G)$ and expected debt payoffs that satisfy (BC), $\gamma_G(q)$ is the face value of debt issued by good entrepreneurs.*

*Proof.* See Appendix. ■

Equation (11) plays the role of an incentive compatibility condition for a bad entrepreneur to not pool with a good entrepreneur on debt issuance.[13] It defines the following relation between $\gamma_G$ and $q$:

$$\gamma_G(q) = \frac{q - A_B}{\eta_G - \eta_B}. \tag{12}$$

Notice that $\gamma_G$ is strictly increasing in $q$. Therefore, a higher price of land is associated with a higher face value of debt that good entrepreneurs issue. It is also associated with a higher loan size per unit of land, which is simply $D(\gamma_G(q)) = \eta_G \gamma_G(q)$. This increase in the loan size is, in fact, sufficiently large to also lead to a decrease in the *fraction* of the land price that the entrepreneur finances with internal funds. Specifically, I define this fraction as

$$\zeta_G(q) \equiv 1 - \frac{D(\gamma_G(q))}{q} = \frac{\eta_B}{\eta_G - \eta_B}\left(\frac{A_G}{q} - 1\right). \tag{13}$$

Therefore, $\zeta_G(q)$ is the equilibrium down payment per unit of land that the good entrepreneur makes with internal funds. Similarly, one can define the leverage ratio, $\lambda_G(q)$, of a good entrepreneur as

[13] I assume that whenever indifferent, a bad entrepreneur does not issue debt.

the reciprocal of the equilibrium down payment, or

$$\lambda_G(q) = \frac{1}{\zeta_G(q)}. \tag{14}$$

Observe that $\zeta_G(q)$ $(\lambda_G(q))$ is a decreasing (increasing) function of $q$ for $q \in (A_B, A_G)$. Thus, a higher price of land is associated with a lower equilibrium down payment (higher leverage ratio) for a good entrepreneur. Next, I discuss the intuition behind these effects.

### 3.2 A debt quality channel

The *debt quality channel* is the positive effect of the price of land on the equilibrium face value of debt that good entrepreneurs use to borrow. The intuition for this effect is as follows. Since a good entrepreneur's project is more likely to succeed, his expected leveraged return per unit of investment for given $q$ and $\gamma$ is higher than that of a bad entrepreneur. For a fixed loan size, $D(\gamma)$ (and a fixed $\gamma$), increasing $q$ implies that an entrepreneur needs to use more of his own funds to buy a unit of land, and so his expected leveraged return decreases. Therefore, if a bad entrepreneur (weakly) prefers not to issue debt with face value $\gamma_G(q_0)$ at some price $q_0$, he strictly prefers not to issue that debt for $q_1 > q_0$. Thus, at $q_1$, the good entrepreneur can issue debt with a face value higher than $\gamma_G(q_0)$.

To see why the debt quality channel is sufficiently strong, so that an increase in the land price also leads to a decrease in the down payment per unit of land (and an increase in the leverage ratio) of a good entrepreneur, let us rewrite the incentive compatibility condition (11) in the following way:

$$\underbrace{A_B - q}_{NPV} + \underbrace{\overbrace{\eta_G \gamma_G}^{\text{Loan size}} \left(1 - \frac{\eta_B}{\eta_G}\right)}_{\text{Implicit subsidy}} = 0. \tag{15}$$

The first term of this expression is the net present value of a unit of investment by a bad entrepreneur, and the second term is the implicit subsidy that a bad entrepreneur receives by pooling with a good entrepreneur on issuing debt with face value $\gamma_G$. Importantly, since $1 - \frac{\eta_B}{\eta_G} \leq 1$, the implicit subsidy is only a fraction of the loan size. A bad entrepreneur is indifferent between investing with a loan of size $\eta_G\gamma_G$ and not investing, if the implicit subsidy exactly covers the NPV shortfall. To maintain indifference, an increase in the price $q$ by one unit must be offset by an increase in the implicit subsidy by one unit. Since the subsidy constitutes only a fraction of the loan size, maintaining indifference requires an increase in the loan size by more than one unit. This, in turn, means that the down payment per unit of land, $\zeta(q)$, must fall. This behavior of the equilibrium down payment serves to amplify the effect of aggregate shocks on the price of land, as I show in Section 3.5.

### 3.3 Entrepreneurial demand and market clearing

Observe that for $q < A_G$,

$$R_G\left(\gamma_G, q, D_{\eta_G}\left(\gamma_G\right)\right) > 1. \tag{16}$$

Therefore, Proposition 1 and Lemma 1 imply that in a separating equilibrium with $q < A_G$, good entrepreneurs use all of their endowment to invest in land. From the budget constraint of a good entrepreneur in Problem (9), it follows that his land demand satisfies,

$$ql_G^E = \lambda_G\left(q\right)e^E. \tag{17}$$

Condition (17) has a very intuitive interpretation. The left-hand side gives the value of assets that an entrepreneur holds after investment decisions are made. The right-hand side consists of the leverage ratio, $\lambda_G = \frac{1}{\zeta_G}$, multiplied by the entrepreneurial net worth, $e^E$.

By using the expression for $\zeta_G$ from (13) and aggregating, I obtain the following land demand by good entrepreneurs

$$L^E \equiv \frac{\phi e^E}{q\zeta_G\left(q\right)} = \frac{\eta_G - \eta_B}{\eta_B}\frac{\phi e^E}{A_G - q}. \tag{18}$$

Note that $L^E$ is increasing in $q$, so entrepreneurial demand for land is increasing in the price of land $q$, whenever $q < A_G$. Substituting for the land demand of consumers (8) into the land market-clearing condition

$$1 = L^E + L^C \tag{19}$$

gives

$$Zh'\left(1 - L^E\right) = q\cdot \tag{20}$$

We can think of condition (20) as a residual supply curve for land. Therefore, the intersections of

(18) and (20) for values of $q \leq Zh'(0)$ are consistent with both agents' optimization and market clearing and, hence, with equilibrium. The next proposition characterizes separating equilibria of this economy.

