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Entrepreneurship and Government Subsidies Under Capital Constraints: A General Equilibrium Analysis

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Abstract

This paper studies the interaction of capital constraints with business formation, growth and destruction, and the policy implications of this interaction. A dynamic general equilibrium model is constructed and shown to be consistent with recent empirical findings on this subject. In the model, agents face uninsurable income risk and costly financial intermediation, and they choose to be either a worker or an entrepreneur. A calibrated version of the model is used to examine two government assistance programs: loan guarantees and grants. The main findings are that both programs can improve welfare and that grants outperform the more popular loan guarantees.

Key words: Borrowing Constraints, Costly Intermediation, Entrepreneurship, Income Subsidies, Interest Subsidies.

JEL Classifications: E44, E62.

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1 Introduction

Entrepreneurship has always occupied a special place of esteem in the United States. "A business of my own" has been the recurring dream of generations of wage earners. In 1992, over 15 million tax-payers filed Schedule C, "Profit or Loss From Business." There are about 5 million full time self-employed people if we count only heads of firms that have employees, which is more than 3 percent of the total labor force (Kirchoff 1994). The US government plays an active role in promoting entrepreneurship. Through the Small Business Administration, about $3 billion is put into the small business community annually in the form of loans and grants. A central issue that concerns economists as well as practitioners is then: should the government interfere in the capital market, and if so, which policies should the government adopt? The purpose of this paper is to provide an answer to this question. Specifically, I develop a dynamic general equilibrium model with explicit capital constraints and endogenously determined occupational choices and then use it to study the interactions of capital constraints with business creation and development, and to conduct policy experiments.

The model is consistent with the following observations documented by recent empirical analysis: (i) the probability of becoming an entrepreneur is positively correlated with an individual's ownership of assets; (ii) the probability of becoming an entrepreneur is negatively correlated with an individual's opportunities in the labor market; (iii) business investment size is positively correlated with an entrepreneur's net assets; (iv) business exit rate is negatively correlated with an entrepreneur's net assets. Two features of the model, uninsurable income risk and costly financial intermediation, contribute to this consistency. The inability to perfectly smooth consumption over time makes poor agents more risk averse and therefore less willing to bear risks and become entrepreneurs. Costly intermediation makes external finance expensive and entrepreneurship less appealing to the capital constrained.

The model is calibrated to match selected statistics in the US economy. In particular, I reproduce the labor income dynamics of households obtained from the Panel Survey of Income Dynamics (PSID) and the firm size distribution, and growth and exit rates by firm derived from the Longitudinal Research Data File (LRD). The model also captures the main patterns of firm size and exit rates with respect to age as documented by empirical studies (Dunne et al.,1989a, Peterson and Rajan 1994), and performs well in replicating the wealth and income inequalities of the US economy.

Given the empirical success of the model, I proceed to conduct two sets of policy experiments. First, I investigate the cost of income taxation with capital constraints and compare it to the case without capital constraints. Secondly, I evaluate the welfare implications of interest subsidies and income subsidies. Interest subsidies are a proxy for the popular loan guarantee programs where government subsidizes the interest payments of new entrepreneurs. Income subsidies function like government grants to new entrepreneurs. The main results can be summarized as follows: (1) using the criterion of "constant revenue," income taxes, either uniform or lump sum, are more distortionary here than in a representative agent economy without capital constraints and with complete insurance; (2) small amounts of both income subsidies and interest subsidies are welfare improving; (3) income subsidies perform better than interest subsidies in terms of social welfare and total output; (4) there exists an optimal level of income subsidies. Small amounts of government subsidies help relax the binding capital constraints new entrepreneurs face so that their entrepreneurial as well as investment decisions are less dependent on their wealth and hence their income history. However, the role of government subsidies is bounded since the marginal gains from the subsidies decrease with the subsidies while the marginal cost increases.

The rest of the paper is organized as follows. In section two I briefly review the related literature. In section three I develop the model, define equilibrium and present theoretical results. The model is calibrated to the US data in section four, and then compared to a representative agent economy in section five. In section six I conduct policy experiments. The last section concludes the paper. Appendix A contains proofs of propositions. Appendix B describes the computational method.

2 Related Literature

An extensive literature has argued that capital constraints play important roles in business creation and development. Evans and Jovanovic (1989), Evans and Leighton (1989), Holtz-Eakin, Joulfaian and Rosen (1994a, 1994b), Blanchflower and Oswald (1990)[1] analyze the relation between entry into entrepreneurship and wealth. Their results show that there is a positive correlation between the probability of becoming an entrepreneur and individuals' ownership of assets. Other authors (Carpenter, Fazzari and Peterson 1994, Hoshi, Kashyap and Scharfstein 1991) document differences across borrowers in the structure of loan contracts, and the relation of these differences to the use of internal funds. They find evidence of significant capital mar-

[1] Holtz-Eakin, Joulfaian and Rosen (1994a), Blanchflower and Oswald (1990) are particularly interesting for two reasons. First, their measure of assets is gifts and inheritances, so it is arguably exogenous to the decision to enter self-employment. Second, they find an effect of assets that is quantitatively large as well as being statistically significant.

ket imperfections even for publicly traded manufacturing companies.[2] Light (1972), Sowell (1981), Meyer (1991) and others argue that lending by formal institutions is not very important in the establishment of small businesses. Bond and Townsend (1996) also find that bank financing is little used for business start-up, which suggests that start-ups are more capital constrained than incumbent businesses.

The notion that small and start-up businesses face special problems compared to large ones has long been recognized by practitioners. These special problems include: (1) small businesses suffer from a chronic shortage of own funds; (2) credit is generally more costly for small businesses to obtain compared to larger businesses, which are able in many cases to negotiate the terms of loans; (3) small businesses have - owing to high risk factors - greater difficulty in financing intangible investments (such as research, training, quality improvement, etc.) which in many cases are vital to their growth. As long ago as 1931, the Macmillan Committee in the United Kingdom pointed out the existence of these special problems. The January 1982 survey of members of the National Federation of Independent Business (NFIB) finds that 33% of the respondents rated "interest rates and financing" as the most important problem which they face as small business persons.

The belief that capital markets do not provide adequate funds for small and start-up businesses is one of the rationales for government assistance programs in many countries. Almost all OECD countries and many developing countries apply special measures and schemes which aim at improving the economic and technological environment of small and new businesses, thereby facilitating the establishment and growth of these enterprises. Though the range and importance of these provisions are markedly different across coun-

[2] Weinberg (1994) on the other hand argues that many of the differing firms' financing behavior can be explained by the life cycle of firm's development.

tries, they are influenced by similar considerations. Among them, the difficulty in raising finance, both for day-to-day operations and for investment in capital and equipment, seem to have played an especially important role in the policy discussions.

There is no consensus among economists with regard to the performance of these government programs, in part due to the lack of a standard general equilibrium model. Since the act of redistributing resources and income associated with subsidies typically introduce distortion, the consideration of the redistributive impact of a government program is incomplete without understanding any efficiency costs related to the program. A number of authors have studied the impact of agency costs or incomplete financial markets on investment (see DeMeza and Webb, 1987, 1988, 1989, Bernanke and Gertler, 1989, 1990 and papers cited in their work). For the most part, they are carried out in static or partial equilibrium frameworks that assume little aggregate distortion and concentrate largely on the impact of subsidies recipients. This paper sets up a dynamic framework to study the inherently dynamic processes of occupational choices, and business creation, growth and destruction, and to provide a quantitative as well as qualitative assessment of government policies. The role of government intervention comes from two sources. First, income redistribution alleviates the capital constraints many agents face and provides liquidity for them so that their occupational choices will be less dependent on their assets or their income history. This is reminiscent of the cross-subsidization role for government suggested by the adverse selection literature (DeMeza and Webb 1987, 1988, 1989, Smith and Stutzer 1989, and Robert Innes 1991; Gale 1991 and Lacker 1994 dispute this view). Secondly, government and private agents face different enforcement problems. Distribution of subsidies differs from lending in that the former is a one-way transfer while the latter is a two-way contractual arrangement. It is costly to enforce noncollateralized loan payment.

3 Structure of the Economy

The key features of the model are: (*i*) uninsurable income risk faced by households takes the form of idiosyncratic shocks to their labor productivity; (*ii*) occupational choices are endogenously determined; (*iii*) households are infinitely lived; (*iv*) entrepreneurs face idiosyncratic productivity shocks and (*v*) the financial market is incomplete.

The modeling of the consumption side of the economy belongs to a larger class of models with heterogenous agents whose importance has been stressed by many authors (Aiyagari 1993, Imrohoroglu 1989, Imrohoroglu and Hansen 1991 and Hugget 1993). My way of modeling the occupational choice follows Banerjee and Newman (1993). Erosa (1995) and Quadrini (1996) model occupational choices similarly. The production side of the economy extends Hopenhayn and Rogerson (1993), where firm level dynamics are generated through time varying idiosyncratic productivity shocks, and the exit of firms is determined by a sufficiently low realization of the productivity shock. The main difference here is that in addition to labor, I introduce capital as an input and the financial market is incomplete, by doing so I allow for full-fledged capital accumulation.

3.1 The Environment

3.1.1 Preferences

I consider a discrete time and infinite horizon economy. A single good is produced in each period. Capital at a given date consists of output accumulated up to that date.

There is a continuum of infinitely lived agents with unit mass. Agents maximize the expected sum of discounted utility $E\sum_{t=0}^{\infty}\beta^t U(c_t)$, where β is a subjective time discount factor, and c_t is consumption in period t. Utility function U satisfies the assumptions of monotonicity and concavity, and the Inada conditions. The latter ensures strictly positive consumptions.

