Explorations on Entrepreneurship and Financial Intermediation*

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Abstract

In this paper we build a dynamic general equilibrium model with heterogeneous agents that allows us to analyze the effect of credit market imperfections in the levels of production, the average size and distribution of firms, as well as the level of financial intermediation of an economy. Households are able to choose whether to become workers or entrepreneurs depending on some productivity shocks. However, if they decide to operate a firm, they will not be able to borrow as much as needed because of the imperfect enforceability of borrowing contracts. As a consequence, the output level of the firm will depend on their ownership of assets. Our main findings are that income per capita decreases a 20% with respect to an economy with perfect capital markets for firms, and that the number of firms will go up because of the depressing effect of lower aggregate productivity on workers' wages.

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1. Introduction

The purpose of this paper is to build a simple model that allows us to analyze the effect of imperfections in the credit market for firms in the levels of production, the average size and distribution of firms, and the level of financial intermediation of an economy.

These credit market imperfections have been studied from two different theoretical perspectives: imperfect information theory and incomplete contracts theory. The first approach emphasizes the effect of different information sets in the process of lending and borrowing (see the classical reference of Stiglitz and Weiss (1981)). For instance, the lender may not know the true level of risk associated with the project it is financing and playing with the price of the credit (the interest rate) can have perverse effects, such as adverse selection: at high interest rates, only projects with high return and high risk will seek a credit.

The second approach builds on the absence of a complete set of contracts. Traditional Arrow-Debreu frameworks imply the existence of a very wide set of feasible contracts. Recently this assumption has been challenged based on the problems related with both writing a completely specified contract and fully implementing it. In this paper, we follow this second approach because of two reasons. First, it has been successfully applied to other areas of economics (as industrial organization or macroeconomics) to model a wide set of economic behaviors. Second, it allows us to analyze the effects of particular institutional arrangements, such as the degree of collateralization of assets, in an economy. Let us illustrate this latest point with two examples. The capacity of a peasant to run into debt in a society in which, by institutional reasons, there does not exist a market for land, is much lower than the credit ceiling of a peasant that can use its land as guarantee. Another example of how the institutional framework affects the efficiency of the financial system is related to the functioning of the judicial system: a crucial aspect, that determines the maximum amount that could be lend to an individual, is the speed at which the financial intermediary gains the property of the collateral in the case that the borrower does not pay the debt.

In order to study these problems, we build an infinitely lived agents dynamic general equilibrium model. One of the central characteristics of the model is the existence of heterogeneous agents. Even if households are ex-ante identical, idiosyncratic risk and the absence of contingent contracts, will disperse the distribution of households along two dimensions: occupation and asset holding. That is, our agents are going to be able to decide both their occupation (entrepreneurs or workers) depending on their assets, skills and the level of market imperfection as well as their asset accumulation. These assets will be specially relevant as they determine how much they can borrow to finance their firms. We will show how the incentive compatibility constrain depends on the level of assets of the household and how the higher the level of these assets the less important it becomes for the agent (for previous similar suggestions about how to model explicitly credit imperfections see Díaz-Giménez et al. (1992) and Kiyotaki and Moore (1997)).

This paper is then related with three different lines of research. The first of these lines studies how financial intermediation and monetary shocks affect the economy. There are both empirical and theoretical papers in this literature. Some examples of the empirical work that suggests that credit constraints alter the way in which firms respond to liquidity shocks are Dunne et al. (1989a and 1989b), Evans (1987a and 1987b), Gertler and Gilchrist (1994), Hall (1987), Hall (1997) and Kashyap et al. (1993 and 1994). In these papers, the authors analyze the response of small *vs.* large manufacturing firms to different monetary policies based on the idea that the size of the firm will affect its ability to use credit channels.

Among the theory papers, we can cite Lucas (1990) and Fuerst (1992). Both introduce money in a dynamic general equilibrium model through a cash-in-advance constraint, with the purpose of modeling the liquidity effect. The Central Bank does open market operations through the private banks. However, these models have problems of their own. They generate wrong implications such as identical long run and short run demand elasticities for money, or a positive and strong correlation of money growth with increases on nominal interest rates, while empirical evidence shows just the opposite.

The second line concentrates on the importance of financial markets in the propagation of aggregate fluctuations. Bernanke and Getler (1989) and Fisher (1996) have looked at the effects of incentive constraints in the propagation of aggregate shocks, but their models are unable to address the dynamics of firm creation and destruction. More recently Cooley and Quadrini (1998a and 1998b) have built models in which those dynamics can be studied.

Finally, the third line of research has analyzed the effects of credit imperfection on firms dynamics. Li (1997) has studied the interaction between credit constraints and firm turnover in the presence of subsidies. Building in previous work by Hart and Moore (1994), Albuquerque and Hopenhayn (1997) present a model in which credit constraints can explain the survival of firms and their dynamics. Monge (1998) extends the contract design of Alburquerque and Hopenhayn to allow for the presence of liquidity cost shocks. As a result, his model predicts how firms respond to interest rate shocks and generate fluctuations in the aggregate creation and destruction of firms.

In this paper, we will overlook both monetary policy[1] and aggregate shocks[2] to exclusively concentrate in the financial intermediation aspect. The main idea is to build a small model, just a prototype or small laboratory, to win further insights on the behavior of these kind of economies. This is an important first step. As we will explain later in detail, these models present a whole set of problems (such as non-convexities and computational difficulties) that need yet to be fully understood.

Despite the simplicity of the model, we have achieved very interesting results. We find that even with very simple productivity shocks, the effect of imperfections on credit markets can imply differences of 20% in the level of income per capita and more than 50% in the real wages. We also find that these imperfections have important effects over the distribution of households in the economy and over the structure of self-employment, that follow existing empirical evidence. All these findings strongly suggest that a more complete model, built over the lines of the one presented here, promises higher rewards with respect to our ability to understand the relation between financial intermediation and the rest of the economy.

The rest of the paper is organized as follows. In Section 2, we describe the model and define the equilibrium of our economy. In Section 3, we describe how the model is calibrated and the results of our computational experiment. We close the paper with some conclusions and some ideas for future research. A short appendix describes in more detail the algorithm used for the computation of the model.

[1] This is addressed in Carranza and Galdón-Sánchez (1999) where the authors discuss the implications for the effectiveness of monetary policy of alternative mechanisms of the monetary transmission, and in particular the role of bank credit. In their paper, they concentrate in the study of two issues: to quantify the relative importance of banks in the process of monetary transmission, and to determine whether shocks in the credit market can create disruptions in the level of economic activity. Their objective is to study how monetary shocks affect the real variables of the economy in the short run and in the long run. They show that monetary shocks affect real variables in the short run but not in the long run.

[2] They are studied in Fernández-Villaverde and Galdón-Sánchez (1999).

2. The Model

This section describes a stylized dynamic general equilibrium model of firm dynamics and financial intermediation. After a brief outline of the environment, the problem of the households is presented, the role of a financial intermediator is described and an equilibrium definition is proposed. Some discussion of the equilibrium and its characteristics finishes the section.