**Proposition 2. (Separating equilibria)** *Consider the above economy.*

1. *Any solution of equations (18) and (20), such that $q \leq Zh'(0)$, gives a pair $\left(q, L^E\right)$ that is consistent with equilibrium. In that equilibrium good entrepreneurs issue debt with face value $\gamma_G(q)$ given by (12) and have a demand for land of $L^E$, which satisfies (18). Consumers buy debt with face value $\gamma_G$ and demand $L^C$ units of land, given by (8). Bad entrepreneurs consume their $t = 0$ endowments.*

2. *Let $\tilde{q} = A_G - \frac{\eta_G - \eta_B}{\eta_B}\phi e^E$. Whenever $\tilde{q} > Zh'(0)$, there is an equilibrium with land price $\tilde{q}$, in which good entrepreneurs hold all of the land in the economy and issue debt with face value $\gamma_G(\tilde{q})$ given by (12). Consumers buy debt with face value $\gamma_G$ and no land. Bad entrepreneurs consume their $t = 0$ endowments.*

3. *There exists an equilibrium with price of land $q = A_G$, in which only good entrepreneurs hold all the land in the economy.*

4. *Given condition (BC), no other separating equilibria exist.*

*Proof.* See Appendix. ■

Proposition 2 shows that there could be equilibrium multiplicity, even among the class of separating equilibria with lender beliefs that satisfy (BC). One reason for this multiplicity is the upward-sloping demand curve for land by entrepreneurs given in (18), which may intersect multiple times with the residual supply curve (20). I now provide conditions, under which (18) and (20) intersect only once for interior values of $L^E$. Specifically, suppose that

$$Zh'(0) < A_G - \frac{\eta_G - \eta_B}{\eta_B}\phi e^E. \tag{21}$$

Condition (21) is sufficient for the existence of at least one *interior* equilibrium, a separating equilibrium, in which both good entrepreneurs and consumers hold land and produce. Additionally, the following condition,

$$-Zh''(L) < \frac{\eta_G - \eta_B}{\eta_B}\phi e^E, \tag{22}$$

for $L \in (0,1)$ and $Z \in \mathcal{Z}$, ensures a unique interior equilibrium, since it bounds the slope of the residual supply curve (20).[14] Given these conditions, the economy has a unique interior equilibrium.

**Proposition 3. (Unique interior equilibrium)** *Suppose that conditions (21) and (22) hold. Then there exists a unique interior separating equilibrium with* $L^E \in (0,1)$ *and* $q^* \in \left(A_B, A_G - \frac{\eta_G-\eta_B}{\eta_B}\phi e^E\right)$ *that jointly satisfy Equations (18) and (20).*

*Proof.* See Appendix. ■

Figure 1 illustrates equilibrium determination in the case of a unique interior equilibrium. It plots the demand for land by good entrepreneurs (solid line) and the residual supply function (20) (dashed line) in the space of land holdings by good entrepreneurs, $L$, and land prices, $q$. Importantly, at the unique interior equilibrium, the demand for land by good entrepreneurs is upward sloping and crosses the residual supply curve from below.

[Figure 1 here]

Below, I will analyze properties of this unique interior equilibrium. This focus is reasonable since the corner equilibria with $L^E = 1$ are not robust to the introduction of limited pledgeability of future output in the spirit of Holmstrom and Tirole (2011). In particular, suppose that entrepreneurs can only credibly sell debt with a face value up to $\chi S$, for some $\chi < 1$. One can then show that for $\chi$ sufficiently small and sufficiently low entrepreneurial endowment $e^E$, the corner equilibria fail to exist.

### 3.4 Pooling equilibria

Apart from separating equilibria, under some conditions, there also exist pooling equilibria of this economy. In a pooling equilibrium, both types of entrepreneurs issue debt with the same face value,

[14] The results in Section 3.5 can also be applied to a case where condition (22) does not hold, so that multiple interior equilibria can exist. In that case the comparative statics in Section 3.5 apply to the interior equilibrium with the smallest value of $L^E < 1$.

$\gamma_{Pool}$. They also issue the same amount of debt $l_B^E(\gamma_{Pool}) = l_G^E(\gamma_{Pool})$, and the price of that debt is given by

$$D_{\eta_{Pool}}(\gamma_{Pool}) = \eta_{Pool}\gamma,$$

where $\eta_{Pool} \equiv (1-\phi)\,\eta_B + \phi\eta_G$.

Proposition 7 in the Online Appendix, characterizes the pooling equilibria of this economy and gives conditions under which no pooling equilibria exist. Specifically, a sufficient condition for the nonexistence of pooling equilibria is $e^E \geq A_B$, which is compatible with good entrepreneurs being reliant on external financing in equilibrium (so the results of the previous section continue to hold).[15] Additionally, in the Online Appendix, I show that a simple belief refinement, such as passive beliefs (e.g., McAfee and Schwartz 1994), rules out all pooling equilibria of this economy.

Given these observations, for the rest of the paper, I focus on separating equilibria. Nevertheless, notice that the debt quality channel also has implications for the set of pooling equilibria of this economy (whenever those exist). Since the advantageous selection effect of the land price expands the set of debt contracts for which there is separation, it also shrinks the set of debt contracts that can be part of a pooling equilibrium.

### 3.5 Amplification

In this section, I explore the equilibrium implications of the debt quality channel. I show how it can act as an amplifier of shocks and leads to positive comovements in output, asset prices, aggregate credit volume, and leverage.

Consider a positive shock to the productivity of the neoclassical sector, $Z$. This leads to an upward shift in the residual supply curve for land (20) for any level of land holdings by good entrepreneurs. Therefore, at the initial level of land holdings by good entrepreneurs, the land price is now higher. However, a higher land price decreases the down payment (increases the leverage ratio) of good entrepreneurs, and this increases the good entrepreneurs' demand for land (by Equation (18)). A higher demand for land by good entrepreneurs increases the price of land further. As a result, this additionally decreases down payments (and increases leverage) and leads to a further increase in entrepreneurial demand for land, and so on. The final effect of this equilibrium

[15] That will be the case if, for example, bad entrepreneurs are sufficiently prevalent ($\phi$ is low) or their technology is sufficiently unproductive.

feedback loop is a higher equilibrium price, and *higher* land holdings by good entrepreneurs.

Thus, a positive productivity shock in the neoclassical sector can increase the equilibrium price of land more than one-for-one. I summarize this observation in the following proposition.

**Proposition 4.** *A shock to productivity, $Z$, has an amplified effect on the equilibrium price of land $q$ in the sense that*

$$\frac{\partial \log q}{\partial \log Z} > 1. \tag{23}$$

*Proof.* See Appendix. ■

The amplified price effect is due to reallocation of land *towards* good entrepreneurs who operate a more productive technology than the neoclassical sector. This reallocation effect also increases aggregate output by more than the direct effect from a higher value of $Z$. Specifically, aggregate output, $Y$, in this economy is

$$Y \equiv A_G L^E + Zh\left(1 - L^E\right). \tag{24}$$

In the case in which there is no reallocation of land between the two sectors (so the general equilibrium effect of a change in $q$ is disregarded), the elasticity of output to a change in $Z$ is

$$\left.\frac{\partial \log Y}{\partial \log Z}\right|_{q\ fixed} = h\left(1 - L^E\right)\frac{Z}{Y}. \tag{25}$$

In contrast, when the general equilibrium effect from changes in the price of land is taken into account, this elasticity becomes

$$\frac{\partial \log Y}{\partial \log Z} = \left.\frac{\partial \log Y}{\partial \log Z}\right|_{q\ fixed} + \underbrace{\left(A_G - Zh'\left(1 - L^E\right)\right)\frac{\partial L^E}{\partial q}\frac{\partial q}{\partial Z}\frac{Z}{Y}}_{reallocation\ effect}. \tag{26}$$

The second term in Equation (26) is positive, since both $\frac{\partial q}{\partial Z} > 0$ and $\frac{\partial L^E}{\partial q} > 0$.