In each period, an agent can be a worker or an entrepreneur. A worker faces fluctuating income caused by a stochastic labor productivity shock denoted by ε. This labor productivity shock follows a first order Markov process with transition probability $g^w(\varepsilon'|\varepsilon)$. We can view the labor productivity shock as a measure of match quality between a worker and his job. This interpretation follows Mortensen and Pissarides (1994a, 1994b). The income fluctuation is not insurable because it is not verifiable by a third party, and therefore agents cannot write contracts contingent on it. A worker also receives an entrepreneurial idea θ at each date, θ indicates the prospects of the business in the event the worker chooses to be an entrepreneur. Specifically, the business quality denoted by the productivity shock of a new entrepreneur with entrepreneurial idea θ is described by the distribution function $\nu^\theta(\varphi)$. This arrangement is meant to capture the notion that there is some sunk cost associated with entrepreneurship. At the time the occupational decision needs to be made, agents receive an imperfect signal of their business quality. A good idea implies a better distribution in the sense of first order stochastic dominance. Entrepreneurial ideas are positively correlated with labor productivity. For a new worker, the labor productivity shock and his associated entrepreneurial idea is drawn from a joint distribution $\nu^w(\varepsilon,\theta)$.

Capital in this model plays two roles: a factor input for production and a means of self insurance against fluctuating income. I restrict capital holdings to be nonnegative through the paper reflecting the need for preventing Ponzi scheme and a restraint that loans are paid back.

3.1.2 Technology

There are two technologies in the economy: a production technology and an intermediation technology.

Production Technology

Entrepreneurs use capital and labor to produce output according to production function $y = f(\varphi, k, n)$, where k is capital input, n is the efficiency units of labor employed, and φ is the firm specific productivity shock. This shock generates much of the firm level heterogeneity in the model. One reason for heterogeneity in firm-level outcomes is differences in entrepreneurial and managerial ability. These differences include the ability to identify and develop new products, to organize activity, to motivate workers, and to adapt to changing circumstances (Lucas, 1978). The shock takes values in R_+ and follows a first order Markov process described by a function $G^e(\varphi'|\varphi)$, with the interpretation that for each current value of the shock denoted by φ, $G^e(\varphi'|\varphi)$ is the distribution function for next period's value of the shock denoted by φ'. The shocks are independent across firms, but each firm's shock will evolve according to the same function G^e. The production function exhibits decreasing return to scale with respect to capital and labor. Capital depreciates at a constant rate δ when used in the production process, $0 < \delta < 1$. The production function satisfies the Inada conditions with respect to its inputs.

Intermediation Technology

In addition to the production sector, there is an intermediation sector which processes all deposits and loans. The financial market in the economy is incomplete. As in Kiyotaki and Moore (1997), a borrower can collateralize part of the loan on the nondepreciated capital after production. However, the intermediary has to spend γ units of monitoring cost for each unit of non-collateralized loan in order to keep track of the debtors so that they cannot renege on the payment (Diamond 1984). A principal virtue of this setup is its simplicity, which allows us to model the financial sector in a minimal way. This arrangement is consistent with the two main implications of the asymmetric information literature in this area, namely, there is a wedge between the price of noncollateralized external funds and the price of internal funds; the premium for external funds depends inversely on the borrower's collateralized net worth relative to the loan obligation. Empirically, it captures the feature of debts of different seniority and the fact that borrowers pay different interest premia for collateralized and non-collateralized loans as documented by Garcia-Cobos (1994).

3.1.3 Sequence of Events

There are two types of agents in the economy: entrepreneurs and workers. Their activities within a period are fully described by the following time line.

Entrepreneurs (Workers)

•beginning of date t

·information is revealed;

(project quality for entrepreneurs, labor productivity and entrepreneurial idea for workers)

·investment and employment decisions by entrepreneurs;

·production takes place;

·consumption decision is made;

·next period's occupational decision is determined.

•end of date t

Agents start each period with a predetermined occupation. They then receive shocks. In particular, workers learn about their labor productivity and the quality of their entrepreneurial ideas, entrepreneurs learn about their business qualities. Once the information is revealed, workers and entrepreneurs engage in borrowing and lending. Production takes place afterwards. At the end of the period, after output has been distributed and loans repaid, agents consume and decide their next period's occupations, i.e. whether to be an entrepreneur or a worker. Since occupational choices for next period are made before the next period shocks are revealed, agents base their decision on the end of period assets and current shocks.

An entrepreneur together with his operating project is called a firm. This one to one correspondence between a firm and an entrepreneur is motivated by the fact that the majority of small and medium firms are proprietorships and partnerships. This arrangement also corresponds well with corporations if we view the consumption of the entrepreneur as dividend distribution.

The state of an entrepreneur is determined by his business quality φ and the beginning of period assets a. The state of a worker depends on his labor productivity ε, entrepreneurial idea θ and the beginning of period assets a. I denote μ_1 to be the measure of workers over (a, ε, θ), and μ_2 to be the measure of entrepreneurs over (a, φ). The state of the economy, $\mu = \{\mu_{1,}$ $\mu_2\}$, then is a probability distribution over the different agents.

3.2 Agents' Problem

An agent's objective is to maximize his expected lifetime utility. He operates in competitive markets, hence takes prices (the interest rate and the wage rate) as given. Before describing the agents' problem, I discuss the evolution of assets.

3.2.1 Evolution of Assets

A worker's assets evolve according to

$$a_{t+1} = r_t a_t + \varepsilon_t w_t - c_t \tag{1}$$

where $(r_t - 1)a_t$ is interest earned on deposits; $\varepsilon_t w_t$ is wage income, which depends on the labor productivity level; and c_t is period t consumption.

An entrepreneur decides how much of his own assets to invest and how much to borrow. The total loan amount is split into two parts, l_t^c and l_t^n,where l_t^c denotes the collateralized amount and l_t^n denotes the non-collateralized amount. The deadweight losses caused by the extra cost associated with non-collateralized loans imply that there is a premium on internal funds (the entrepreneur's own assets), therefore, an entrepreneur will always invest his own assets first before he resorts to the financial intermediary for loans. His assets change according to

$$a_{t+1} = f(\varphi_t, k_t, n_t) - w_t n_t + (1-\delta)k_t + r_t \max\{a_t - k_t, 0\} - r_t l_t^c - (r_t+\gamma)l_t^n - c_t, \tag{2}$$

where

$$r_t l_t^c \leq (1-\delta)k_t, \tag{3}$$

$$l_t^c + l_t^n = \max(k_t - a_t, 0). \tag{4}$$

Here, k_t is capital input, n_t is labor input, $\max\{k_t - a_t, 0\}$ is total borrowed funds, and $\max\{a_t - k_t, 0\}$ is deposits by entrepreneurs whose investment is less than their assets. I assume perfect competition in intermediation. Income consists of two parts: profits from undertaking projects and interest earned on deposits. Note that production takes place within a period, which significantly simplifies the analysis.

3.2.2 Entrepreneurs' Problem

In this paper, I study stationary equilibria in which the distribution of agents over individual states is constant over time. Consequently all the aggregate variables, such as the prices of capital and labor are constant and can be treated parametrically in the optimization problem of the agent. In order to simplify notation, I omit the time index.

Define $V^e(\varphi, a)$ to be the value function of an entrepreneur whose beginning of period assets are a and productivity shock is φ. Define $V^w(\varepsilon, \theta, a)$ to be the value function of a worker with labor productivity shock ε, entrepreneurial idea θ and assets a.

An entrepreneur's problem is defined recursively as follows,

$$V^e(\varphi, a) = \max_{\{l^c, l^n, k, n, c, a', d\}} \{U(c) + \beta \max\{\int_{\varphi'} V^e(\varphi', a') g^e(\varphi'|\varphi) d\varphi', \int_{\theta}\int_{\varepsilon} V^w(\varepsilon, \theta, a')\nu^w(\varepsilon, \theta) d\varepsilon d\theta\}\} \quad (5)$$

s.t.

$$a' + c \leq \pi(\varphi, a) \quad (6)$$

$$c, a' \geq 0, \quad (7)$$

where π is the income and is defined as:

$$\pi(\varphi, a) = \max_{\{l^c, l^n, k, n\}} \{f(\varphi, k, n) - wn + (1-\delta)k - rl^c - (r+\gamma)l^n + r\max\{a-k, 0\}\}$$

s.t.

$$rl^c \leq (1-\delta)k$$

$$l^c + l^n = \max(k-a, 0)$$

Expression (6) is the budget constraint. The nonnegativity constraint (7) precludes intertemporal borrowing.[3] Since the worse that can happen to an agent next period is becoming an entrepreneur and receiving the lowest technology draw (which is normalized to zero in the analysis), this assumption is equivalent to the policy of borrowing up to the amount that the borrower will be able to repay with certainty at the end of the following period. The expected value of continuing to be an entrepreneur next period conditional on this period's productivity shock φ and beginning of next period's assets a' is $\int V^e(\varphi', a')g^e(\varphi'|\varphi)d\varphi'$, the expected value of becoming a worker is $\int\int V^w(\varepsilon, \theta, a')\nu^w(\varepsilon, \theta)d\varepsilon d\theta$. If the expected value of being an entrepreneur exceeds that of being a worker, the entrepreneur remains in business, otherwise he will become a worker next period. I denote this occupational decision by d. It takes the value of 1 if the agent chooses to be an entrepreneur and of 0 otherwise.

3.2.3 Workers' Problem

A worker's problem is defined recursively as:

[3] As opposed to intratemporal borrowing by entrepreneurs represented by l^c and l^n.

$$\begin{aligned} V^w(\varepsilon,\theta,a) &= \max_{\{c,a',d\}} \{U(c) + \beta \max\{\int_{\varphi} V^e(\varphi,a')v^{\theta}(\varphi)d\varphi, \\ & \int_{\theta'}\int_{\varepsilon'} V^w(\varepsilon',\theta',a')g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta'\}\} \end{aligned} \tag{8}$$

s.t.

$$a' + c \leq \varepsilon w + ra, \tag{9}$$

$$c, a' \geq 0. \tag{10}$$

Workers choose consumption c, next period's capital a' and next period's occupational decision d. The right hand side of expression (9) is a worker's income which consists of his wage and interest on deposits.