2.1. The Environment

We have an economy with households, some of which operate firms, and a financial intermediator. There is one final good (that we will use as numeraire) that can be used for consumption or to supply capital services. In our economy, there are two technologies: the first one produces the final good and the second, a storage technology, allows the households to carry the final good from one period into the next. Households will have access to the first technology providing that they pay a fixed cost in terms of effort. The financial intermediator will have access to the second technology.

The timing of the economy will be as follows. At the beginning of the period, the different shocks are realized. Then, the agents will produce according to their occupational choice and, at the end of the period, will decide, depending on their present shocks and their access to the credit market, if they want to become entrepreneurs or workers in the next period. In order to take this decision, they will take expectations over prices as given (or equivalently they will take as given the law of motion for the household measure). After production, households will make their remaining two decisions: how much to consume and how much to save. Then markets will clear.

2.2. Households

In any period, there is a continuum of *ex-ante* identical, infinitely-lived, households with total, constant, measure Γ. Without loss of generality, we will normalize this total measure to one. Households have standard preferences over consumption streams $\{c_t\}_{t=0}^{t=\infty}$ that can be represented by a period utility function $u(c_t)$ such that $u(\cdot) : \mathcal{R}_+ \rightarrow \mathcal{R}$. Usual assumptions about $u(\cdot)$ are made: $u(\cdot) \in C^2$, $u'(\cdot) > 0$, $u''(\cdot) < 0$ for all $c_t > 0$, $\lim_{c \rightarrow 0} u'(c) = \infty$ and $\lim_{c \rightarrow \infty} u'(c) = 0$. It is assumed than preferences allow for a Von Neumann-Morgenstern representation where the relevant probabilities follow the transition probabilities over the state space outlined below. Given a discount factor $0 < \beta < 1$, life-time utility can be written as:

$$E_0 \sum_{t=0}^{\infty} \beta_t U(c_t) \tag{2.1}$$

where E_0 is the conditional expectation operator evaluated given the available information at period 0.

Households engage in two economic activities: production activities (including the decision regarding their occupation) and asset accumulation. Each household is endowed with one unit of time in every period. Since the utility function does not depend on leisure, this unit of time is offered inelastically to meet the input requirements of production activities. There are two of these production activities: being an entrepreneur or being a worker.

As an entrepreneur, the household pays a fixed cost ϕ measured in utility terms (this cost can be easily interpreted as the additional effort cost of being an entrepreneur over being a worker). Once this fixed cost is paid, the household gains access to the production technology. This technology, that produces the final good, can be represented by a plant production function $f(\cdot) : \mathcal{R}_+^2 \to \mathcal{R}$:

$$z_t f(k_t, l_t) \tag{2.2}$$

where $z_t > 0$ is an idiosyncratic productive shock[3] and k_t and l_t are the level of input services used by the technology. This level of labor services l_t is net of the labor input of the household, who needs to use all its time endowment just to operate the technology. Notice that the occupational choice cannot be reverted in the same period, i.e. after observing the productivity shock, the household cannot go back to be a worker until the next period. Each of these production technologies operated by a household can be understood as a firm.

We will assume that the final good technology needs strictly positive amounts of both inputs services to produce a strictly positive amount of final good, that is increasing in both arguments and concave in each of the arguments separately. Moreover, $f(\cdot) \in C^2$, $f_i^{'}(k_t, l_t) > 0$, for all $i \in \{k_t, l_t > 0\}$, $\lim_{k \to 0} f_k^{'}(k_t, 1) = \infty$ and $\lim_{k \to \infty} f_k^{'}(k_t, 1) = 0$. This technology presents decreasing returns to scale

[3]Note that even if these shocks are idiosyncratic, we are not imposing independence across realizations of the shock for the different households. As a consequence, an appropriate law of large numbers can be showed carefully to operate in this economy and realized probabilities will be equal to theoretical probabilities almost surely. We will keep this assumption throughout the paper. For technical details and further references see Uhling (1996).

(for instance because of some *scope-of-control* problem) and depreciates the capital it uses at a constant rate $0 < \eta < 1$.

In an environment without any constraint, the input demands will be given by the solution to:

$$\pi(z_t) = \max_{\{k_t,l_t\}} \{z_t f(k_t, l_t) - w_t l_t - r_t b_t\} \tag{2.3}$$

We will call these input demands $\widehat{k_t}$ and $\widehat{l_t}$. However, as explained in more detail in the subsection about financial intermediation, firms will not be able to operate at the level that maximizes profits because of the existence of borrowing constraints. Since the level of assets of the household, used as an additional resource, will determine the tightness of these constraints, in general the demand for labor and capital services will depend both on the productivity shock and the level of assets (for fixed inputs prices), $k_t = g_k(z_t, a_t)$, $l_t = g_l(z_t, a_t)$. Then the profits of operating the technology will be:

$$\pi(z_t, a_t) = \max_{\{k_t,l_t\}} \{z_t f(k_t, l_t) - w_t l_t - r_t b_t\} \tag{2.4}$$

$$k_t = g_k(z_t, a_t) \tag{2.5}$$

$$l_t = g_l(z_t, a_t) \tag{2.6}$$

where w_t is the wage per unit of labor services and r_t the interest rate on capital (or user cost of capital).

The net demand of capital will be given by $k_t^d = \max(0, g_k(z_t, a_t) - a_t)$, i.e. the firm uses first all the capital of the household and then borrows the rest to produce. Of course, in the case where $a_t > \widehat{k_t}$, the household can operate the firm at the unrestricted level and keep the difference $\left(a_t - \widehat{k_t}\right)$ invested in the financial intermediator. Notice that, in any case, we still define the profit from an economic point of view (income less payments to inputs) even if they are owned by the household. This accounting convention will later simplify the process of writing the household budget constraint, since the assets of the household will always be paid the market interest rate regardless of where they are invested.

The second production activity is just the offer by the household of its unit of time in the labor market. This unit of time can supply δ_t units of labor services, or more loosely, the household has an individual labor productivity δ_t. This labor productivity follows a random process, described in further detail below, and is an additional source of idiosyncratic risk. Given a wage w_t for unit of labor services, the income associated with the second production activity is then:

$$\delta_t w_t \tag{2.7}$$

The distribution of the stochastic shocks, z_t and δ_t, will depend on the household past shock and the production activity involved in the last period:

1. If the household was an entrepreneur in the period $t-1$ with shock z_{t-1} and remains as an entrepreneur in period t, it will receive a productivity shock from a kernel[4] $G_e(z_{t-1}, dz_t)$ defined on a compact set $E_1 \in \mathcal{R}$.

2. If the household was an entrepreneur in $t-1$ and wants to become a worker in t, its labor productivity will come from a probability distribution $H_w(\cdot)$ defined on a compact set $W_1 \in \mathcal{R}_+$.

3. If the household was a worker in the period $t-1$ and becomes an entrepreneur in period t, it will receive a productivity shock from a probability distribution $H_e(\cdot)$ defined on a compact set $E_2 \in \mathcal{R}_+$.

4. If the household was a worker in period $t-1$ and decides to remain as a worker in period t, it will receive a labor productivity shock from a kernel $G_w(\delta_{t-1}, d\delta_t)$ defined on a compact set $W_2 \in \mathcal{R}_+$.