Looking at aggregate credit volume, $\mathcal{L}$, defined as the aggregate value of debt issued in equilibrium, or

$$\mathcal{L} \equiv D\left(\gamma_G\left(q\right)\right) L^E, \tag{27}$$

it follows that $\mathcal{L}$ is increasing in $q$, since both $L^E$ and $D\left(\gamma_G\left(q\right)\right) = \eta_G \gamma_G\left(q\right)$ increase in $q$. Therefore, both the loan size (given by $D$) and the number of loans ($L^E$) increase with $q$. Finally, since $q$ is increasing in $Z$, it follows that aggregate credit volume increases in $Z$, as well.

To get a sense of when the amplification effect in Proposition 4 is likely to be large, let us rewrite the elasticity $\partial \log q/\partial \log Z$ as

$$\frac{\partial \log q}{\partial \log Z} = \frac{1}{1 - \left|\epsilon_{h',L}\left(L^C\right)\right| \frac{L^E}{L^C} \frac{\eta_B}{\eta_G - \eta_B} \lambda_G\left(q\right)}. \tag{28}$$

Here, $\epsilon_{h',L}\left(L^C\right)$ denotes the elasticity of the marginal productivity of consumers' technology with respect to consumers' land holdings, and $\lambda_G\left(q\right)$ is the equilibrium leverage ratio of good entrepreneurs. Importantly, the right-hand side is increasing in $\lambda_G\left(q\right)$. Therefore, the price amplification effect of the debt quality channel is larger whenever entrepreneurial leverage is higher. Intuitively, higher equilibrium leverage is associated with greater dependence on external financing and, hence, with a stronger effect of asset price changes on entrepreneurial demand.[16]

Shocks to entrepreneurial net worth have similar equilibrium effects for the land price, output, leverage, and aggregate credit volume. Specifically, an increase in entrepreneurial net worth leads to a rightward shift in the demand for land by good entrepreneurs; as a result, this leads to an equilibrium feedback between the land price and entrepreneurial land holdings, similar to the one described above for the case of a shock to $Z$. With net worth shocks, the equilibrium feedback creates an amplified response of entrepreneurial land holdings as summarized in the following proposition.

**Proposition 5.** *A shock to entrepreneurial net worth, $e^E$, has an amplified effect on the equilibrium land holdings of entrepreneurs,*

$$\frac{\partial \log L^E}{\partial \log e^E} > 1. \tag{29}$$

*Proof.* See Appendix. ■

Intuitively, the change in entrepreneurial leverage induced by the equilibrium response of the price of land leads to a heightened sensitivity of entrepreneurial investment to changes in net worth.

[16]The Online Appendix contains a simple numerical example that illustrates the magnitude of this effect.

# 4 Greater Heterogeneity

In this section, I study a case with richer heterogeneity in terms of entrepreneur types. Specifically, suppose that there are three entrepreneurial types ($N = 2$), which I refer to as bad ($\theta_0 = B$), mediocre ($\theta_1 = M$), and good ($\theta_2 = G$), with a distribution in the population given by $1 - \phi_M - \phi_G$, $\phi_M$, and $\phi_G$, respectively. There are several reasons for considering such an extension. First, greater type heterogeneity is arguably more realistic. Second, even though the main insight from the two-type model carries over in this case, an additional important compositional effect arises in the presence of greater type heterogeneity. This compositional effect is due to the debt quality channel being stronger for some creditworthy types compared with others.

As in the two-type case, I consider separating equilibria, in which, given the price of land, creditworthy entrepreneur types borrow with the highest possible repayment that is consistent with separation. Also, as in the case with two types, I analyze interior equilibria in which entrepreneurs do not hold all of the land in the economy. Since much of the analysis overlaps with the two-type case from Section 3, I discuss only features not present in the two-type case, and the rest of the analysis is contained in the Online Appendix.

Define $\gamma_M(q)$ and $\gamma_G(q)$ as the solutions to the following two equations:

$$R_B\left(\gamma_M, q, D_{\eta_M}(\gamma_M)\right) = \frac{A_B - \eta_B \gamma_M}{q - \eta_M \gamma_M} = 1, \tag{30}$$

and

$$R_M\left(\gamma_G, q, D_{\eta_G}(\gamma_G)\right) = \frac{A_M - \eta_M \gamma_G}{q - \eta_G \gamma_G} = R_M\left(\gamma_M, q, D_{\eta_M}(\gamma_M)\right), \tag{31}$$

for $q \in (A_B, A_M)$. Equations (30) and (31) are incentive compatibility conditions for bad and mediocre entrepreneurs, respectively. As Proposition 9 in the Online Appendix shows, they determine the highest repayments for mediocre and good entrepreneurs, which are consistent with separation, given $q$.[17]

[17] With more than two types, condition (BC) alone cannot rule out other separating equilibria, in which mediocre entrepreneurs use repayments in the set $(\gamma_G(q), \gamma_M(q))$. This is a feature of signaling games where "Intuitive Criterion"-type refinements guarantee only a unique separating equilibrium with two types. However, stronger belief refinements can ensure that there exist only separating equilibria in which mediocre entrepreneurs use $\gamma_M(q)$. An example is the concept of "Universal Divinity" (Cho and Sobel 1990). Rather than introducing a new belief condition, in this section, I focus on the class of separating equilibria with repayments by mediocre entrepreneurs given by $\gamma_M(q)$. See the Online Appendix for a discussion about why such a restriction is reasonable. Also, see the Online

Solving for $\gamma_M$ and $\gamma_G$, we have

$$\gamma_\theta(q) = \frac{q - A_B}{\eta_\theta - \eta_B}, \ for\ \theta \in \{M, G\}. \tag{32}$$

As in the two-type case, both $\gamma_M$ and $\gamma_G$ are strictly increasing in $q$. Additionally, $\gamma_M(q) > \gamma_G(q)$. These repayments correspond to the following down payments per unit of land,

$$\zeta_\theta(q) = \frac{\eta_B}{\eta_\theta - \eta_B}\left(\frac{A_\theta}{q} - 1\right), \ for\ \theta \in \{M, G\}. \tag{33}$$

Again, $\zeta_M$ and $\zeta_G$ are decreasing in $q$, for $q \in (A_B, A_M)$. In addition, $\zeta_M(q) < \zeta_G(q)$. Therefore, as in the two-type case, a higher price of land increases the face value of debt and decreases the down payments of creditworthy entrepreneurs. These effects are a manifestation of the debt quality channel, and the intuition for them was extensively discussed in Section 3.2.

The new insight, relative to the two-type case, is that among the creditworthy entrepreneurs, the type with a lower repayment probability borrows with a higher promised repayment and has higher leverage. Intuitively, a good entrepreneur has a higher probability of success, so he obtains a larger loan for the same face value of debt than a mediocre entrepreneur. Therefore, a bad entrepreneur obtains a larger implicit subsidy by pooling with a good entrepreneur than by pooling with a mediocre entrepreneur. Put differently, the asymmetric information problem is more severe for a good entrepreneur than for a mediocre entrepreneur. Therefore, to separate on debt issuance, a good entrepreneur has to use *more* of his own funds (and thus borrow with a lower face-value debt) than does a mediocre entrepreneur. The difference in the face value of debt issued by mediocre and good entrepreneurs is sufficiently large, so that down payments also are lower for mediocre entrepreneurs, despite the lower price of debt.