3.3 Definition of Equilibrium

A stationary equilibrium in this economy consists of a pair of prices (r, w), a set of decision rules $\{l^c, l^n, k, n, c, a', d\}(\varphi, a)$, $\{c, a', d\}(\varepsilon, \theta, a)$, a pair of value functions $\{V^e(\varphi, a), V^w(\varepsilon, \theta, a)\}$ and a probability measure $[\mu^e(\varphi, a), \mu^w(\varepsilon, \theta, a)]$, such that:

(1) the decision rules are generated by agents' problems (5) and (8),

(2) the labor market clears:

$$\int\int\int \varepsilon\mu^w(\varepsilon,\theta,a)d\varepsilon d\theta da = \int\int n(\varphi,a)\mu^e(\varphi,a)d\varphi da, \tag{11}$$

(3) capital market clears:

$$\begin{aligned}
&\int\int (l^c(\varphi,a) + l^n(\varphi,a))\mu^e(\varphi,a)d\varphi d \\
= &\int\int\int a\mu^w(\varepsilon,\theta,a)d\varepsilon d\theta da + \\
&\int\int \max(a-k,0)\mu^e(\varphi,a)d\varphi da, \qquad (12)
\end{aligned}$$

(4) the distribution of households $\mu = [\mu^e, \mu^w]$ is a fixed point of the mapping which describes the law of motion of the distribution of agents over the individual states. This law of motion is consistent with individual decision rules.

$$\begin{aligned}
&\mu^w(\varepsilon,\theta,a) \\
= &\int\int\int \mu^w(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})g^w(\varepsilon|\widetilde{\varepsilon})h(\theta|\widetilde{\varepsilon})1(a'(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})=a)1(d(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})=0)d\widetilde{\varepsilon}d\widetilde{\theta}d\widetilde{a} \\
&+\int\int \mu^e(\widetilde{\varphi},\widetilde{a})\nu^w(\varepsilon,\theta)1(a'(\widetilde{\varphi},\widetilde{a})=a)1(d(\widetilde{\varphi},\widetilde{a})=0)d\widetilde{\varepsilon}d\widetilde{a}, \qquad (13)
\end{aligned}$$

$$\begin{aligned}
\mu^e(\varphi,a) = &\int\int\int \mu^w(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})1(a'(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})=a)1(d(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})=1)\nu^{\widetilde{\theta}}(\varphi)d\widetilde{\varepsilon}d\widetilde{\theta}d\widetilde{a}+ \\
&\int\int \mu^e(\widetilde{\varphi},\widetilde{a})g^e(\varphi|\widetilde{\varphi})1(a'(\widetilde{\varphi},\widetilde{a})=a)1(d(\widetilde{\varphi},\widetilde{a})=1)d\widetilde{\varphi}d\widetilde{a}. \qquad (14)
\end{aligned}$$

where $1(A)$ is an index function which equals 1 if A is true and 0 otherwise., the expression $\mu^w(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})g^w(\varepsilon|\widetilde{\varepsilon})h(\theta|\widetilde{\varepsilon})1(a'(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a}) = a)1(d(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a}) = 0)$ in the right hand side of (13) is the measure of workers at state $(\widetilde{\varepsilon},\widetilde{\theta},\widetilde{a})$ who continue to be workers next period with labor shock ε, entrepreneurial idea θ and assets a; the term $\mu^e(\widetilde{\varphi},\widetilde{a})\nu^w(\varepsilon,\theta)1(a'(\widetilde{\varphi},\widetilde{a}) = a)1(d(\widetilde{\varphi},\widetilde{a}) = 0)$ is the mass of entrepreneurs at state $(\widetilde{\varphi},\widetilde{a})$ who become workers and whose next period assets are a and labor shocks are ε and entrepreneurial ideas are θ. The terms in the right hand side of expression (14) can be interpreted similarly.

3.4 Characterization of Equilibrium

In this section, I examine the behavior of agents to see if the model implications are consistent with related microeconomic evidence. In the propositions below, I will rely on the following assumptions.

Assumption 1. The distribution $\nu^{\theta}(\varphi)$ is increasing in θ in the sense of first order stochastic dominance, i.e. $\int_0^{\varphi} \nu^{\theta}(s)ds \leq \int_0^{\varphi} \nu^{\theta'}(s)ds$, for $\varphi \in [\underline{\varphi}, \overline{\varphi}]$, if $\theta \geq \theta'$.

Assumption 2. The cumulative distribution function $G^{w}(\varepsilon'|\varepsilon)$ is decreasing in ε, as is the cumulative distribution function $H(\theta|\varepsilon)$.

The first part of assumption 2 says labor endowment shocks are persistent. The second part indicates a positive correlation between labor productivity and entrepreneurial ability.

Assumption 3. The cumulative distribution function $G^{e}(\varphi'|\varphi)$ is strictly decreasing in φ.

Assumption 3 implies that productivity shocks are persistent; those with good shocks this period are more likely to receive a good shock next period.

Assumption 4. For any $\varphi > 0$, $G(0|\varphi) > 0$; $G(0|0) = 1$.

Zero productivity corresponds to a state where no production takes place, or an exit state. Assumption 4 implies that a firm has a strictly positive probability of failing at any time. This is a stronger version of the usual assumption that guarantees a finite life span of firm and therefore ensures the existence of an ergodic set.

In equilibrium, there will be a positive measure of both entrepreneurs and workers because the marginal product of each input to production is infinite when the input is zero (we can rewrite the production function so that entrepreneurial ability is an input to the production as well).

Proposition 1. Entrepreneurs with higher assets invest more in their businesses and pay a lower effective interest rate on their loans.

The effective interest rate is the average interest rate a borrower pays on his loans including collateralized as well as noncollateralized loans. The intuition of Proposition 1 is straightforward. Entrepreneurs with more assets will be able to borrow more collateralized loans, therefore the cost associated with external finance are smaller for them. Comparing two entrepreneurs with the same productivity shock, the one with higher assets will invest more in his business, and he pays a lower average interest rate on his loans. These results are consistent with the findings in Garcia-Cobos (1994) and Holtz-Eakin, Joulfaian and Rosen (1994a).

Proposition 2. There exists a threshold labor ability level $\varepsilon^*(a, \theta)$ such that a worker with labor productivity shock ε and entrepreneurial idea θ will become an entrepreneur if his labor ability is below this level, otherwise he remains to be a worker. Likewise, there exists a cutoff level of the quality of entrepreneurial idea $\theta^*(\varepsilon, a)$ such that a worker at state (a, ε, θ) will become an entrepreneur if his entrepreneurial idea has a higher quality than this cutoff level. Moreover, there exists a reservation business productivity level $\varphi^*(a)$ such that an entrepreneur will continue his business if it is of a higher quality than the cutoff level, or he will exit and become a worker.

Proposition 2 says that there is a continuum of people who become entrepreneurs depending on their entrepreneurial idea, labor productivity and asset holding. At the extremes, there are those with good entrepreneurial ideas ("super stars") and those with low labor productivity (often labeled as "misfits" by sociologists). This is a very interesting phenomenon. In Evans and Leighton (1989), one of the key findings is that unemployed workers, lower paid wage workers, and men who have changed jobs a lot are more likely to enter self-employment or to be self-employed at a point in time, all else equal. Townsend and Bond (1996) report similar findings. The anecdotal evidence about the history of Chinese and Japanese immigrants to the US in Light (1972) also supports this finding. The last part of Proposition 2 says good quality firms will survive, everything else the same.

Proposition 3. $\mathbf{r} < \mathbf{1}/\beta$.

Aiyagari (1994) has illustrated how the presence of borrowing constraints in a model with heterogeneous agents leads to oversavings in the sense that equilibrium interest rate lies below the rate of time preference. Proposition 3 says this continues to hold for this economy despite the introduction of entrepreneurship.

Under additional assumptions on the stochastic process of labor productivity, entrepreneurial idea and business quality that requires the income stream from working second order stochastic dominates the income stream from being an entrepreneur, agents' occupational decisions are described by Proposition 4.

Proposition 4. There exists a reservation asset level $\mathbf{a}^*(\varepsilon, \theta)$ such that a worker with labor productivity shock ε and entrepreneurial idea θ will become an entrepreneur if his asset holding is above this reservation level. Moreover, $a^*(\varepsilon, \theta)$ decreases in θ and increases in ε. Similarly, there exists a threshold asset level $\widehat{a}(\varphi)$ decreasing in φ, such that entrepreneurs with productivity shock φ will continue to run their businesses if their assets exceed $\widehat{a}(\varphi)$, and they will exit

otherwise.

Then the above results suggest a positive correlation between the probability of becoming an entrepreneur and the agent's asset holdings, which is consistent with the empirical literature. Holtz-Eakin, Joulfaian and Rosen (1994a) analyze a matched sample of federal estate and personal income tax returns and find that as the size of the inheritance increases, so does the probability of becoming an entrepreneur. Blanchflower and Oswald (1990), Evans and Jovanovic (1989) also find similar results. Holtz-Eakin, Joulfaian and Rosen (1994b) find that liquidity constraints exert noticeable influence on the viability of entrepreneurial enterprises. Dunne, Roberts and Samuelson (1989) who study 200,000 plants that entered the US manufacturing sector in the 1967-1977 period also find that plant failure rates decline with size and age. In my simulation, I will not impose restrictions on the productivity shocks and its transition process. Instead I calibrate them to the data and demonstrate that the model generates results that are consistent with the empirical observations.

4 Computing an Equilibrium

4.1 Parameterization

Five sets of parameters need to be calibrated. These parameters are related to (*i*) agents' preferences; (*ii*) agents' labor productivity; (*iii*) production technology; (*iv*) productivity shock process and (*v*) intermediation technology. One period is assumed to be five years. There are two reasons for this choice. First, I use the Census of Manufactures data set to calibrate my productivity process, and the time interval of this data set is five years. Second, a time period of this length eases the computational burden significantly.

Preferences

Preferences are of the standard form:

$$U(c) = \frac{c^{1-\sigma}}{1-\sigma},$$

where σ is the relative risk aversion. It takes a value of 2 which is within the range for this parameter that has been used in the literature. Time discount rate β is chosen so that the annual deposit interest rate is about 4%.