We will denote an appropriate $\sigma-$algebra (in our simulation typically the power set) for each of these sets as $\sigma(i)$, $i \in \{E_1, E_2, W_1, W_2\}$. In order to assure the existence and uniqueness of an invariant measure of households, we will make the following technical assumptions about the transition kernels G_e and G_w:

1. They satisfy the *Feller Property*[5].

2. $G_i(z, \cdot)$ dominates $G_i(z', \cdot)$ for any $z' \geq z$ and $i = e, w$.

[4] Given a state space S with a $\sigma-$algebra $\sigma(S)$, we define a kernel as an operator $P : S \times \sigma(S) \to [0,1]$ where $P(x,B) = \Pr\{X_t \in B | X_{t-1} - x\}$ for any $x \in S$ and any $\sigma-$measurable set B, such that for each fixed x the function $B \mapsto P(x,B)$ is a probability measure and for each fixed B the function $x \mapsto P(x,B)$ is measurable. Note that this definition implies a Markov property in the stochastic process for the random variable X_t and the possibility of defining meaningful regular conditional probabilities for well behaved events.

[5] Remember that the *Feller Property* implies that for any σ-measurable function f, the operator Tf:

$$Tf = \int f(x')\, P(x, dx')$$

for all $x \in S$, maps the space of bounded continuous functions on S into iself (Stokey, Lucas and Prescott (1989)).

3. There exist $c \in S \in \{E_1, W_2\}$, $\varepsilon > 0$ and $N \geq 1$ such that $G_i^N(a, [c, b]) \geq \varepsilon$ and $G_e^N(b, [a, b]) \geq \varepsilon$ for $i = e, w$. This condition is sometimes referred as *Mixing Condition.*

We also assume the existence of a measure ν such that $H_e \ll \nu$ and $H_w \ll \nu$ (where "$\ll$" stands for "absolute continuity with respect to") and, consequently, the existence of a Radon-Nykodim derivative with respect to ν is assured[6].

The second economic activity of households is the accumulation of assets. These assets are the shares of the financial intermediator of the economy. As described later, this financial intermediator will distribute its income equally among all the shares, at a rate i_t. This financial intermediator will also issue a number of shares equal to the amount of the final good it owns. This behavior implies that the price of the share *post-dividend* will be always one[7]. All the other intertemporal trades in the economy, including all the different contingent contracts that insure households against their idiosyncratic shocks, are excluded because of the lack of enforceability in the case of contractual default. This is the same reason we use to exclude short-selling of shares: there is no way to enforce the return of the shares once the lending contract expires.

This assumption has been used extensively in the literature of models with heterogeneous agents (for a general review see Ríos-Rull (1995)) to study a wide variety of issues (such as the cost of business cycles, the effects of social security, public finance, wealth distribution, etc...) and in the consumption literature to study deviations from marginal utility smoothing both in cross-sections and in time series (an example among many others is Carroll (1992)). Even if its quite extreme character of precluding most intertemporal trade has been challenged recently (see for instance Krueger (1999)) from both theoretical and empirical perspectives, it is still a powerful alternative to other descriptions of trading opportunities in actual economies. In addition, it is "relatively" easy to implement computationally while other alternatives still present a substantial burden[8].

Households that operate a firm are then indexed by a type (z_t, a_t) and households that just work are indexed by a type (δ_t, a_t). In that way, we can define

[6] This condition is equivalent to the *mixing condition* above. Given our compactness assumption, the other two conditions are satisfied trivally for H_e and H_w .

[7] This eliminates the existence of financial bubbles. For a more rigourous argument about how to rule out some explosive paths in dynamic models see Obstfeld and Rogoff (1983)).

[8] For a review of computational issues regarding economies with heterogeneous agents see Ríos-Rull (1997). For a more detailed description of the difficulties inherent to the analysis of models with endogenous borrowing constraints and the necessary simplifications to compute equilibria with firms see Quintin (1999).

the measure of entrepreneurs $\Phi_{et}(z_t, a_t)$ and the measure of workers $\Phi_{lt}(z_t, a_t)$. Taking the Cartesian product of these two measures we have the total measure of households $\Phi_t = \Phi_{et} \times \Phi_{lt}$. In a similar way, we can let μ_0 be the measure of households that were workers in period $t-1$ and become entrepreneurs in period t, and let μ_1 be the measure of households that were entrepreneurs in $t-1$ and become workers in t. These last two measures have a clear interpretation: the entry and exit of firms in each period. Firms with a low productivity shock that are owned by entrepreneurs with a low level of assets will tend to be unprofitable when compared to the alternative of being a worker, therefore they will be closed. At the same time, workers with high level of assets and relatively low labor productivity will tend to open a firm since their constraint is not so tight and the opportunity cost of their lost wage is lower.

This notation highlights the two decisions of the household: the consumption/saving decision and the occupational decision. These two choices will be closely related. As $\pi(z_t, a_t)$ will be in general increasing in a_t, those households with higher assets will find more attractive to create (or keep) a firm than those other households with lower level of assets, even if they have a lower productivity. The existence of borrowing constraints creates then a distortionary effect: production is not undertaken by those with higher productivity, but by those with better access to financing. As a consequence, households will tend to overaccumulate assets, not only as a way to insure themselves against idiosyncratic shocks but also as a way to ease the effect of the borrowing constraints and to be able to switch activities. For latter use, we now define the occupational choice by the indicator functions $I_{te}(z_t, a_t; \Phi_t)$ and $I_{tw}(\delta_t, a_t; \Phi_t)$, where 0 means that the household stays in the same occupation and 1 means a change in activity.

Given the environment described above and the structure of the state space, the problem of the household can be written in a recursive form with two value functions, one for the households operating a firm:

$$V_e(z_t, a_t; \Phi_t) = \max_{\{c_t, a_{t+1}\}} \left\{ U(c_t) + \beta \max_{I_{te}} \left\{ \begin{array}{c} -\phi + \int V_e(z_{t+1}, a_{t+1}; \Phi_{t+1}) G_e(z_t, dz_{t+1}), \\ \int V_w(\delta_{t+1}, a_{t+1}; \Phi_{t+1}) H_w(d\delta_{t+1}) \end{array} \right\} \right\} \tag{2.8}$$

$$\text{s.a. } c_t + a_{t+1} \leq \pi(z_t, a_t) + (1+i_t)a_t$$

and one for the household that works:

$$V_w(\delta_t, a_t; \Phi_t) = \max_{\{c_t, a_{t+1}\}} \left\{ U(c_t) + \beta \max_{I_{tw}} \left\{ \begin{array}{c} -\phi + \int V_e(z_{t+1}, a_{t+1}; \Phi_{t+1}) H_e(dz_{t+1}), \\ \int V_w(\delta_{t+1}, a_{t+1}; \Phi_{t+1}) G_w(\delta_t, d\delta_{t+1}) \end{array} \right\} \right\} \tag{2.9}$$

$$\text{s.a. } c_t + a_{t+1} \leq \delta_t w_t + (1 + i_t) a_t$$

However these two value function do not satisfy standard assumptions in dynamic programming. In particular, they do not need to be concave. This lack of concavity is due to the binary choice between occupations: a household cannot be 0.5 entrepreneur and 0.5 worker but just one or the other. Then the commodity space is not convex and without this convexity, the usual theorems that assure concavity of the value and policy functions do not apply.