Given a price of land of $q < A_M$, it follows that both creditworthy entrepreneur types (i.e., the good and the mediocre types) use all of their net worth to invest in land. Using the down payment conditions (33) and aggregating across entrepreneurs give the following land demand functions for each type

$$L_\theta^E = \frac{\phi_\theta e^E}{q\zeta_\theta(q)}, \ for\ \theta \in \{M, G\}. \tag{34}$$

Appendix for a discussion of pooling and semi-separating equilibria in that case.

By combining these leads to the total entrepreneurial demand for land, I obtain

$$L^E = \sum_{\theta \in \{M,G\}} L^E_\theta = \sum_{\theta \in \{M,G\}} \frac{\eta_\theta - \eta_B}{\eta_B} \frac{\phi_\theta e^E}{A_\theta - q}. \tag{35}$$

An interior equilibrium with repayments by entrepreneurs given by $\gamma_M$ and $\gamma_G$ is determined by the intersection of condition (35) and the residual supply curve (20), for values of $L^E \in (0,1)$.[18]

Since the debt quality channel operates even in the environment with three types, an amplification result similar to that for the two-type case continues to hold, as I show in Proposition 12 in the Online Appendix. The intuition for the amplification effect – reallocation of land from consumers towards entrepreneurs who have higher productivity – is the same as before.

In addition to the amplification effects and the aggregate comovements, richer heterogeneity among creditworthy types leads to a new type of compositional effect. To show this effect, define $\mathcal{L}_M \equiv D_{\eta_M}(\gamma_M) L^E_M$ (resp. $\mathcal{L}_G$) as the volume of credit to mediocre (good) entrepreneurs. Consider the share of credit extended to mediocre entrepreneurs,

$$\frac{\mathcal{L}_M}{\mathcal{L}} = \frac{D_{\eta_M}(\gamma_M) L^E_M}{D_{\eta_M}(\gamma_M) L^E_M + D_{\eta_G}(\gamma_G) L^E_G}. \tag{36}$$

One can show that $\frac{\mathcal{L}_M}{\mathcal{L}}$ is an increasing function of $q$. Therefore, as the price of land increases, relatively more credit is extended to borrowers of relatively *lower* quality among the creditworthy borrowers in the economy. Not surprisingly, given these compositional effects, the average probability of repayment for the aggregate stock of debt

$$\overline{\eta} \equiv \frac{\eta_M L^E_M + \eta_G L^E_G}{L^E_M + L^E_G} \tag{37}$$

declines in $q$. Finally, credit volume to mediocre entrepreneurs has a higher relative response to changes in the price of land. The following Proposition summarizes these observations for the credit market in terms of equilibrium responses to exogenous shocks.

**Proposition 6.** *A shock to productivity $Z$ induces the following equilibrium effects on the credit market:*

[18] Proposition 10 in the Online Appendix shows this result. Also, Proposition 11 provides sufficient conditions for the existence and uniqueness of an interior equilibrium among the class of separating equilibria with repayments by mediocre entrepreneurs given by $\gamma_M(q)$.

1. *(credit boom)* $\frac{\partial \mathcal{L}}{\partial Z} > 0$

2. *(procyclical leverage)* $\frac{\partial \zeta_M}{\partial Z} < 0$ *and* $\frac{\partial \zeta_G}{\partial Z} < 0$

3. *(relaxed lending standards)* $\frac{\partial}{\partial Z}\left(\frac{\mathcal{L}_M}{\mathcal{L}}\right) > 0$

4. *(lower repayment probability)* $\frac{\partial \overline{\eta}}{\partial Z} < 0$

5. *(differential sensitivity)* $\frac{\partial \log \mathcal{L}_M}{\partial Z} > \frac{\partial \log \mathcal{L}_G}{\partial Z}$

*Proof.* See Appendix. ∎

This compositional effect arises because mediocre and good entrepreneurs face an asymmetric information problem of different severity when borrowing. Specifically, since mediocre entrepreneurs use down payments lower than those used by good entrepreneurs, they are also more dependent on external financing in equilibrium. Thus, the debt quality channel is stronger for mediocre entrepreneurs than for good entrepreneurs, so that a change in the asset price, $q$ (for example, due to a shock to $Z$), has a stronger effect on the former group's demand for land and credit volume.

# 5 Empirical Relevance

The model is consistent with a number of stylized facts about the cyclical behavior of credit markets and cross-sectional differences between borrowers of different quality.

*1. Credit and asset price booms.* The debt quality channel leads to a positive comovement between aggregate output, asset prices, and credit volume. It also leads to an amplified asset price response to aggregate shocks. These comovements, combined with the strong asset price response, are consistent with the main stylized facts on credit booms and asset market volatility in both developing and developed economies, as documented by Gourinchas, Valdés, and Landerretche (2001), Schneider and Tornell (2004), and Mendoza and Terrones (2008), among others.

*2. Procyclical leverage.* The debt quality channel also leads to a positive comovement of aggregate output and individual leverage ratios. This comovement is consistent with evidence from Covas and Den Haan (2011) on the procyclicality of debt issuance and changes in firm assets. The cyclical coefficients that the authors estimate for these variables suggest that firm debt-asset ratios (and hence, leverage ratios) are procyclical. To show this directly, I extend their empirical results and examine the cyclicality of firm leverage. I focus on the same annual Compustat selection of firms (which excludes financial firms and utilities), but do so for the period 1971–2014. Figure 2 plots changes in firm debt-asset ratios (averaged across firms), together with the cyclical component of GDP of the corporate sector. The contemporaneous correlation between the two series is 0.46.

[Figure 2 here]

*3. Differential sensitivity of credit volume.* Proposition 6 shows that credit volume to lower-quality borrowers should be more sensitive to aggregate shocks than is credit volume to higher-quality borrowers. This prediction is consistent with the time-series behavior of debt issuance for different quality borrowers, as illustrated in Figure 3. The figure plots the (log) growth of new corporate bond issuance from 1980 to 2014.[19] As the figure shows, lower quality borrowers, such as high-yield firms, experienced substantially more powerful credit cycles compared with higher quality borrowers, such as investment-grade companies.

[Figure 3 here]

*4. Lending standards.* According to Proposition 6, periods of aggregate credit market expansion should be associated with a relaxation in lending standards, in the sense that the share of credit to lower quality borrowers increases. In addition, credit extended in those periods should have a lower average repayment probability. This prediction is consistent with a number of empirical studies documenting the countercyclicality in lending standards or procyclicality in "risk taking" by lenders (Asea and Blomberg 1998; Lown and Morgan 2006; Jimenez and Saurina 2006; Maddaloni and Peydro 2011; Dell'Ariccia, Igan, and Laeven 2012).[20]

[19]The large drop in 1989-1990 in the High Yield series reflects the collapse of the high-yield bond market after the savings and loan crisis.