Labor Productivity

The stochastic process for labor productivity shock ε is approximated by the stochastic process of labor income. I use the Panel Survey of Income Dynamics for the approximation.[4] The natural logarithm of labor income is assumed to be a first-order, autoregressive process with a serial correlation coefficient ρ and a standard deviation η. Equation (15) below describes the stochastic process of labor income,

$$\log(y_t) = \rho \log(y_{t-1}) + \eta(1-\rho^2)^{1/2}\varepsilon_t, \quad \varepsilon_t \sim \text{Normal } (0,1) \tag{15}$$

I use the procedure described in Tauchen (1986) to approximate the autoregression with a first-order Markov chain that has two states. Thus the parameters for the Markov process are the values for the two states and a probability transition matrix that I denote by Π_ε. The values of η and ρ are chosen from various studies of individual market earnings (see Aiyagari 1994 for a summary), these studies suggest that $\eta \in \{0.2, 0.4\}, \rho \in \{0, 0.6\}$. I choose $\eta = 0.2, \rho = 0.6$. Results reported in this paper will not change much if I choose other combinations. The correlation between entrepreneurial ideas and labor productivity is hard to measure, because the observation is truncated. I consider two extreme cases: perfect correlation and zero correlation.

[4]PSID is a national survey conducted annually on a sample of families since 1968.

In this paper, I report the results of the first case since casual observations seem to be in favor of a positive correlation between labor productivity and entrepreneurial ideas. The second specification does not change my results significantly. All the qualitative features are preserved.

Production Technology

The production function has the Cobb-Douglas form

$$f(\varphi, k, n) = A\varphi k^{\alpha} n^{\lambda},$$

where A is a scaling factor normalized to 1, α is the capital income share set to 0.3 and λ is the labor income share set to 0.62 respectively. These numbers are consistent with the observed US income shares.

For the stochastic process for the labor productivity shock φ, I use the same Tauchen (1986) procedure. I match the following statistics derived from Longitudinal Research Data File[5]: (i) serial correlation in log employment for survivors is 0.93; (ii) variance of growth rates for survivors is 0.53. A four state Markov process is used. A fifth state $\varphi = 0$ is set so that whenever it is reached, a firm will stay there forever, i.e. the firm will exit. The probabilities of going from the other four states to this state are chosen so that (i) average exit rate over a five year interval is 0.367. (ii) the average exit rate for firms with 5 to 19 employees is 0.39, 20 to 49 employees 0.347, 50 to 99 employees 0.346, 100 to 249 employees 0.291and above 250 employees 0.191.[6] The initial distribution of shock is approximated by the size distribution for firms aged $0 - 6$ years. Capital depreciation rate δ is set to 0.24, which is equivalent to an annual depreciation rate of 0.06. The annual capital to output ratio is about 3 at this depreciation rate.

[5] The LRD, housed in the Census Bureau's Center for Economic Studies, is a national sample of manufacturing establishments, consisting of a sequence of contiguous five year panels beginning in the years 1963, 1967, 1972, 1977 and 1982.

[6] Dunne et al. (1989).

Intermediation Technology

The financial sector intermediates the flow of funds to entrepreneurs at cost γ per unit for noncollateralized loans. This cost determines the difference between the interest rate on loans and the deposit rate. Diaz-Gimenez, Prescott, Alvarez and Fitzgerald (1992) report the average interest rates paid on various categories of household borrowing and lending to banks and other intermediaries for selected years. Based on these data, they calibrate the annual nominal interest spread at 5.5%. In the benchmark model, I choose 4%. I carry out sensitivity analysis to see how this value affects the results.

Table 1 summarizes my parameterization.

4.2 Equilibrium for the Benchmark Model

In this section, I present the results of my calibration given the parameter values discussed above. Appendix B contains a description of the computational method. Table 2 presents the US statistics and corresponding model statistics. Table 3 reports other related statistics. Several properties emerge.

One interesting finding concerns firms' growth rate. It is monotonically decreasing with size conditional on survival, and the unconditional expected growth rate increases initially with size and then decreases. This is consistent with the findings in Dunne, Roberts and Samuelson (1989), Davis, Haltiwanger and Schue (1993) and Hall (1987). Constrained firms will start with a suboptimal amount of capital and therefore will be smaller than unconstrained firms. As a result, constrained businesses have a greater tendency to reinvest earnings into the business than unconstrained firms since the return to capital invested in the business is higher for the constrained firms. Therefore, smaller firms will grow faster than larger ones conditional on survival. However small firms fail more frequently than larger ones. Hence the unconditional growth rates for these firms depend on the net effect of the two forces.

The statistics related to cohorts indicate two patterns: first, the probability of exit is decreasing in age, and second, the average size is increasing in age. Both of these properties have been noted by empirical work in this area (see Evans 1987b and Dunne, et al., 1989 for example).

The model also has strong implications for income and wealth inequalities. The Gini coefficients for income and wealth generated by the model are 0.57 and 0.934, respectively. In the US data, the Gini coefficient for income is about 0.4 and that for net wealth is about 0.8. Given that I have infinitely lived agents and no corporate sector, it is not surprising that my numbers are bigger.[7]

I now use the estimates to evaluate the impact of capital constraints on business start-ups. Without capital constraints, given my parameterization, workers with better entrepreneurial ideas will become entrepreneurs independent of their wealth. With capital constraints, this is no longer true. Some agents with good entrepreneurial ideas become workers due to the lack of funds, on the other hand some agents with not so good entrepreneurial ideas enter into entrepreneurship because their apple internal funds makes operating the project less expensive hence increases their net profits despite of it lower quality.

As mentioned earlier, my infinite horizon model can be interpreted as an overlapping generations model in which agents live one period and each produce one descendent who inherits his occupation and assets. Hence, an agent's beginning-of-period assets could be viewed as his inheritance. My model shows that agents with higher inheritance are more likely to be self-

[7]In Aiyagari (1994), with no entrepreueurship, liquidity constraints on the household sector generates much smaller Gini coefficients, 0.12 for net income and 0.32 for wealth.

employed. The annual wealth to output ratio for entrepreneurs is 2.41, while that for workers is 1.03. Moreover, smaller firms and firms with lower assets are more likely to fail. The average wealth of failed entrepreneurs is 81.9% of that of an average entrepreneur.

4.3 Comparative Statics Results

To gain some intuition about how the model works some comparative statics experiments are undertaken.

First, consider an increase in relative risk aversion which corresponds to a decrease in the intertemporal elasticity of substitution in consumption. Fewer agents become entrepreneurs, both income and wealth inequality increase. Average business size also increases.

A decrease in collateralized loans or an increase in the intermediation cost of noncollateralized loans increases the deadweight losses associated with external finance. Hence the capital constrained will find their projects less profitable compared with those with more assets, everything else the same. The reservation asset level for entry becomes higher while that for exit becomes lower. Table 4 reports the sensitivity analysis with respect to the intermediation cost.

Welfare here is defined as the sum of utilities of all of the agents in the economy. This utilitarian social welfare function is reasonable for several reasons. First, it can be thought of as steady-state ex-ante welfare, i.e., welfare of a typical consumer before he realizes his initial assets and shocks. Second, if we interpret the infinitely-lived agents as a family of altruistically-linked one-period-lived generations, this welfare criterion weights all the dynastic families equally. The third justification is that it has been used widely in this class of models. The welfare change is measured as the percent increase or decrease in benchmark consumption at every date and state that equates the level of welfare in the alternative case and the reference case.

To summarize the findings, as the intermediation cost increases, i.e. as the financial market becomes more rigid, fewer people will undertake their projects, average firm size rises, the economy spends more resources on monitoring, both output and welfare are lower, and the income and wealth distributions become more unequal. These findings suggest the nonlinearity of financial market rigidity effects: changes in the financial condition of firms that are well above standard requirements have a smaller effect than changes in the financial condition of firms close to the margin. Younger firms, firms with a high degree of idiosyncratic risk and firms that are not well collateralized, which are on average smaller firms, are more likely to bear additional costs due to informational frictions, and therefore are more likely to be at the margin. This is consistent with the literature that studies the role of credit market frictions in the propagation of monetary policy shocks. See Bernanke and Gertler (1996) for a recent survey of this literature. Specifically, an increase in annual per unit monitoring cost of one percentage point reduces total output by 1% and welfare by 1.38%, while a decrease in per unit monitoring cost of one percentage point increases output by 1.2% and welfare by about 1.434%.

5 The Cost of Income Taxation

The economy studied here can be compared to a similar representative agent economy where the agent receives average labor endowment and the aggregate technology has the average productivity level. In this section, I focus on the comparison of the cost of income taxation in these two environments. The purpose is to gain some understanding of the financing of government subsidies that will be studied in the next section.

I use the standard public finance "constant revenue" criterion for evaluation. Two policy regimes are studied. One is a uniform income tax, and the other is a lump sum tax. The results are reported in Table 5 and Table 6. Numbers corresponding to output, welfare and per capital assets are the percentage changes after the tax is imposed.

One common finding with these two experiments is that government fiscal policies are much more distortionary in my model than in the representative agent economy. In the uniform income tax regime, collecting 0.0186 units of revenue, which is 4.09% of the total output of my model economy, cause output to drop by 50% more in my economy than in the representative agent economy. The decline in welfare is almost twice as much as in the representative agent economy. Moreover, in my framework, a lump sum tax is distortionary. To collect the same amount of revenue, output decreases almost half as much as in the uniform income tax regime in my economy, while in the representative agent economy output is not affected. The decline in welfare is almost three times as in the representative agent economy. This is not surprising, because with capital constraints, net wealth plays an important role in agents' decisions. Any policy that affects agents' wealth will distort their decisions directly, especially for agents at the margin of becoming entrepreneurs. The distortion here has a first order effect, while in the representative agent economy, the distortion is through budget constraint which is more of second order. These results suggest that some caution must be exercised in evaluating fiscal policies in the absence of capital constraints.

Another interesting question is the effect of income taxes on entrepreneurial activity. For uniform income tax rates of 0, 0.05, 0.20 and 0.25, the corresponding percentage of entrepreneurs are $2.423, 2.479, 2.557$ and 2.576, respectively. One reason entrepreneurship increases is that with proportional income tax, rich agents pay more in absolute amount than poor agents resulting in a more even after tax income distribution. Therefore poor agents get a better chance to become entrepreneurs. Increasing the tax rate from 0 to 0.05 generates the same amount of revenue as moving from 0.20 to 0.25, yet the output and welfare distortions associated with the latter case are more evident. The percentage decline in output for the two cases are 1.095 and 1.365, respectively, and the percentage decline in welfare are 5.924 and 7.513, respectively. This indicates that the marginal cost of taxation increases with the tax rate. See Table 6.