There are two basic routes to scape this problem. The first is to assume the existence of lotteries. Households consumption and labor activity get disconnected in this way as a random device assigns occupational choices and consumption bundles. Wisely designed, lotteries convexify the problem and standard results will follow. This solution however kills most of the interesting action behind the existence of borrowing constraints since choices are made over the space of lotteries and not over their characteristics. It also seems difficult to justify an environment in which intertemporal contracts cannot be enforced but in which lotteries, that rise a whole spectrum of moral hazard and dynamic inconsistency issues, can be fully implemented.

The second route is to assume risk-neutral agents, as done in Quintin (1999) or in the literature of firm dynamics, where firms have linear preferences over profits (as in Hopenhayn and Rogerson (1993)). However, if agents are risk neutral, they do not have any incentive to accumulate assets to create a buffer for self-insurance and they do not care about zero consumption in a number of periods, as long as they accumulate enough capital to become entrepreneurs. These implications are clearly contraintuitive and at odds with the most basic empirical evidence.

We do not find any of these two solutions satisfactory and the authors are still working in a different approach (Fernández-Villaverde and Galdón-Sánchez (1999)). In this paper, we have taken a pragmatic (yet completely atheoretical) approach[9]. First, we note that the dynamic programming algorithm does not require concavity to converge to the true value function but just monotonicity assumptions[10]. From this value function we can also find the correct (up to

[9] However we are not the first to follow this pragmatic path. The dual approach to optimal fiscal and monetary policy builds a value function that incorporates an implementability constraint (see Chari and Kehoe (1998)). This new value function is not necesarilly concave either. However, the experience accumulated tend to suggest that the practical problems associated with this non-concavity are of second order.

[10] Either of a *uniform increase assumption* or of a *uniform decrease assumption*. For a more complete treatment see Bertsekas and Shreve (1996), in particular proposition 5.15 that assures

computability limits), stationary, policy functions that characterize the household problem. We have then computed the value functions using the dynamic programming algorithm and we have found that, except for very small values of the asset grid, the value functions that we found were concave. As a consequence, we will make the assumption that the value functions are concave, proceed with our analysis and explicitly note where we can have problems because of the lack on concavity.

2.3. Financial Intermediator and Firm Behavior

There is a representative financial intermediator in the economy with access to a storage technology. This intermediator receives final goods from the households, that want to buy its shares, or gives them back to those who want to sell its shares. The financial intermediator has two possibilities to use the total amount of final goods it owns:

1. It can use them in the storage technology. This technology transforms one unit of the good at the beginning of the period into $(1 + i_s)$ units at the end of the period and carry it over to the next period.

2. It can lend them for one period to the firms. One unit of final goods provides a unit of capital services in the period and suffers a depreciation $0 < \eta < 1$. We will call the quantity lent to a particular firm b_t.

However, once the firms have produced and paid labor[11], they cannot be forced to give the capital they borrow or the interest rate payments $r_t b_t$ back. In this case, the intermediator gets a share $0 < \theta < 1$ of the profits of the firm. We can think of this amount as the quantity that the intermediator will get if it uses the legal system to enforce the contract. The difference from the total recovery of the profits involves aspects such as the opportunity cost of delayed funds, lawyers expenditures and administrative headcost associated with the enforcement. Note that the financial intermediator cannot seize the assets of the household even if they are invested in itself. Also a default decision today neither carries any kind of

convergence in our particular model.

[11] We do not allow here for the possibility of default on debts derived from labor services. In addition to simplify the analysis, an empirical reason justifies this choice. Most legal systems concede an absolute priority to the payment of labor services in case of bankrupcy and specially strong enforcement mechanisms that make default on labor payment extremely difficult.

stigma or reputational consequence for the future nor implies any claim to future income of the household.

The financial intermediator will then only lend a quantity b_t such that the firm does not have any incentive to default, but not the whole quantity needed by the household to operate the firm at an optimal level. If the firm defaults, the household income is:

$$(1-\theta)\,\pi\,(z_t, a_t) + (1+r_t)b_t \tag{2.10}$$

The first term is the amount of profits that the household keeps for itself and the second term is the amount of payments to the financial intermediator that it saves. If the firm meets its contractual obligations, the household gets the whole profit of the firm:

$$\pi\,(z_t, a_t) \tag{2.11}$$

The incentive compatibility constraint then implies that this second quantity needs to be higher that the first in order not to observe any default in equilibrium:

$$\pi\,(z_t, a_t) \geq (1-\theta)\,\pi\,(z_t, a_t) + (1+r_t)b_t \tag{2.12}$$

or, more compactly:

$$\theta\pi\,(z_t, a_t) \geq (1+r_t)b_t \tag{2.13}$$

The profit function of the household is then:

$$\begin{aligned} \pi\,(z_t, a_t) &= \max_{\{k_t, l_t, b_t\}} \{z_t f\,(k_t, l_t) - w_t l_t - r_t b_t\} && (2.14) \\ \text{s.a. } k_t &\leq b_t + a_t && (2.15) \\ b_t &\leq \theta\pi\,(z_t, a_t) && (2.16) \end{aligned}$$

and the demand for inputs (again for fixed input prices) is given by the solution to this problem:

$$\begin{aligned} k_t &= g_k\,(z_t, a_t) && (2.17) \\ l_t &= g_l\,(z_t, a_t) && (2.18) \end{aligned}$$

These two functions will be increasing in both arguments. In particular, conditional on a fixed level of the productivity shock, the demand will grow with the level of household assets up to the point where the borrowing constraint is not binding. Behind this point, the firm is in its first best and does not need to increase its demand for inputs. As an example, Figures 1 and 2 show the input demand of the household against asset holdings for the parametrization used in the numerical exercise described in Section 3 (basically a Cobb-Douglas production function with decreasing returns to scale and a two-points random process for productivity) and inputs prices $w = 1.2$ and $r = 0.15$.

[Figure 1 here]
[Figure 2 here]

The point where the constraint disappears is increasing in z_t: the optimal level of inputs goes up with productivity more rapidly in this example than the appropriability of profits and consequently the constraint is tighter for higher productivities. Figure 3 completes the numerical description of the firm behavior: profits are increasing in the assets up to the point where the borrowing constraint does not bind any more.

[Figure 3 here]

The income that the intermediator generates by unit of final good is equal to i_t, the interest rate net of depreciation (recall that by a simple arbitrage condition it will always be the case that $i_t = r_t - \eta$). If the demand for capital services at the interest rate $i_s + \eta$ is lower than the supply of assets, the intermediator will use the surplus in the storage technology. In the case that $i_t > i_s$, the storage technology will not be used. We can think of this storage technology as an outside opportunity, such as the investment in a foreign country or T-bills, that puts a lower bound in the interest rate. We will call the total amount of good stored in one period S_t.

By the Law of Large Numbers, this intermediator income is deterministic: for a fixed measure of households, the realized productivity shocks will equal the theoretical probabilities and consequently there will be not aggregate uncertainty. Finally, this intermediator operates under zero cost and assuming free entry in the business of intermediation, this will drive the cost of intermediation to zero and the returns to its shares equal to i_t. We want to emphasize that given these assumption, the ownership of these shares is equivalent to the trade of an uncontingent bond with a positivity constraint.