[20]Greenwood and Hanson (2013) show that the credit quality of corporate bond issuers is also countercyclical. Other papers have also studied theoretically the cyclicality of lending standards (e.g., Rajan 1994; Berger and Udell 2004; Dell'Ariccia and Marquez 2006; Martin 2008). Dell'Ariccia and Marquez (2006) also study lending standards in a model of asymmetric information. However, in that model, lending standards change because of a switch from a separating to a pooling equilibrium in response to an exogenous shock. Martin (2008) studies a model of endogenous cycles in lending standards, again, due to switches between a separating and a pooling regime. In contrast to these papers, in my model fluctuations in lending standards take place in a separating equilibrium. Finally, behavioral explanations such as belief extrapolation (Barberis et al. 2015) can also lead to procyclical lending standards.

*5. Cross-sectional differences.* Finally, as discussed in Section 4, the model predicts that lower squality borrowers (mediocre entrepreneurs) should borrow with a lower down payment than do higher quality borrowers (good entrepreneurs) and thus should have higher leverage. In addition, given separation in equilibrium, lower quality borrowers should also borrow at a higher interest rate than higher quality borrowers.[21] This is consistent with a number of empirical studies (Deng, Quigley, and Van Order 2000 and Lam, Dunsky, and Kelly 2013 for mortgage markets; Einav, Jenkins, and Levin 2012 for the auto loans market).

# 6 Concluding Comments

I studied the interaction between asset prices and asymmetric information in credit markets and identified an important new effect of asset prices on credit markets: a debt quality channel. Asset prices affect credit markets by influencing the incentives of bad borrowers to pool with higher quality borrowers and, from there, the equilibrium down payment and leverage that borrowers use. The higher the asset price, the less willing are bad borrowers to pool with good borrowers and the lower the equilibrium down payment. This interaction can amplify aggregate shocks and create a positive comovement between output, asset prices, and leverage.

From a policy perspective, the fact that asset prices affect down payments and the leverage of individual borrowers suggests a pecuniary externality that agents fail to internalize when making their private asset demand decisions. A prediction of my model is that instability, in the sense of a stronger response of equilibrium prices to shocks, increases with equilibrium leverage. Nevertheless, regulation that lowers equilibrium leverage, and thus ensures asset price stability, may have a negative effect on aggregate output, since it would move productive entrepreneurs even further away from their optimal scale.

Additionally, in a dynamic macroeconomic environment, the debt quality channel may have important interactions with a collateral-channel-type mechanism. The combination of my intratemporal mechanism with the intertemporal collateral channel may lead to powerful amplification effects

[21] In the model, the price of a $\gamma-$debt contract and the interest rate on that debt are related via $r(\gamma) = \frac{\gamma}{D(\gamma)} - 1$, since the promise to deliver $\gamma$ at $t = 1$ has a $t = 0$ value of $D(\gamma)$. Since mediocre entrepreneurs face a lower price of their debt, they also face a higher interest rate. Other models that feature similar cross-sectional predictions due to asymmetric information on repayment probabilities and borrower sorting include Brueckner (2000) (for the case of mortgage market) and Einav, Jenkins, and Levin (2012) (for auto loans). However, these papers do not explore general equilibrium effects when the price of the underlying physical asset is determined endogenously.

of financial frictions. Exploring both of these issues is important for future research.

## Appendix

I first show a set of lemmas, which I later use for equilibrium characterization. First, I show that given the assumption on the production function of consumers from Section 2.1, type $\theta_0$ entrepreneurs never invest in a separating equilibrium.

**Lemma 2.** *Type $\theta_0$ entrepreneurs never invest in a separating equilibrium of this economy.*

*Proof.* Suppose toward a contradiction that a $\theta_0$-type entrepreneur does invest in a separating equilibrium and let $\gamma_{\theta_0}$ be the face value of debt that that type issues. Therefore, $D\left(\gamma_{\theta_0}\right) = \eta_{\theta_0}\gamma_{\theta_0}$ and $\overline{R}_{\theta_0} = R_{\theta_0}\left(\gamma_{\theta_0}, q, D\left(\gamma_{\theta_0}\right)\right) = \frac{A_{\theta_0} - \eta_{\theta_0}\gamma_{\theta_0}}{q - \eta_{\theta_0}\gamma_{\theta_0}}$. However, given the consumer's technology $q > A_{\theta_0}$ in any equilibrium of this economy. This, however, means that $\overline{R}_{\theta_0} < 1$, which by Lemma 1 implies that the $\theta_0$-type entrepreneur does not invest in land - a contradiction. ■

Next, I summarize several important properties of $R_\theta\left(\gamma, q, D\left(\gamma\right)\right)$.

**Lemma 3.** *For $\theta \in \Theta$, $R_\theta\left(\gamma, q, D\right)$ is decreasing in $q$ and increasing in $D$. Additionally, suppose that $D\left(\gamma\right) = D_{\tilde{\eta}}\left(\gamma\right) = \tilde{\eta}\gamma$, $\forall\gamma$. Then, $R_\theta\left(\gamma, q, D_{\tilde{\eta}}\left(\gamma\right)\right)$ is (weakly) decreasing in $\gamma$, iff $\tilde{\eta}S \leq q$.*

*Proof.* It is immediate that $\frac{\partial R_\theta}{\partial q} < 0$ and $\frac{\partial R_\theta}{\partial D(\gamma)} > 0$, $\forall\gamma$. To show the last statement, note that for $D_{\tilde{\eta}}\left(\gamma\right) = \tilde{\eta}\gamma$,

$$R_\theta\left(\gamma, q, D_{\tilde{\eta}}\left(\gamma\right)\right) = \frac{A_\theta - \eta_\theta\gamma}{q - \tilde{\eta}\gamma}.$$

Therefore, $\frac{\partial R_\theta}{\partial \gamma} \leq 0$ iff $\tilde{\eta}S \leq q$ and $\frac{\partial R_\theta}{\partial \gamma} > 0$ iff $\tilde{\eta}S > q$. ■

Finally, I make the following observation regarding what constitutes a profitable deviation for a type-$\theta$ entrepreneur.

**Lemma 4.** *Let $v_\theta$ be the (candidate) equilibrium shadow value of net worth for an entrepreneur of type $\theta$, and let $\hat{D}\left(\gamma\right)$, for some $\gamma \in [0, S]$, denote an alternative price of $\gamma-$debt. If $R_\theta\left(\gamma, q, \hat{D}\left(\gamma\right)\right) > v_\theta$, then given the alternative debt price, an entrepreneur of type $\theta$ is strictly better off investing all net worth in land and issuing debt with face value $\gamma$, compared to his (candidate) equilibrium leverage and scale decision.*

*Proof.* Showing this follows from a comparison of the entrepreneur's maximized payoff given his equilibrium actions, which by Lemma 1 is $V_\theta^E = v_\theta e^E$, and the payoff he achieves if he deviates, which is $\hat{V}_\theta^E = R_\theta\left(\gamma, q, \hat{D}(\gamma)\right) e^E$. Then, $R_\theta\left(\gamma, q, \hat{D}(\gamma)\right) > v_\theta$ immediately implies that $\hat{V}_\theta^E > V_\theta^E$. ■

Lemma 4 shows that comparing the equilibrium shadow value of net worth and the expected return on equity in case of deviation is sufficient for determining if an entrepreneur has an incentive to deviate from his (candidate) equilibrium action.