6 Policy Analysis - - Government Subsidies

So far, I have studied the positive questions of the effects of capital constraints on the economy and the cost of income taxation with capital constraints. In this section, I use the calibrated model to answer two quantitative questions about public policies, more specifically, government income subsidies and interest subsidies. One question is concerned with determining the costs and benefits of each program and identifying the optimal level of subsidy. The other is concerned with comparing the two programs.

As discussed in the introduction, numerous countries, both developed and developing, provide public financial assistance in various forms to small firms. In this section, I choose interest subsidies and income subsidies as representative alternatives and study their effects. With interest subsidies, the government helps finance the interest cost associated with start-up entrepreneurs' loan payments. With income subsidies, a lump sum transfer is given to new entrepreneurs. The expenditures are financed by uniform income taxes in both cases.[8] Loan guarantee programs can be viewed as special cases of interest subsidies. Examples of income subsidies include the "Unemployed Entrepreneurs Program" carried out in 1979 in France, the "Entrepreneur Allowance Scheme" adopted by the British government in 1982, and the experiment conducted by US Department of Labor in 1986 to give out start-up business funds in lieu of unemployment insurance. Income subsidies function like government grants.

Before I carry out the experiments, it is useful to examine the optimal entrepreneurial decision rules in an economy without capital constraints and uninsurable income risk. This will help us understand the function of government subsidies. In an economy without capital constraints and uninsurable income risk, an individual's occupational decision is independent of his assets, as depicted by line AA' in Figure 5. Agents with good entrepreneurial ideas and/or low labor productivity become entrepreneurs. With capital constraints, agents' asset holdings also play an important role. Since workers with high labor productivity are more likely to accumulate assets independent of their entrepreneurial ideas, in equilibrium some agents with bad entrepreneurial ideas and/or high labor productivity may become entrepreneurs which is undesirable from the social point of view. BB' depicts this situation.

Government subsidies affect the welfare of the economy in five ways: who becomes an entrepreneur (extensive margin); how much entrepreneurs invest (intensive margin); the monitoring cost associated with external finance; the cost of raising revenue through distortionary taxation; and the interaction between subsidy programs and market incompleteness.

Interest subsidies directly affect the composition of new entrepreneurs. Given the same level of asset holding, good entrepreneurs, i.e. the ones

[8] Many Federal credit activities (loan subsidies and guarantees) are channeled through financial intermediaries' information capital as here.

with good entrepreneurial ideas, need to borrow more than the not-so-good entrepreneurs, and they will benefit more from the interest subsidies. Hence interest subsidies create a greater incentive for good business entries in the extensive margin. See figure 5 line CC'. However this is accomplished at a cost. Since the monitoring cost associated with external finance is entirely born by society, when new entrepreneurs make their investment decision they will borrow beyond the amount that is socially desirable. This moral hazard problem in the intensive margin will reduce the benefits of interest subsidies substantially.

On the other hand, income subsidies create a moral hazard problem at the extensive margin. The indiscriminate distribution of income subsidies to new entrepreneurs will attract individuals with bad entrepreneurial ideas but sufficient assets into entrepreneurship. Therefore such government subsidies could have a negative effect in the sense that it is pushing the "wrong people" into entrepreneurship.

Both interest subsidies and income subsidies help overcome market incompleteness because by offering a subsidy, the government makes the decision to start a new business less dependent on an agent's wealth, and therefore less dependent on the history of labor productivity shocks that a worker has confronted. However on the negative side, in anticipation of government subsidies, agents will reduce their savings, especially those who will become entrepreneurs later. The decline in aggregate saving will partly undo the positive effects of government subsidies. In addition, the distortions caused by the income taxation used to finance the government subsidies will also partially offset the positive effects of the subsidies.

In Table 7, I report the results of the experiment in which government subsidizes all of the interest costs incurred by new entrepreneurs through a flat income tax. I also compare this to an income subsidy that results in the same amount of expenditure.

A small amount of both interest subsidy and income subsidy is welfare improving. This is because both subsidies relax the binding capital constraints many entrepreneurs face, and hence improve the entrepreneurial activities in the economy. These subsidies also help ameliorate market incompleteness, making agents more able to smooth consumption over time, and hence agents' occupational decisions are less dependent on their wealth and past income history. The third reason is the different enforcement problem that the government and private lenders face. Subsidies are a one-way transfer from government to the recipients, while lending is a two-way contractual arrangement. Hence subsidies do not involve any enforcement problem, while uncollateralized debt involves the monitoring costs.

Income subsidies outperform interest subsidies in terms of social welfare and output. With interest subsidies, the government displaces private credit arrangements, while income subsidies provide more appropriate incentives for business entry. Business quality declines in both cases, but by a lesser degree in the case of interest subsidies since it is more capable of attracting good business entry.

Table 8 reports experiments with different levels of the income subsidy. The marginal gains of the subsidy decreases with its amount while the marginal cost associated with its finance increases. Hence we observe output and welfare initially increase, then decrease. Aggregate capital follows the same pattern, but starts to fall earlier than output and welfare. The inequalities in income and wealth of the economy are reduced, though not by a significant amount. Business quality declines since the business turnover rate rises as income subsidies increase. There exists an optimal level of income subsidy in terms of social welfare and aggregate output.

6.1 Government with Enforcement Technology

The role of government comes from two sources: their ability to provide some degree of insurance for private agents through income redistribution and to save intermediation cost through subsidies. For the second role, one may ask why tax collection is enforceable. This has to do with a deeper question which is how government as an institution differs from private agents. One can think of reasons why government might have better enforcement technologies than private agents: the wide reach of government agencies make the record keeping on its citizens much easier, the existence of prison which serves as a threat to tax evaders, etc. However, such an assumption favor government intervention over private contractual arrangements might be thought to artificially. In this section, I go to the other extreme and study the case in which the government faces the same enforcement problem as private agents. This exercise will separate the welfare gains from public provision of liquidity and public cost saving.

The tax here is assumed to be levied on firms before the distribution of wage and profits.[9] Just as private agents can, the government can collateralize their tax payments (which can be viewed as debt private agents owe to the government). The collateral for tax payment is what is left over of the nondepreciated capital which has not been used as collateral for bank loans. For each unit of noncollateralized tax payment, the same amount of monitoring cost is needed. This implicitly assume that tax payment is junior to debt payment. Though it is not true in reality, it does provide us with a lower bound on what government can achieve through different enforcement

[9] Firms deducting payroll tax from its wage payments is a common practice.

technology. Table 9 reports the result. About 97% of the output gain is from liquidity provision, only 3% comes from the cost saving. And about 93% of the welfare gain comes from liquidity effect, 7% is from saving on monitoring cost. In another words, the majority of the output and welfare improvement comes from the public provision of liquidity. The reason is that the monitoring cost government can save is proportional to the amount of subsidies that is required, given the latter is a relatively small number, the cost is thus also small.

7 Conclusion

There are two main contributions of this paper. The first is the development of a dynamic computable general equilibrium model where the impact of capital constraints on the inherent dynamic processes of business creation, growth and destruction are studied. This pushes the existing literature to a better understanding of financing constraints and business dynamics. The second contribution of this paper is the explicit study of government assistance programs, especially the finding that grants outperform the more popular loan guarantees.

Another important policy implication of the model concerns income distribution. A standard policy which aim at reducing income inequality is redistribute wealth from the rich to the poor. A common policy device is the taxation of inheritance. However, as I demonstrated, giving subsidies to entrepreneurs can actually reduce social inequality, contrary to this conventional wisdom. The reason is two-fold. On the one hand, subsidies relax binding capital constraints, workers have a greater incentive to become entrepreneurs, hence social mobility is greatly improved. On the other hand, subsidies, especially income subsidies, are able to reduce deadweight losses, and therefore total output increases. This policy implication is especially important for developing countries where the incompleteness of financial markets is likely to be severe.

The technical difficulty involved in solving and analyzing a particular equilibrium limits the modeling of incomplete financial market. Although it is beyond the scope of this paper, it is reasonable to conjecture that the qualitative results of this paper will survive the introduction of more complicated modeling of incomplete financial markets. The intuition is simple. As long as the return on internal funds exceeds that of external funds, we will always observe the wealth effects on firms turnover, while the channels through which interest subsidies and income subsidies affect business will remain unchanged.

The structure developed here can also be used to investigate the cost of capital constraints over the business cycle. An important issue in this literature has been to reproduce quantitatively the different responses of firms small and large to aggregate and monetary shocks. This literature treats the distribution of firm size as exogenous. Hence it is an open question whether financial market incompleteness is capable of generating these differences. With endogenously determined occupational choices and endogenously generated firm dynamics, the model developed in this paper allows for full-fledged capital accumulation and captures the asymmetric impact of capital constraints on small firms vs large firms, therefore the extension of the model to accomodate business cycles appears to be productive.

Appendix A: Proofs of Propositions

Proof of Proposition 1. Define $k^*(\varphi, a) = \arg\max_{k,l}\{f(\varphi, k, n) - rk - wl + (1-\delta)k\}$, and $k^{**}(\varphi, a) = \arg\max_{k,l}\{f(\varphi, k, n) - (r+\gamma)(r+\delta-1)/rk - wl\ \}$.

Let us denote the collateralized loan by $l^c(\varphi, a)$, the non-collateralized loan by $l^n(\varphi, a)$, total capital investment by $k(\varphi, a)$, the interest premium by $i(\varphi, a)$. It is easy to show that (for notation simplicity, I omit the state variables),

Case 1: $a \geq \frac{r+\delta-1}{r}k^*$

$l^c = \max(k^* - a, 0); \qquad l^n = 0; \qquad k = k^*; \qquad i = r.$

Case2: $\frac{r+\delta-1}{r}k^{**} \leq a < \frac{r+\delta-1}{r}k^*$

$l^c = \frac{1-\delta}{r+\delta-1}a; \qquad l^n = 0; \qquad k = \frac{r}{r+\delta-1}a; \qquad i = r.$

Case 3: $a < \frac{r+\delta-1}{r}k^{**}$

$l^c = \frac{1-\delta}{r}k^{**}; \qquad l^n = k^{**} - a - l^c; \qquad k = k^{**};$

$i = r + \gamma - \frac{\gamma(1-\delta)}{r(k^{**}-a)}k^{**}.$

Given that $k^* > k^{**}$ and that $r + \gamma - \frac{\gamma(1-\delta)}{r(k^{**}-a)}k^{**}$ is decreasing in a, Proposition 1 follows immediately. (see figure 1 and 2) Q.E.D.