2.4. Equilibrium

Once the model has been described, we are ready to propose an appropriate concept of equilibrium:

Definition 2.1. *A Recursive Competitive Equilibrium for this economy is two value functions* $\{V_e(z_t, a_t; \Phi_t), V_w(\delta_t, a_t; \Phi_t)\}$ *and a set of policy functions* $\{c_{te}(z_t, a_t; \Phi_t)$, $a_{te}(z_t, a_t; \Phi_t)$, $I_{te}(z_t, a_t; \Phi_t)$, $k_{te}(z_t, a_t; \Phi_t)$, $l_{te}(z_t, a_t; \Phi_t)$, $c_{te}(\delta_t, a_t; \Phi_t)$, $a_{te}(\delta_t, a_t; \Phi_t)$, $I_{te}(\delta_t, a_t; \Phi_t)\}_{t=o}^{t=\infty}$ *for the households; functions for allocations* $\{Y_t(\Phi_t)$, $C_t(\Phi_t)$, $X_t(\Phi_t)$, $S_t(\Phi_t)\}$ *and aggregate inputs* $\{K_t(\Phi_t), L_t(\Phi_t)\}_{t=o}^{t=\infty}$; *their rental prices* $\{r_t(\Phi_t), i_t(\Phi_t), w_t(\Phi_t)\}_{t=o}^{t=\infty}$; *and a law of motion* $\{\Psi_t(\Phi_t)\}_{t=o}^{t=\infty}$ *for the measure of households such that:*

1. *All households solve their recursive problem:*

$$V_e(z_t, a_t; \Phi_t) = \max_{\{c_t, a_{t+1}\}} \left\{ U(c_t) + \beta \max_{I_{te}} \left\{ \begin{array}{c} -\phi + \int V_e(z_{t+1}, a_{t+1}; \Phi_{t+1}) G_e(z_t, dz_{t+1}), \\ \int V_w(\delta_{t+1}, a_{t+1}; \Phi_{t+1}) H_w(d\delta_{t+1}) \end{array} \right\} \right\} \tag{2.19}$$

$$\text{s.a. } c_t + a_{t+1} \leq \pi(z_t, a_t) + (1 + i_t) a_t$$

$$V_w(\delta_t, a_t; \Phi_t) = \max_{\{c_t, a_{t+1}\}} \left\{ U(c_t) + \beta \max_{I_{tw}} \left\{ \begin{array}{c} -\phi + \int V_e(z_{t+1}, a_{t+1}; \Phi_{t+1}) H_e(dz_{t+1}), \\ \int V_w(\delta_{t+1}, a_{t+1}; \Phi_{t+1}) G_w(\delta_t, d\delta_{t+1}) \end{array} \right\} \right\} \tag{2.20}$$

$$\text{s.a. } c_t + a_{t+1} \leq \delta_t w_t + (1 + i_t) a_t$$

2. *The firms solve their problem:*

$$\pi(z_t, a_t) = \max_{\{k_t, l_t, b_t\}} \{z_t f(k_t, l_t) - w_t l_t - r_t b_t\} \tag{2.21}$$

$$\text{s.a. } k_t \leq b_t + a_t \tag{2.22}$$

$$b_t \leq \theta \pi(z_t, a_t) \tag{2.23}$$

3. *The financial intermediator solves its problem and redistributes the income to households.*

4. *Prices are such that markets clear:*

$$Y_t = \int z_t f(k_{te}(z_t, a_t; \Phi_t), l_{te}(z_t, a_t; \Phi_t)) \, d\Phi_{et} + S_t i_s \tag{2.24}$$

$$= C_t + X_t \tag{2.25}$$

$$C_t = \int c_{te}(z_t, a_t; \Phi_t)\, d\Phi_{et} + \int c_{tw}(\delta_t, a_t; \Phi_t)\, d\Phi_{wt} \tag{2.26}$$

$$X_t = K_{t+1} - (1-\eta) K_t \tag{2.27}$$

$$K_t = S_t + \int a_{te}(z_t, a_t; \Phi_t)\, d\Phi_{et} + \int a_{tw}(\delta_t, a_t; \Phi_t)\, d\Phi_{wt} \tag{2.28}$$

$$L_t = \int \delta_t d\Phi_{wt} \tag{2.29}$$

5. *The arbitrage condition holds:*

$$r_t(\Phi_t) = i_t(\Phi_t) \geq i_s$$

6. *And the law of motion $\Phi_t(\Psi_t(\cdot))$ is consistent with individual behavior:*

$$\Theta_{t+1}(\cdot) = \Psi_t(\Theta_t(\cdot)) \tag{2.30}$$

The principal issue about this concept of equilibrium is that, given the non-convexity in the agent's problem, we can not guarantee in general the existence and uniqueness of this equilibrium. However, if we proceed with our assumption (and computational evidence) that the value functions are convex, existence and uniqueness can be shown to hold. These arguments, together with the assumptions made about the different stochastic processes, allow us to assure the existence of an invariant measure:

Proposition 2.2. *Given our previous assumptions and if an equilibrium exist, there is a unique invariant measure of households for this economy*

This proposition is a direct application of Theorem 12.10 in Stokey, Lucas and Prescott (1989).

With this invariant measure, we will concentrate in the study of the steady state of this economy:

Definition 2.3. *A Steady State for this economy is a recursive competitive equilibrium such that:*

1. *The constant measure of households coincides with the invariant measure implied by Proposition 1.*

2. *Input prices are constant over time.*

The main reason to concentrate in the analysis of the steady state is computational. The key issue arises because the household measure itself becomes a state variable. Measures are infinite dimensional objects that are not easy to represent in a finite way even if a lot of information is stored. As a consequence, keeping track of their evolution over time is a daunting task (see Krusell and Smith (1998) for a proposal to reduce the dimensionality of this problem). Moreover, in the absence of aggregate uncertainty or changes in the environment, the dynamics of the model are not that interesting by themselves. In the next section, we offer some quantitative exploration on the behavior of the model in this steady state.

3. A Numerical Example

This section tries to show some basic implications of this economy. As we mention in the introduction, our main objective is to gain insights about how a model following the lines of the one previously exposed can work. We understand our model as a small prototype of a future, more complete environment. As a consequence, aware of this preliminary stage of research, we will not calibrate the model in the usual sense since we will not try to match any data, but rather suggest some "reasonable" values for the parameters of the model and explore its behavior.