**Proof of Lemma 1.** The results follow directly from the optimization problem of the entrepreneur. Let $v$ be the Lagrange multiplier on the budget constraint and $\kappa_c$, and $\kappa_\gamma$ be the multipliers on the corresponding inequality constraints. Taking first order conditions (which are necessary and sufficient because of linearity), we have:

$$c_0^E: \quad 1 - v + \kappa_c = 0,$$

$$L^E(\gamma): \quad Pr(a > \gamma|\theta^i)E[a - \gamma|a > \gamma, \theta^i] - v(q - D(\gamma)) + \kappa_\gamma = 0 \;\; \gamma \in [0, S].$$

The first condition implies that, $v \geq 1$. The second condition can be rewritten as

$$\left(Pr\left(a > \gamma|\theta\right) E\left[\frac{a - \gamma}{q - D(\gamma)}|a > \gamma, \theta\right] - v + \frac{\kappa_\gamma}{q - D(\gamma)}\right) = 0,$$

or

$$\left(R_\theta\left(\gamma, q, D(\gamma)\right) - v + \frac{\kappa_\gamma}{q - D(\gamma)}\right) = 0.$$

Then, $\overline{R}_\theta < 1$ implies that $R_\theta\left(\gamma; q, D(\gamma)\right) < 1$, for $\gamma \in [0, S]$ and so $l^E(\gamma) = 0$, for $\gamma \in [0, S]$. Similarly, $\overline{R}_\theta > 1$ implies that $R_\theta\left(\gamma; q, D(\gamma)\right) > 1$, for some $\gamma \in [0, S]$ and so $v > 1$, which implies that $\kappa_c > 0$ and $c_0 = 0$. Finally, $\overline{R}_\theta \geq 1$ implies that $l^E(\gamma) \geq 0$, for $\gamma$ s.t. $R_\theta\left(\gamma; q, D(\gamma)\right) \geq 1$.

Finally, note that $v_\theta = \max\left\{1, \overline{R}_\theta\right\}$ is the shadow value of wealth for an entrepreneur given his type and prices, so $V_\theta^E = v_\theta e^E$. That an entrepreneur does not issue debt with face value $\gamma$, such that $R_\theta\left(\gamma, q, D(\gamma)\right) < v_\theta$ follows from observing that by the definition of $v_\theta$ and $\overline{R}_\theta$,

$V_{\theta}^{E} = v_{\theta} e^{E} \geq \overline{R}_{\theta} e^{E} > R_{\theta}\left(\gamma, q, D(\gamma)\right) e^{E}.$ ■

**Proof of Proposition 1.** By Lemma 2, in any separating equilibrium, a bad entrepreneur does not invest, so by Lemma 1,

$$\overline{R}_{B}\left(\gamma, q, D_{\eta_{B}}\left(\gamma\right)\right) \leq v_{B} = 1,\ \gamma \in \left[0, S\right]. \tag{38}$$

Next, by Lemma 3,

$$R_{B}\left(\gamma, q, D_{\eta_{G}}\left(\gamma\right)\right) > 1 = v_{B},\ \gamma > \gamma_{G}\left(q\right). \tag{39}$$

Therefore, for $q < A_{G}$, there cannot exist a separating equilibrium with face value of debt $\tilde{\gamma} > \gamma_{G}\left(q\right)$.

Suppose that there is a separating equilibrium with land price $q < A_{G}$, in which good entrepreneurs issue debt with face value $\tilde{\gamma} < \gamma_{G}\left(q\right)$ and debt with face value $\gamma^{'} \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right)$ is not traded. From the definition of $\gamma_{G}$ and by Lemma 3,

$$v_{B} = 1 = R_{B}\left(\gamma_{G}, q, D_{\eta_{G}}\left(\gamma_{G}\right)\right) > R_{B}\left(\gamma^{'}, q, D_{\eta_{G}}\left(\gamma^{'}\right)\right),\ \gamma^{'} \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right). \tag{40}$$

Therefore, for lenders' beliefs to satisfy (BC) it must be the case that $D\left(\gamma^{'}\right) = D_{\eta_{G}}\left(\gamma^{'}\right)$, for $\gamma^{'} \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right)$. However, again by Lemma 3,

$$R_{G}\left(\tilde{\gamma}, q, D_{\eta_{G}}\left(\tilde{\gamma}\right)\right) < R_{G}\left(\gamma^{'}, q, D_{\eta_{G}}\left(\gamma^{'}\right)\right),\ \gamma^{'} \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right). \tag{41}$$

Nevertheless, by Lemma 4, for $\hat{D}\left(\gamma^{'}\right) = D_{\eta_{G}}\left(\gamma^{'}\right)$, good entrepreneurs would be strictly better off deviating and issuing any debt with face value $\gamma^{'} \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right)$. This, however, contradicts the assumption that any debt with face value $\gamma' \in \left(\tilde{\gamma}, \gamma_{G}\left(q\right)\right)$ is not traded. ■

**Proof of Proposition 2.** Statement 1 follows from the discussion preceding the proposition.

To show statement 2, observe that for $\tilde{q} = A_{G} - \frac{\eta_{G} - \eta_{B}}{\eta_{B}} \phi e^{E}$, we have that

$$1 = \frac{\phi e^{E}}{\tilde{q} \zeta_{G}\left(\tilde{q}\right)}. \tag{42}$$

Then, whenever $\tilde{q} > Zh'\left(0\right)$, $\tilde{q}$ is consistent with a market clearing condition, in which good entrepreneurs demand $L^E = 1$ and consumers demand $L^C = 0$. In that equilibrium good entrepreneurs issue debt with face value $\gamma_G(\tilde{q})$.

To show statement 3, observe that at $q = A_G$,

$$R_B(\gamma, q, D_{\eta_G}(\gamma)) = \frac{A_B - \eta_B \gamma}{A_G - \eta_G \gamma} = \frac{\eta_B}{\eta_G} < 1, \tag{43}$$

for $\gamma < S$.[22] Therefore, bad entrepreneurs do not invest in land irrespective of the price of debt of any face value. Additionally, at $q = A_G$, $q > Zh'(0)$, so consumers do not find it profitable to operate their backyard technology and $L^C = 0$. It follows that $L^E = 1$ and good entrepreneurs demand all of the land in the economy. The face value of debt issued in equilibrium satisfies

$$\gamma \geq \max\left\{\frac{A_G - \phi e^E}{\eta_G}, 0\right\}, \tag{44}$$

that is $\gamma$ is the smallest face value of debt which good entrepreneurs can issue so that $L^E = 1$.