Proof of Proposition 2. Let us look at a worker's problem first,

$$\begin{aligned} V^w(\varepsilon, \theta, a) &= \max\{U(c) + \beta \max\{\int V^e(\varphi', a')\nu^\theta(\varphi')d\varphi, \\ &\quad \int\int V^w(\varepsilon', \theta', a')g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)\ d\varepsilon'\ \}\} \\ s.t. \qquad c + a' &\leq \varepsilon w + ra \\ c, a' &\geq 0. \end{aligned}$$

Following standard dynamic programming argument,[10] $V^w(\varepsilon, \theta, a)$ is increasing in a and ε, $V^e(\varphi, a)$ is increasing in a and φ. The expected value

[10] Stokey, Lucas and Prescott "Recursive Methods in Economic Dynamics" (1989).

of becoming an entrepreneur is independent of worker's labor ability, while the expected value of continuing to be a worker is strictly increasing in labor ability in the case θ and ε are uncorrelated, therefore there exists a cutoff labor ability level for each asset holding so that an worker will become an entrepreneur if his labor ability is below this level, otherwise he remains to be a worker. By continuity, the result will still hold for small positive correlation between labor ability and entrepreneurial idea. Similar results can be proved with respect to θ. Following the same arguments, the case for entrepreneurs can be proved likewise.

Proof of Proposition 3.[11] From proposition 2, I have

For $\varepsilon \leq \varepsilon^*(a,\theta)$

$$\begin{aligned} V^w(\varepsilon,\theta,a) &= \max_{c,a'>0}\{U(c)+\beta\int V^e(\varphi',a')\nu^e(\varphi')d\varphi'\} \\ s.t. \qquad c+a' &\leq \varepsilon w + ra; \end{aligned}$$

otherwise

$$\begin{aligned} V^w(\varepsilon,\theta,a) &= \max_{c,a'>0}\{U(c)+\beta\int\int V^w(\varepsilon',a')g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)\ d\varepsilon' d\theta'\ \} \\ s.t. \qquad c+a' &\leq \varepsilon w + ra. \end{aligned}$$

For $\varphi \geq \varphi^*(a)$,

$$\begin{aligned} V^e(\varphi,a) &= \max\{U(c)+\beta\int V^e(\varphi',a')g^e(\varphi'|\varphi)d\varphi'\ \} \\ s.t. \qquad c+a' &\leq f(\varphi,k,n)-wn+(1-\delta)k\ + r\max(a-k,0)-(r+\gamma)l^n \\ &\quad -rl^c \end{aligned}$$

[11] The proof is inspired by a similar proof in Gomes, Greenwood and Rebelo (1996).

$$
\begin{aligned}
rl^c &\leq (1-\delta)k \\
l^c + l^n &= \max(k-a,0);
\end{aligned}
$$

otherwise

$$
\begin{aligned}
V^e(\varphi,a) &= \max\{U(c)+\beta \int V^w(\varepsilon',\theta',a')\nu^w(\varepsilon',\theta')d\varepsilon' d\theta'\} \\
s.t. \qquad c+a' &\leq f(\varphi,k,n)-wn+(1-\delta)k \ +r\max(a-k,0)-(r+\gamma)l^n \\
&\quad -rl^c \\
rl^c &\leq (1-\delta)k \\
l^c + l^n &= \max(k-a,0).
\end{aligned}
$$

A worker's asset accumulation is governed by the following condition,

$$U'(c^w(\varepsilon,\theta,a)) \geq \beta r \int\int V_2^w(\varepsilon',\theta',a')g^w(\varepsilon'|\varepsilon)h(\theta|\varepsilon)d\varepsilon', \text{ for } \varepsilon \geq \varepsilon^*(a,\theta);$$

$$U'(c^w(\varepsilon,\theta,a)) \geq \beta r \int V_2^e(\varphi',a')g^e(\varphi'|\varphi)d\varphi', \text{ for } \varepsilon \leq \varepsilon^*(a,\theta).$$

$$U'(c^e(\varphi,a)) \geq \beta\, \tilde{r} \int V_2^e(\varphi',a')g^e(\varphi'|\varphi)d\varphi', \text{ for } \varphi \geq \varphi^*(a);$$

$$U'(c^e(\varphi,a)) \geq \beta\, \tilde{r} \int\int V_2^w(\varepsilon',\theta',a')\nu^w(\varepsilon',\theta')d\varepsilon' d\theta', \text{ for } \varphi \leq \varphi^*(a).$$

From profit function, it is obvious that $\tilde{r} \geq r$.

These inequalities hold with equalities whenever the borrowing constraint does not bind.

Integrate the first two inequalities with respect to the stationary distribution over the part of the state space applying to workers, do the same to the next two inequalities applying to entrepreneurs and sum the resulting inequalities, I get

$$
\begin{aligned}
& \int_\varepsilon \int_\theta \int_a U'(c^w(\varepsilon,\theta,a))\mu^w(\varepsilon,\theta,a)d\varepsilon d\theta da + \int_\varphi \int_a U'(c^e(\varphi,a))\mu^e(\varphi,a)d\varphi da \\
\geq \; & \beta r[\int_{\varepsilon \geq \varepsilon^*(a,\theta)} \int_\theta \int_a \int_{\varepsilon'} \int_{\theta'} V_2^w(\varepsilon',\theta',a') \; g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta' \mu^w(\varepsilon,\theta,a)d\varepsilon da \\
& + \int_{\varepsilon \leq \varepsilon^*} \int_\theta \int_a \int_{\varphi'} V_2^e(\varphi',a')g^e(\varphi'|\varphi)d\varphi' \mu^w(\varepsilon,\theta,a)d\varepsilon d\theta da \\
& + \int_{\varphi \geq \varphi^*} \int_a \int_{\varphi'} V_2^e(\varphi',a')g^e(\varphi'|\varphi)d\varphi' \mu^e(\varphi,a)d\varphi da \\
& + \int_{\varphi \leq \varphi^*} \int_a \int_{\varepsilon'} \int_{\theta'} V_2^w(\varepsilon',\theta',a')\nu^w(\varepsilon',\theta')d\varepsilon' d\theta' \mu^e(\varphi,a)d\varphi da] \\
> \; & \beta r[\int_{\varepsilon \geq \varepsilon^*} \int_a \int_{\varepsilon'} \int_{\theta'} V_2^w(\varepsilon',\theta',a')g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta' \mu^w(\varepsilon,\theta,a)d\varepsilon da + \\
& \int_{\varepsilon \leq \varepsilon^*} \int_a \int_{\varphi'} U'(c^e(\varphi',a'))g^e(\varphi'|\varphi)d\varphi' \mu^w(\varepsilon,\theta,a)d\varepsilon d\theta da + \\
& \int_{\varphi \geq \varphi^*} \int_a \int_{\varphi'} U'(c^e(\varphi',a'))g^e(\varphi'|\varphi)d\varphi' \mu^e(\varphi,a)d\varphi da + \\
& \int_{\varphi \leq \varphi^*} \int_a \int_{\varepsilon'} \int_{\theta'} U'(c^w(\varepsilon',\theta',a'))\nu^w(\varepsilon',\theta')d\varepsilon' d\theta' \mu^e(\varphi,a)d\varphi da] \\
= \; & \beta r[\int_a \int_{\varepsilon'} \int_{\theta'} U'(c^w(\varepsilon',\theta',a))\mu^w(\varepsilon',\theta',a)d\varepsilon' d\theta' da \\
& + \int_a \int_{\varphi'} U'(c^e(\varphi',a))\mu^e(\varphi',a)d\varphi' da]
\end{aligned}
$$

The inequality is a result of borrowing constraint binding for a group of agents with positive measure. The last equation comes from the law of motion for the distribution. I then have $\beta r < 1$.

Proof of Proposition 4. (I prove the first part of Proposition 4, the second part can be done similarly.)

Let $M_1 = \int \int V^w(\varepsilon',\theta',a')g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta'$, $M_2 = \int V^e(\varphi',a')\nu^e(\varphi'|\theta)d\varphi'$. By standard dynamic programming argument,[12] $V^w(\varepsilon',\theta',a')$ and $V^e(\varphi',a')$

[12] Stokey, Lucas and Prescott "Recursive Methods in Economic Dynamics" (1989).

are both increasing functions of a', so are M_1 and M_2. By assumption 4, at a=0, any entrepreneur has a positive probability of reaching state 0 where income is zero. However this will not happen to a worker at that wealth level. By Inada conditions of the utility function, I then have $M_1(0) > M_2(0)$. Each value function is possibly not differentiable at two points: the point where agents is indifferent between borrowing and not borrowing, the point the agent is indifferent between two occupations. For consistency, at those points, I take right derivatives.

For the region where borrowing constraints do not bind, by envelop theorem,

$\frac{\partial M_1}{\partial a'} = r \int \int U'(c^w(\varepsilon', \theta', a'))g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta' \equiv r \int U'(c^w(a'))\Gamma^1(dc^w(a'))$,

$\frac{\partial M_2}{\partial a'} = r' \int U'(c^e(\varphi', a'))\nu^e(\varphi'|\theta)d\varphi' \equiv r' \int U'(c^e(a'))\Gamma^2(dc^e(a'))$; for the region where borrowing constraints bind, the consumption coincides with the period income, and we have

$\frac{\partial M_1}{\partial a'} = r \int \int U'(c^w(\varepsilon', \theta', a'))g^w(\varepsilon'|\varepsilon)h(\theta'|\varepsilon)d\varepsilon' d\theta' \equiv r \int U'(c^w(a'))\Gamma^1(dc^w(a'))$,

$\frac{\partial M_2}{\partial a'} = r' \int U'(c^e(\varphi', a'))\nu^e(\varphi'|\theta)d\varphi' \equiv r' \int U'(c^e(a'))\Gamma^2(dc^e(a'))$; where $r' \geq r$ (this comes directly from entrepreneurs' profit function).