3.1. Functional Forms

First, we need to specify the functional forms. For the utility function a standard CRRA utility is assumed:

$$\frac{C^{1-\sigma}-1}{1-\sigma} \tag{3.1}$$

where $\sigma > 0$. The final good technology is Cobb-Douglas without imposing homogeneity of degree one:

$$z_t k_t^{\alpha} l_t^{\gamma}$$

such that $\alpha + \gamma < 1$

The sets E_1, E_2, W_1, W_2 will have each of them just two points (with $\sigma-$algebra equal to the power set). The support of E_1 and E_2 will coincide, as well as the support of $W_1$and W_2. We will call these points b (for bad) and g (for good). Consequently, the kernels $G_e(\cdot)$ and $G_w(\cdot)$ take the form of a transition matrix:

$$G_e(\cdot) \;=\; \begin{pmatrix} \lambda_{gg}^{e} & \lambda_{gb}^{e} \\ \lambda_{bg} & \lambda_{bb} \end{pmatrix} \tag{3.2}$$

$$G_e(\cdot) = \begin{pmatrix} \lambda^w_{gg} & \lambda^w_{gb} \\ \lambda^w_{bg} & \lambda^w_{bb} \end{pmatrix} \tag{3.3}$$

and the probability measures:

$$H_e(\cdot) = (\lambda^e_b, 1) \tag{3.4}$$
$$H_e(\cdot) = (\lambda^w_b, 1) \tag{3.5}$$

3.2. Values for the Parameters

As mention before, no attempts are made here to match empirical data with the results of the model but just to explore some quantitative implications for a set of "reasonable" numbers. The numbers chosen are:

1. For the preference parameters, 0.94 for the discount factor β, 2 for σ and 0.05 for ϕ, the effort of running a firm.

2. For the final good production function, $\alpha = \gamma = 0.4$, such that $\alpha + \gamma = 0.8 < 0$ as required.

3. The appropiability factor $\theta = 0.6$.

4. The interest rate i_s of the storage technology is 0.04 and depreciation $\eta = 0.06$.

5. The points in E_1, E_2 are $\{1.4, 1.8\}$.

6. The points in W_1, W_2 are $\{0.7, 1.3\}$.

7. The transition matrices:

$$G_e(\cdot) = \begin{pmatrix} 0.8 & 0.2 \\ 0.2 & 0.8 \end{pmatrix} \tag{3.6}$$

$$G_e(\cdot) = \begin{pmatrix} 0.8 & 0.2 \\ 0.2 & 0.8 \end{pmatrix} \tag{3.7}$$

   These matrices are then equal, symmetric, with a high level of persistence (the second highest eigenvalue is 0.6) and satisfy the assumptions explained in Section 2.

8. The initial distributions:

$$H_e(\cdot) = (0.9, 0.1) \tag{3.8}$$
$$H_e(\cdot) = (0.6, 0.4) \tag{3.9}$$

This choice of points imply that most new firms will have low productivity and most new workers also will provide low amount of labor services although in a less skewed fashion than in the first distribution.

3.3. Results

The parameters chosen above assure that the firms will be always constrained in their financial decisions in the range of relevant assets (those with (computer-) positive mass of households), regardless of their productivity level. Figure 4 shows the constrained demand for capital given the level of assets of the household. This demand has a constant slope, higher than the 45 degree line, represented by a dotted line. The difference between the total capital demand and the 45 degree line represents the amount borrowed by the firm from the financial intermediator.

[Figure 4 here]

Figure 5 plots the labor demand that shows an equal pattern, two positive-slope demand on the level of assets without any leveling in the relevant set.

[Figure 5 here]

Finally, Figure 6 shows the level of profits, also increasing in the level of assets as expected.

[Figure 6 here]

The value functions are plotted in Figures 7 and 8 for the entrepreneur and the worker respectively. As we have mentioned before in the discussion about the convexity of the household problem, these value functions are concave except for very low level of assets. This feature was robust to several different changes in the parameters and reinforce the belief that theoretical departures from concavity are not going to be specially severe. In any case, this issue deserves a more careful exploration in the future.

[Figure 7 here]
[Figure 8 here]

The total production in the economy is 1.959 units of final good, where 1.8 are produced by the firms and 0.1959 by the storage technology. The wage is 1.154. The interest rate is 0.04, equal to the storage technology. This implies that even at this minimum level (where the user cost of capital is 0.1), capital demand is lower than capital supply. The intuition behind this result is straightforward: households want to accumulate a relatively big amount of assets as a buffer stock and as collateral to become entrepreneurs. Then, even with very low interest rates, the capital market will not clear. We have checked the robustness of this result. Even assuming $i_s = 0$, capital supply is still higher than capital demand. Moreover, the depreciation rate, 0.06, is already in the lower areas of plausible values, so changing this parameter will not help us greatly. The only other possibility is then having $i_s < 0$. We do not see this alternative neither very interesting nor empirically relevant. Basically this result suggest that limits in the enforcement technology of contracts can have substantial effects on the level of intermediation in a economy even if credit markets are otherwise perfectly deregulated.

The measure of households is plotted in Figure 9. Each of the four subplots represent a one-dimensional marginal distribution, entrepreneurs with bad productivity shock, entrepreneurs with good productivity shock, workers with bad productivity shock and workers with good productivity shock. The strong symmetry of the transition matrices is clear if we compare the different distributions. In particular, they are basically the same distribution at different scales except for the entrepreneur with a high shock were the relative sizes are skewed in favor of the households with a higher level of assets as predicted by the theory.

[Figure 9 here]

The principal characteristic of these measures is the relatively high level of assets accumulated by households. Nearly all the distribution is above 6 units of final good, or more than five times the annual wage for one unit of labor services. As it has been already explained, the total lack of intertemporal trade and the advantages of being an entrepreneur create strong incentives to accumulate wealth well above the observed patterns for most of the population. At the same time, it is not possible to generate as much inequality as observed in the economy. These problems to generate empirically plausible wealth distributions are shared by most heterogenous agents models (see Quadrini and Ríos-Rull (1997)).

It is of great interest to compare the results of this model with the case where firms do not have any borrowing constraint, even if intertemporal trade is still precluded, beyond asset accumulation, with a positive constraint.

The first major difference is the level of total production, 2.375, a 20% higher than in the first economy. We can see then how even a very stylized model as ours can generate substantial differences in income per capita. In addition, all this output is generated by firms, as the interest rate goes up to 4.7% and the financial intermediator does not have any incentive to operate the storage technology in the period (although it still uses it to carry goods from one period to another). Wages also go up even more, to 1.74, a 56% increase.

Another important feature is that the measure of firms is lower in this economy, 0.455 instead of 0.522. This counterintuitive result derives from this higher wage: now there is a lower incentive to operate small, low productive firms and a high incentive to operate a small number of highly productive plants. Indeed this is what empirical evidence strongly suggest: there is substantially less self-employment in the richer nations and the average size of firms is bigger (for a review of the empirical evidence see Qintin (1999)). We consider the ability of this very small model to reproduce this stylized fact as an important success of the theory.

Again, in Figure 10 we plot the four marginal distributions for the case in which firms do not have any borrowing constraint. Now, even the subplots still resemble each other quite a bit, we appreciate more differences among them. It is important to notice that now some agents have very small amount of assets or even zero. Given that the desire to accumulate assets to became an entrepreneur has disappeared, the only motive left is consumption smoothing and those households with repeated bad shocks will tend to accumulate in the left tails of the distribution.