Finally, statement 4 follows from Proposition 1. ■

**Proof of Proposition 3.** The interior equilibrium price and land holdings of good entrepreneurs, $(q, L^E)$, are given by the solution to equations (20) and (18). By Proposition 2 any solution to this system constitutes an equilibrium. To see that the system has at least one solution, it is sufficient to substitute for $L^E$ from (18) into (20) and consider a single equation in $q$, i.e.

$$Zh'\left(1 - \frac{\phi e^E}{\frac{\eta_B}{\eta_G - \eta_B}(A_G - q)}\right) = q. \tag{45}$$

Note that at $q = A_B$, the left-hand side is $Zh'\left(1 - \frac{\phi e^E}{A_B}\right) > Zh'(1) > A_B$, for $Z \in \mathcal{Z}$. Similarly, by (21), at $q = \tilde{q} = A_G - \frac{\eta_G - \eta_B}{\eta_B}\phi e^E$, the left-hand side of (45) is $Zh'(0) < A_G - \frac{\eta_G - \eta_B}{\eta_B}\phi e^E$. Since the left-hand side is continuous in $q$, it follows that there is a value of $q \in \left(A_B, A_G - \frac{\eta_G - \eta_B}{\eta_B}\phi e^E\right)$ that solves equation (45). Furthermore, note that the slope of the left-hand side of equation (45) is given by

$$-Zh''\left(1 - \frac{\phi e^E}{\frac{\eta_B}{\eta_G - \eta_B}(A_G - q)}\right)\frac{\phi e^E}{\frac{\eta_B}{\eta_G - \eta_B}(A_G - q)}\frac{1}{A_G - q}. \tag{46}$$

[22] Also, $\lim_{\gamma \to S} R_B(\gamma, q, D_{\eta_G}(\gamma)) = \frac{\eta_B}{\eta_G}$.

Since $\frac{\phi e^E}{\frac{\eta_B}{\eta_G-\eta_B}(A_G-q)} \leq 1$, for $q \in \left(A_B, A_G - \frac{\eta_G-\eta_B}{\eta_B}\phi e^E\right)$, and given condition (22), it follows that

$$-Zh''\left(1-\frac{\phi e^E}{\frac{\eta_B}{\eta_G-\eta_B}(A_G-q)}\right)\frac{\phi e^E}{\frac{\eta_B}{\eta_G-\eta_B}(A_G-q)}\frac{1}{A_G-q} < 1,$$

for $q \leq A_G - \frac{\eta_G-\eta_B}{\eta_B}\phi e^E$. Therefore,

$$Zh'\left(1-\frac{\phi e^E}{\frac{\eta_B}{\eta_G-\eta_B}(A_G-q)}\right) - q \tag{47}$$

is monotone in $q$ for $q \in \left(A_B, A_G - \frac{\eta_G-\eta_B}{\eta_B}\phi e^E\right)$, and so (45) has a unique solution. ■

**Proof of Proposition 4.** Substituting for $L^E$ from equation (18) into equation (20) and using the Implicit Function Theorem, we have that

$$\frac{\partial q}{\partial Z} = \frac{h'\left(1-L^E\right)}{1+Zh''\left(1-L^E\right)\frac{\partial L^E}{\partial q}},$$

where

$$\frac{\partial L^E}{\partial q} = \frac{\phi e^E}{\frac{\eta_B}{\eta_G-\eta_B}(A_G-q)^2} = L^E\frac{1}{A_G-q} > 0.$$

Therefore, $1+Zh''\left(1-L^E\right)\frac{\partial L^E}{\partial q} < 1$, and so,

$$\frac{\partial \log q}{\partial \log Z} = \frac{\partial q}{\partial Z}\frac{Z}{q} = \frac{1}{1+Zh''\left(1-L^E\right)\frac{\partial L^E}{\partial q}} > 1.$$

Finally, notice that we cam re-write $\partial \log q/\partial \log Z$ as

$$\begin{aligned}\frac{\partial \log q}{\partial \log Z} &= \frac{1}{1+Zh''\left(L^C\right)\frac{\partial L^E}{\partial q}} \\ &= \frac{1}{1+\frac{Zh''(L^C)L^C}{q}\frac{L^E}{L^C}\frac{q}{A_G-q}}.\end{aligned}$$

Using the equilibrium relation $q = Zh'\left(L^C\right)$ and equations (13) and (14), we obtain

$$\begin{aligned}\frac{\partial \log q}{\partial \log Z} &= \frac{1}{1+\frac{Zh''(L^C)L^C}{Zh'(L^C)}\frac{L^E}{L^C}\lambda_G\left(q\right)\frac{\eta_B}{\eta_G-\eta_B}} \\ &= \frac{1}{1-\left|\epsilon_{h',L}\left(L^C\right)\right|\frac{L^E}{L^C}\frac{\eta_B}{\eta_G-\eta_B}\lambda_G\left(q\right)},\end{aligned}$$

where

$$\epsilon_{h',L}\left(x\right) \equiv \frac{\partial \log h'\left(x\right)}{\partial \log x}$$

is the elasticity of the marginal productivity of the consumer's technology with respect to the land holdings of consumers. ■

**Proof of Proposition 5.** Taking logs on both sides of the eq. (18) we get

$$\log L^E = \log\left(\frac{\eta_G-\eta_B}{\eta_G}\phi\right) + \log e^E - \log\left(A_G - q\right).$$

Therefore,

$$\frac{\partial \log L^E}{\partial \log e^E} = 1 + \frac{\partial q}{\partial e^E}\frac{e^E}{A_G-q} > 1 \tag{48}$$

since by equation (20)

$$\frac{\partial q}{\partial e^E} = -Zh''\left(1-L^E\right)\frac{\partial L^E}{\partial e^E} > 0.$$

■

**Proof of Proposition 6.** Statements 1 and 2 follow directly from observing that $\frac{\partial \mathcal{L}}{\partial q} > 0$, $\frac{\partial \zeta_M}{\partial q} < 0$, $\frac{\partial \zeta_g}{\partial q} < 0$ and combining those with Proposition 12 from the Online Appendix.

To show Statement 3, consider the ratio

$$\frac{\mathcal{L}_G}{\mathcal{L}_M} = \frac{\eta_G\gamma_G\phi_G\zeta_M}{\eta_M\gamma_M\phi_M\zeta_G} = \frac{\eta_G\phi_G}{\eta_M\phi_M}\frac{A_M-q}{A_G-q},$$

and notice that

$$\frac{\partial}{\partial q}\left(\frac{A_M-q}{A_G-q}\right) < 0. \tag{49}$$

Combining this with Proposition 12 and with the observation that

$$\frac{\mathcal{L}_M}{\mathcal{L}} = \frac{1}{1 + \frac{\mathcal{L}_G}{\mathcal{L}_M}}$$

is decreasing in $\frac{\mathcal{L}_G}{\mathcal{L}_M}$ gives us the result.

To show Statement 4, notice that

$$\frac{L_G^E}{L_M^E} = \frac{\frac{\phi_G}{\frac{1}{\eta_G - \eta_B}(A_G - q)}}{\frac{\phi_M}{\frac{1}{\eta_M - \eta_B}(A_M - q)}} = \frac{(\eta_G - \eta_B)\,\phi_G}{(\eta_M - \eta_B)\,\phi_M}\frac{A_M - q}{A_G - q},$$

and apply (49) and Proposition 12.