Under the technical assumption that Γ^1 second order stochastic dominates Γ^2, and that $U'' > 0$, we have $\frac{\partial M_2}{\partial a'} \geq \frac{\partial M_1}{\partial a'}$. Therefore, if M_2 intersects M_1, it is from below and they intersect only once. Since a' is increasing in a, this implies that there exists $a^*(\varepsilon, \theta)$, workers (ε, θ, a) chooses to be an entrepreneur next period if and only if his assets is above this cutoff level. The monotonicity of $a^*(\varepsilon, \theta)$ in ε follows directly from the fact that M_1 is increasing in ε, while M_2 does not change with ε. Similarly, $a^*(\varepsilon, \theta)$ decreases in θ. Q.E.D.[13]

[13] Given that there is a correspondence between period consumption and period income, the above assumption is equivalent to the restraint that the income stream from being a worker second order stochastic dominates that of being an entrepreneur at each asset

Appendix B: Computation Method

I use a method of successive approximation to numerically solve for a stationary equilibrium for this economy. The iterative procedure consists of several steps. I begin with a guess for the prices (interest rate and wage), then use value iteration to solve the functional equations defined in the worker and the entrepreneur's problems. Next, the invariant distribution corresponding to these decision rules is found by iterating on equation (13) and (14). Together with the decision rules, the invariant distributions are used to examine the market clearing conditions. New values are increased if there is an excess demand and decreased if there is an excess supply at the previous prices.[14] The algorithm is therefore based on the conjecture that the excess demand for credit and labor are decreasing in the interest rate and wage, respectively. Although this has not been proven, this appears to be the case for all the economies examined here.

The method used to solve for the decision rules involves discretizing the state space by choosing a grid of feasible asset holdings. The minimum asset level could not go beyond zero since intertemporal borrowing is not allowed, the maximum level is chosen so that agents' next period asset position will not reach the upper bound. The grid is chosen to be sufficient fine so that our results are not affected by adding grid points. I chose 500 grid points for the assets, together with 5 productivity shocks and 2 labor productivity shocks, there are totally 3500 states. The optimal value functions and decision rules for this finite state discounted dynamic programming problem are obtained by successive approximations. This approach involves starting

level.

[14] I choose to iterate on wage first given interest rate till labor market clears, then iterate on interest rate till both markets clear. It is more difficult according in my experience to iterate two prices at the same time.

with initial approximations for the value functions, and using them to obtain a subsequent approximation by computing the right side of the two value functions. This process continues until the sequence of value functions so obtained converges.

Given that the state transition function implied by the equilibrium decision rules is ergodic, there exists a unique invariant distribution. To compute the invariant distribution, I begin with an initial approximation, and evaluate (13) and (14) using decision rules obtained. The result is used as the next candidate, and the process is repeated until successive approximations are sufficiently close. Once the invariant distribution is found, the market clearing constraints are evaluated and a new candidate for the prices is chosen. The procedure is then repeated as described above.

Lemma. The transition matrix for the economy is ergodic.

Proof. First, given that production function satisfies Inada Conditions, in equilibrium there will be both positive measure of workers and entrepreneurs. Secondly, as long as the stochastic processes on labor productivity and business quality satisfies the "mixing" condition which requires agents being able to reach the best and worst state in finite steps from any state (see assumption 12.1, p.381, SLP 1989), the ergodicity of the economy is established. Q.E.D.

This lemma demonstrates the roles played by the labor productivity shocks. Without this feature, it is likely that the economy will not be ergodic, i.e. the economy may degenerate into a situation which resembles "poverty trap": some agents will remain poor forever and never have a chance of moving up. This case is not interesting for our purposes, and thus I assume it away.

Table 1: Calibrated Parameters

Parameter		**Value**
Preference		
σ	relative risk aversion	2
β	time discount rate	0.76
ε	labor productivity shock	(0.803 1.197)
ν_ε	inital distribution	(0.5 0.5)
Technology		
A	technology coefficient	1
α	capital income share	0.3
λ	labor income share	0.62
δ	capital depreciation rate	0.24
γ	intermediation cost	0.22
φ	productivity shock	[0.805 0.93 1.072 1.26]

Transition matrix for labor productivity shock:

$$\begin{bmatrix} 0.53 & 0.47 \\ 0.47 & 0.53 \end{bmatrix}$$

Transition matrix for business productivity shock:

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.38 & 0.5318 & 0.0882 & 0 & 0 \\ 0.34 & 0.0485 & 0.5430 & 0.0685 & 0 \\ 0.22 & 0 & 0.081 & 0.642 & 0.057 \\ 0.20 & 0 & 0 & 0.114 & 0.686 \end{pmatrix},$$

Initial distribution for business productivity shock:

$$\begin{pmatrix} 0.52 & 0.3415 & 0.1383 & 0.0002 & 0 \\ 0.42 & 0.4144 & 0.1653 & 0.0003 & 0 \end{pmatrix}.$$

Table 2: US Economy vs. Model Economy

	US Economy	**Model Economy**
Serial correlation in log employment[1]	0.93	0.93
Variance in growth rates	0.52	0.50
Mean employment	61.7	67.8
Exit rate	37%	42%
Firm Size Distribution		
1-19	0.52	0.54
20-199	0.37	0.37
200-499	0.10	0.07
500+	0.01	0.02
Exit Rate		
1-19	0.38	0.38
20-199	0.34	0.34
200-499	0.25	0.22
500+	0.20	0.20

Note: 1. Five year interval.

2. Difference in log employment, five interval and survivors only.

Table 3: Additional Summary Statistics of Baseline Model

	Firm Size			
	1-19	20-99	100-499	500+
Employment share	0.07	0.24	0.29	0.40
Growth rate[1]	-0.63	-0.08	0.01	-0.52
Growth rate[2]	0.42	0.40	0.30	-0.4
Average Size and Exit Rates by Age Cohort				
Cohort age		1	2	5
Average size		61.5	81.03	163
Average exit rate		0.35	0.34	0.31
Other Statistics				
Entrepreneurs				2.42
Loans as a percent of total capital investment				48.6
Percentage of output used in intermediation				4.45
Gini coefficient (income)				0.57
Gini coefficient (wealth)				0.934

Note: 1. Mean employment growth rate of all firms.
2. Mean employment growth rate of successful firms.

Table 4: Sensitivity Analysis

	Intermediation Cost		
	0.22[1]	0.30	0.16
Entrepreneur (%)	2.423	2.26	2.465
Average firm size	67.87	71.2	65.5
Capital per individual	0.2957	0.2900	0.3156
Percent of output used in intermediation	4.45	6.05	2.92
Output	0.4547	0.4502	0.4598
Welfare change(%)	0	-1.38	+1.434
Gini (income)	0.57	0.575	0.562
Gini (wealth)	0.934	0.938	0.929

Table 5: Cost of Income Taxation: 1

	Uniform Tax		**Lump Sum Tax**	
	Model	Representative	Model	Representative
Tax rate	0.05	0.028	0.0166	0.0166
Output Change	-1.095%	-0.693%	-0.525%	0
Welfare Change	-5.924%	-3.242%	-7.47%	-2.702%

Note: 1. Revenue collected 0.018604 (4.09% of total output).
2. Representative refers to the representative agent economy.

Table 6: Cost of Income Taxation: 2

	Model	Rep.	Model	Rep.	Model	Rep.
Tax Rate	0.05	0.028	0.20	0.11	0.25	0.137
Revenue	0.0186	0.0186	0.0718	0.718	0.0899	0.0899
Output change(%)	-1.095	-0.693	-5.495	-2.866	-6.785	-3.346
Welfare change(%)	-5.924	-3.242	-23.69	-12.71	-29.42	-15.64
Entrepreneur(%)	2.479		2.557		2.576	

Table 7: Interest vs Income Subsidies: A Comparision

	Baseline	Interest Subsidy	Income Subsidy
Tax rate	0	0.0122	0.0112
Output Change(%)	0	+2.707	+5.43
Welfare Change(%)	0	+3.365	+8.181
Firm Size	67.8	48.1	31.65
Capital	0.2956	0.30866	0.30935
Exit rate	42%	59.1%	68.9%
Bank loans	48.6%	49.5%	53.3%
Entrepreneurs(%)	2.423	3.205	5.09
Gini (income)	0.57	0.542	0.539
Gini (wealth)	0.934	0.918	0.909

Table 8: Income Subsidies

Subsidy	0(Baseline)	0.05	0.1	0.12	0.14	0.16
Tax rate	0	0.002	0.008	0.0094	0.013	0.017
Output change(%)	0	2.83	4.47	5.29	5.57*	5.49
Welfare change(%)	0	3.92	6.44	7.80	8.56	9.15
Average size	68.7	50.9	38.4	33.2	28.9	24.9
Capital	0.296	0.294	0.309	0.309*	0.306	0.301
Firm Exit rate(%)	42	52.8	68.9	68.9	68.9	68.9
Bank loans[1](%)	48.6	50.1	52.3	53.3	53.3	53.3
Entrepreneurs(%)	2.42	3.15	4.2	4.79	5.43	6.23
Gini (income)	0.572	0.557	0.550	0.540	0.539	0.53
Gini (welfare)	0.934	0.927	0.915	0.910	0.908	0.905

Note: 1. Bank loans as a percentage of total investment.

continued

Subsidy	0.20	0.21	0.22
Tax rate	0.0278	0.0321	0.041
output change(%)	5.31	5.02	3.68
Welfare change(%)	9.67*	9.65	8.85
Average firm size	18.4	17.1	15.6
Capital	0.288	0.285	0.274
Firm exit rate(%)	68.9	68.9	68.7
Bank loans	53.3	53	52.6
Entrepreneurs	8.26	8.82	10.1
Gini (income)	0.521	0.519	0.44
Gini(welfare)	0.901	0.898	0.889