[Figure 10 here]

4. Conclusions

In this paper we have presented and simulated a small model of financial intermediation and entrepreneurship. Despite all its simplifications, we have found very interesting results. Market credit imperfections can have important effects on the behavior of the economy: when the level of assets of the household enter into the decision of becoming an entrepreneur, it will no longer be the case that the most productive firms are operated but those owned precisely by the asset-rich households. We have presented a preliminary number for this effect, 20% of income per capita, that strongly suggest we are not dealing with minor issues (we can compare this number for instance with the famous Lucas (1987) number for the welfare cost of business cycles to see that it is at a totally different order of magnitude). We have also found that with market imperfections more households own firms than in the case without market imperfections. This is another remarkable result since the empirical evidence supports this claim. Also, with credit market imperfections, an important part of the assets of the economy can be left unproductive in some kind of storage technology when there still are profitable investment opportunities. This kind of situation also seems to resemble the anecdotal evidence of countries with badly-working legal systems and it will help to explain the observed correlation between financial development, measured as the level of financial intermediation over income, and economic growth (for an extensive review of all these aspects and of existing evidence see Levine (1997)).

We are aware, however, that even if this small model is able to generate all these results, there is still a substantial amount of work to be done. In particular, a more complete environment is needed, trying to find a microeconomic fundation for the restrictions to intertemporal trade and a complete treatment of empirical issues in the calibration. Also, the study of the relation of aggregate shocks with firm dynamics in the presence of credit imperfections is an open issue. Some research on this area is presented in Carranza and Galdón-Sánchez (1999) and in Fernández-Villaverde and Galdón-Sánchez (1999), but there still is substantial room from improvement.

Despite of the preliminary level of this research, some policy implications seem to be clear. Institutions do matter. In particular, institutions that allow legal contracts to be enforced. Without a proper set of institutions, we can simultaneously observe agents who want to lend and agents who want to borrow and yet, theory is not able to reach Pareto improving trades just because they do not have any reason to believe that the other agent will meet its contractual obligations. Learning how to overcome these problems and how to design efficient institutions is an area of research that will yield profitable results for social arrangements.

5. Appendix: Computation of the Model

This appendix describes the computation of the model. The basic algorithm used to compute the steady state is:

- Discretize the individual state space by choosing a finite grid for assets, $\widetilde{a} = \{0, ..., a_{\max}\}$. Choices of $a > a_{\max}$ can be computed using linear interpolation (although given the parametrization used this was never the case). The joint measure over assets, shocks and occupational activity can be then represented as a finite-dimensional array.
- Guess an initial distribution of agents $\Phi_0(\cdot)$ and a steady state equilibrium value of input prices $\{r, w\}$.
- Compute the demand for inputs and the level of operation of firms given the asset position of the owners using a fixed point iteration procedure.
- Solve the problem of entrepreneurs and workers with a double value function iteration.
- Compute the policy functions associated with the value functions.
- Use the policy functions to find the invariant measure $\Phi(\cdot)$ associated with these policy functions.
- Check market clearing given policy functions and the measure $\Phi(\cdot)$.
- Update the price vector until markets clear.

The algorithm was repeated several times using different initial guesses to check that the convergence to an equilibrium is global. The algorithm was repeated for the case where firms can operate at optimal levels changing step 3 appropriately. The code was written in Matlab 5.3 and run on a Windows NT Intel workstation and it is available from the authors upon request.

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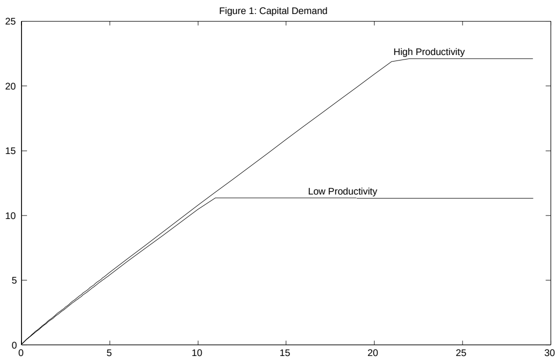


Figure 1: Capital Demand
High Productivity
Low Productivity
25
20
15
10
5
0
0
5
10
15
20
25
30

Figure 6.1:

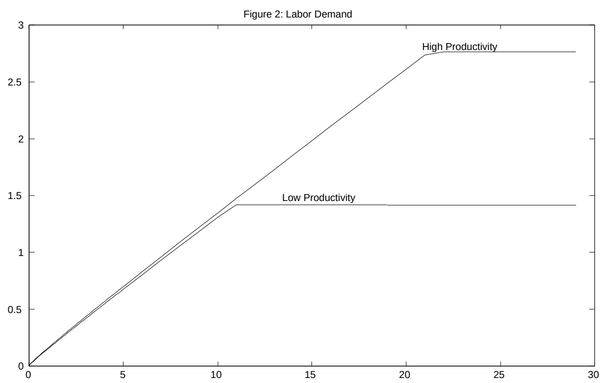


Figure 2: Labor Demand
High Productivity
Low Productivity
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30

Figure 6.2:

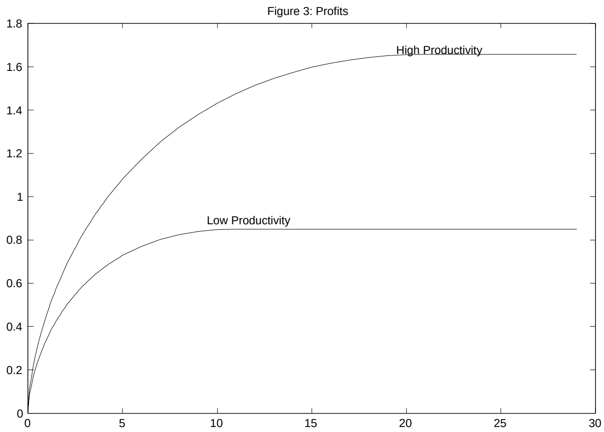


Figure 3: Profits
High Productivity
Low Productivity
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30

Figure 6.3:

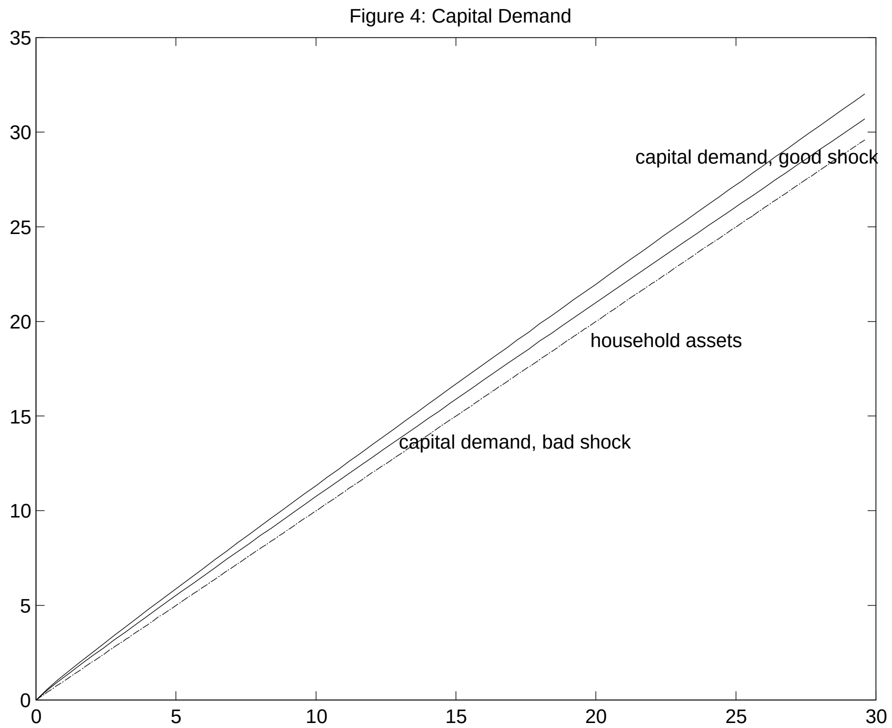


Figure 4: Capital Demand
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
capital demand, good shock
household assets
capital demand, bad shock