Finally, to show Statement 5, notice that

$$\begin{aligned}
\frac{\partial \log \mathcal{L}_M}{\partial Z} &= \frac{\partial \log \mathcal{L}_M}{\partial q} = \frac{\partial \log L_M^E}{\partial q} + \frac{\partial \log D_{\eta_M}(\gamma_M)}{\partial q} \\
&= \frac{1}{A_M - q} + \frac{1}{q - A_B},
\end{aligned}$$

and similarly,

$$\frac{\partial \log \mathcal{L}_G}{\partial Z} = \frac{1}{A_G - q} + \frac{1}{q - A_B}.$$

The result follows from a direct comparison and noting that $A_M < A_G$. ■

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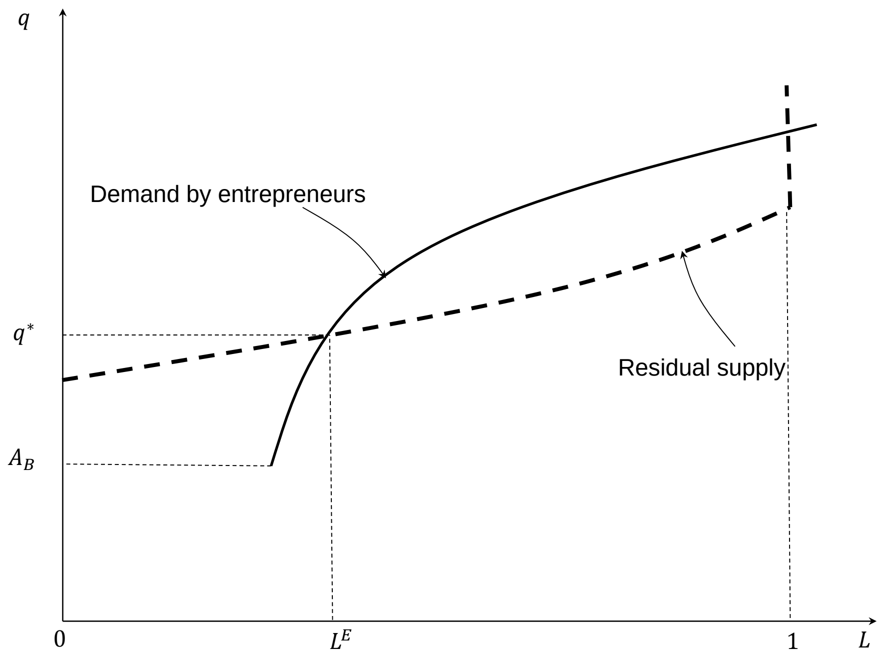


**Figure 1. Unique interior equilibrium**

The figure shows equilibrium determination in the case of a unique interior separating equilibrium.

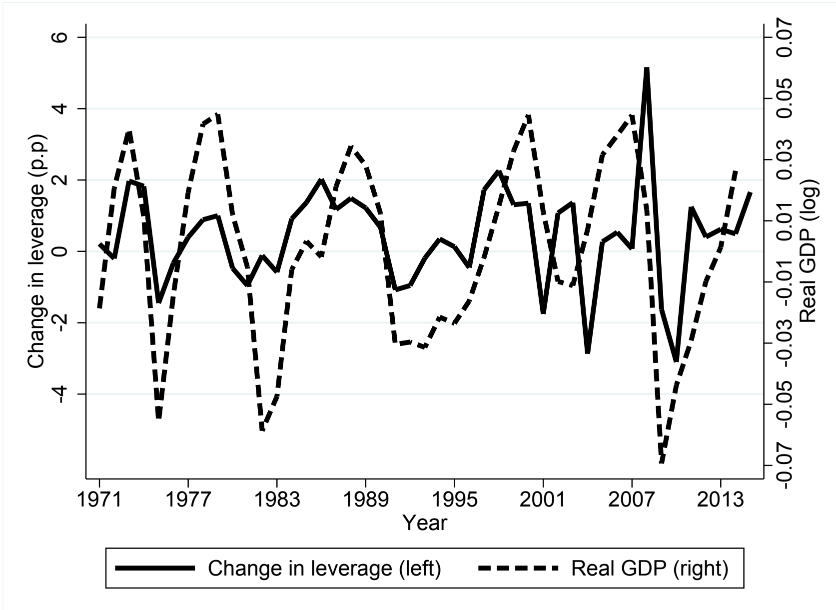


**Figure 2. Cyclicality of firm leverage, 1971–2014**

The figure plots changes in firm leverage against the cyclical component of (log) real GDP of the corporate sector. Leverage is defined as the debt-asset ratio, which is total liabilities, divided by total assets. The cyclical component of (log) real GDP of the corporate sector obtained from HP filtering with a smoothing coefficient of 100. *Sources:* Compustat and BEA.

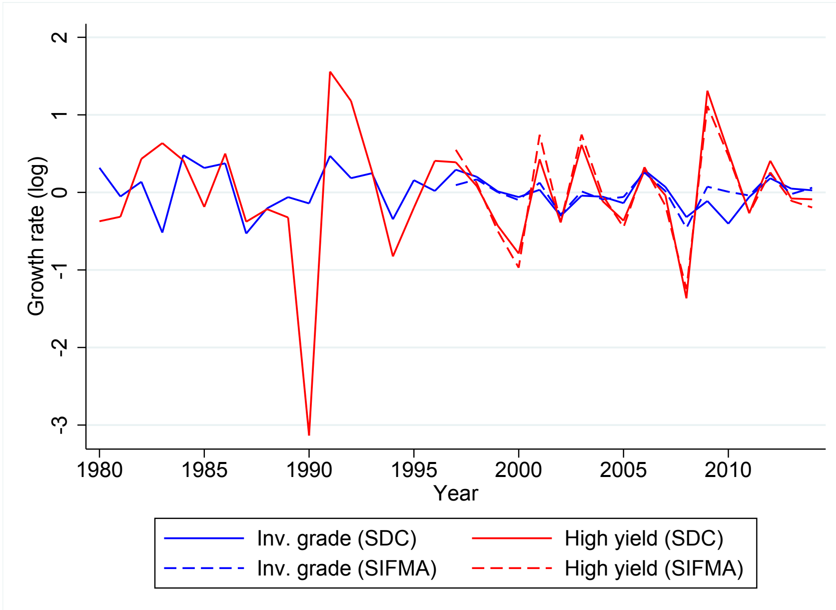


**Figure 3. Corporate bond issuance, 1980–2014**

The figure plots the (log) growth in corporate bond issuance for high-yield and investment-grade firms. "Inv. grade" refers to issuance of new bonds by investment-grade firms. "High yield" refers to issuance of new bonds by high-yield firms. The figure plots log deviations from a linear time trend. *Sources:* SDC (solid) and SIFMA (dash).