Table 9: Income Subsidies with Enforcement Problem

	Income Subsidy	0.05	0.1	0.12	0.14
no collection cost	Tax rate	0.002	0.008	0.0094	0.013
	Output change(%)	2.83	4.47	5.29	5.57*
	Welfare change(%)	3.92	6.44	7.80	8.56
with collection cost	Tax rate	0.0024	0.0089	0.012	0.0169
	Output change(%)	2.877	4.41	5.23	5.46*
	Welfare change(%)	3.786	5.973	7.468	7.17

	Income Subsidy	0.16	0.20	0.21	0.22
no collection cost	Tax rate	0.017	0.0278	0.0321	0.041
	Output change(%)	5.49	5.31	5.02	4.60
	Welfare change(%)	9.15	9.67*	9.65	8.85
with collection cost	Tax rate	0.0204	0.0326	0.039	0.048
	Output change(%)	5.36	5.23	4.85	4.05
	Welfare change(%)	8.446	9.03*	8.71	6.87

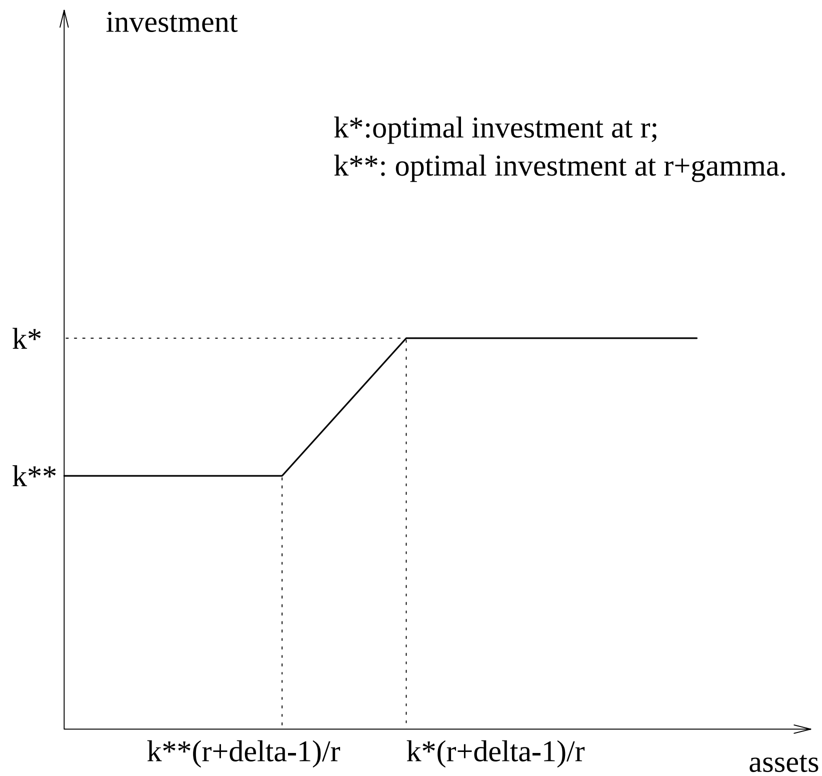

Figure 1: Investment as a Function of Assets

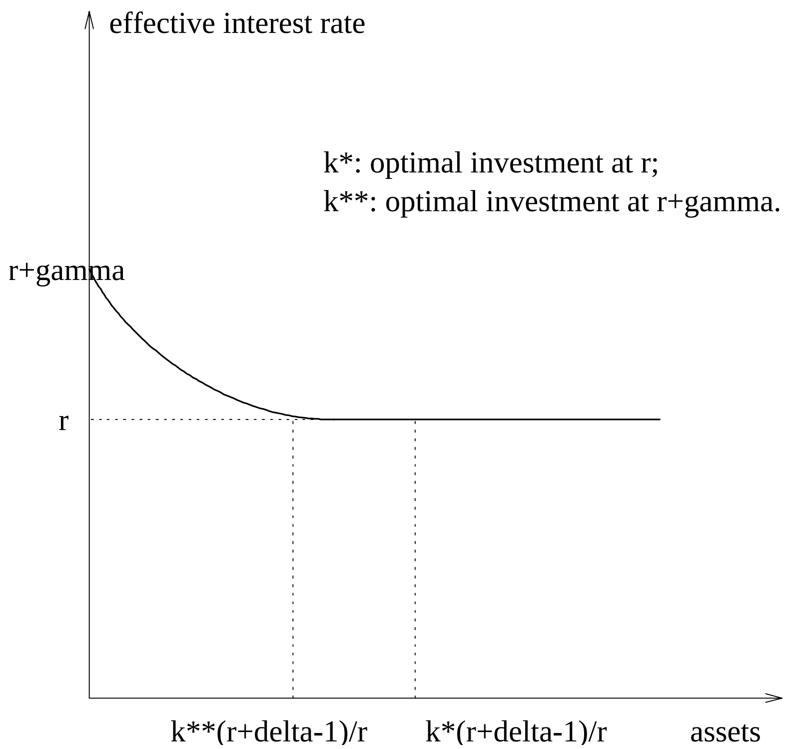

Figure 2: Effective Interest Rate as a Function of Assets

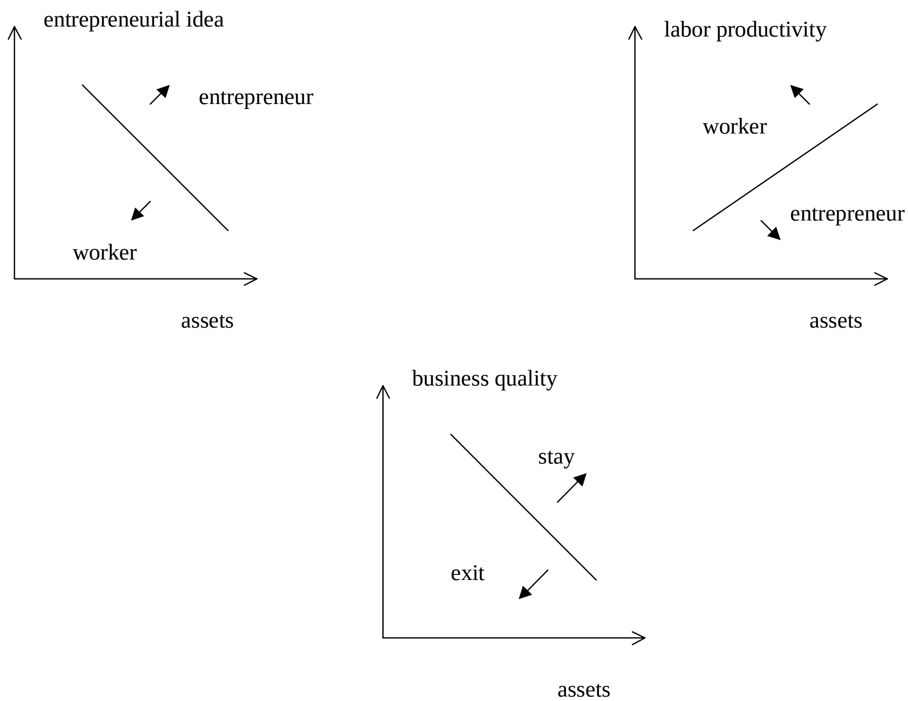

Figure 3: Firm Entry and Exit

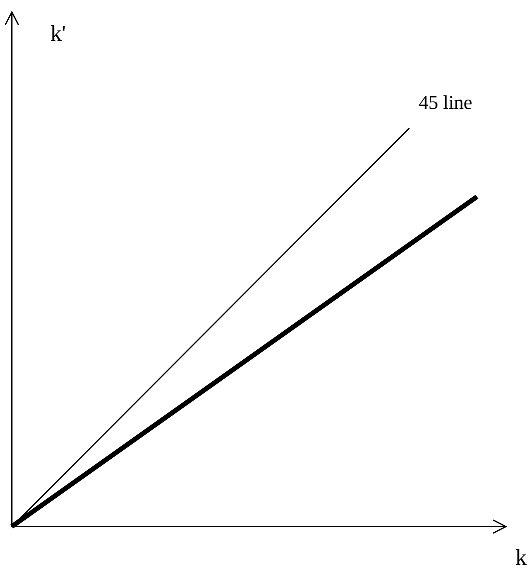

Figure 4: Next Period's Capital as a Function of Current Capital

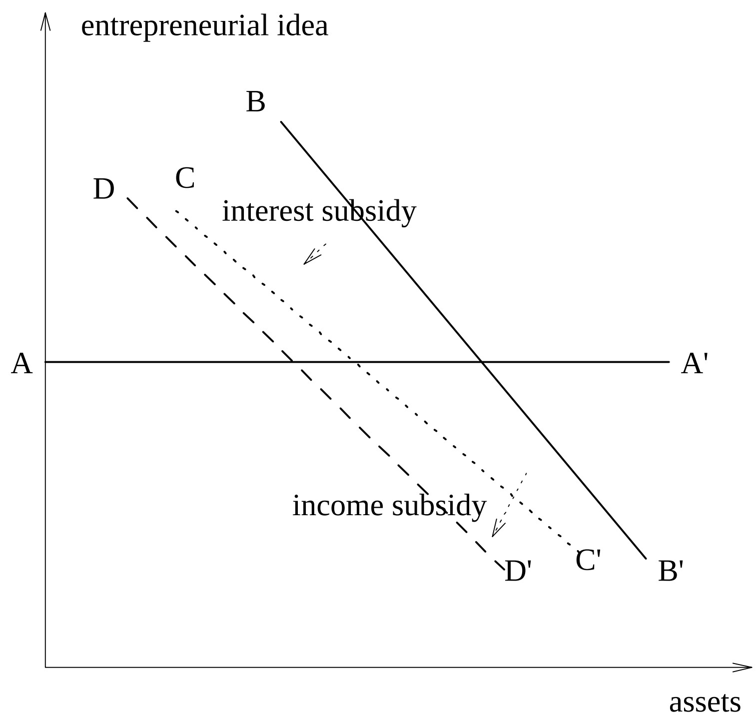

Figure 5: Interest Subsidy vs Income Subsidy

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