Figure 6.4:

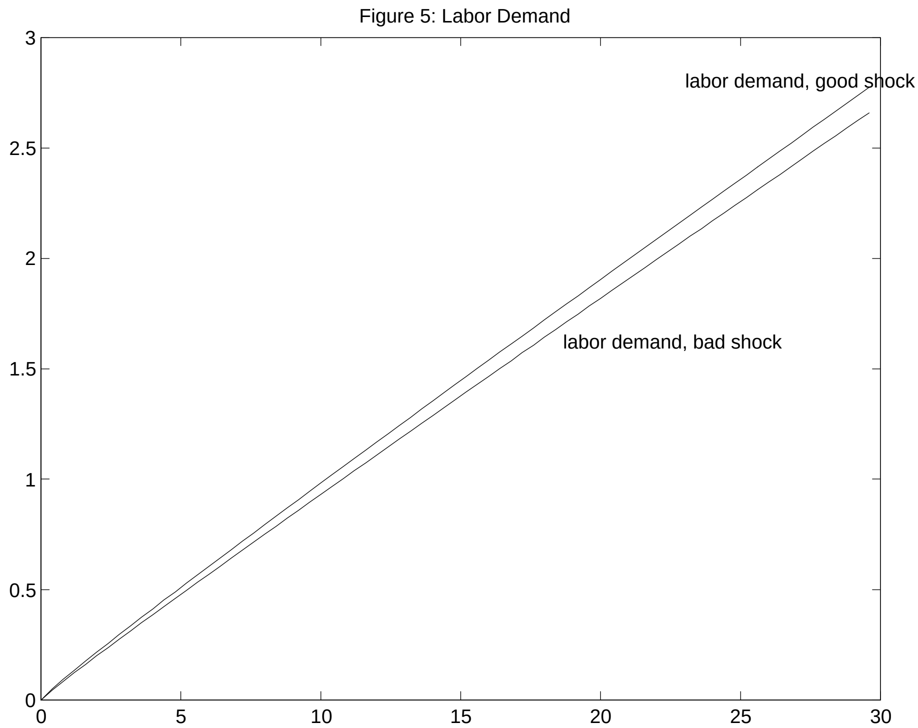


Figure 5: Labor Demand
labor demand, good shock
labor demand, bad shock
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30

Figure 6.5:

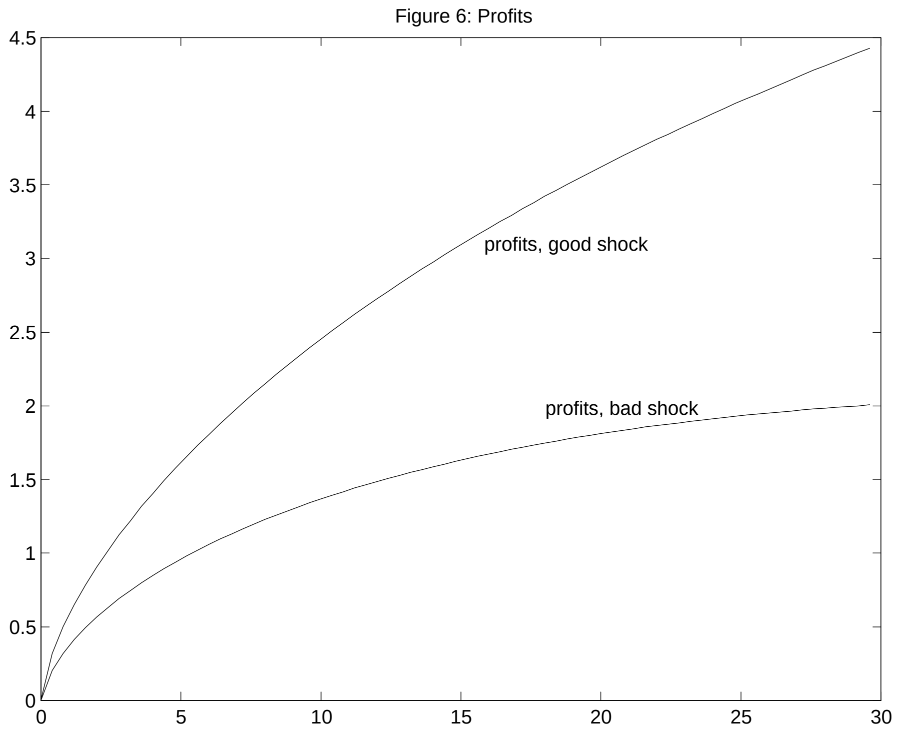


Figure 6: Profits
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
profits, good shock
profits, bad shock

Figure 6.6:

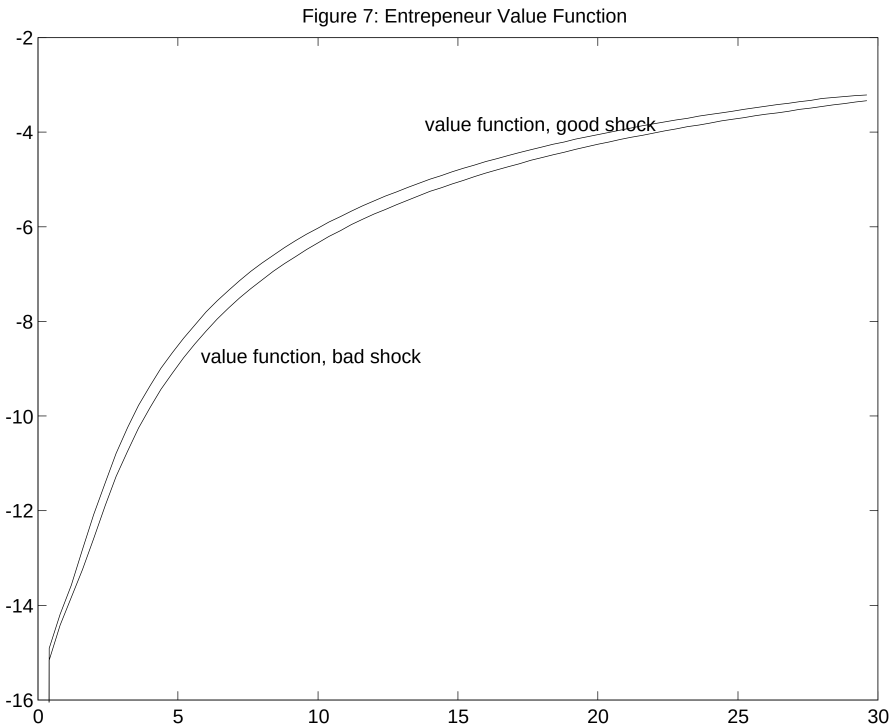


Figure 7: Entrepeneur Value Function
value function, good shock
value function, bad shock
-2
-4
-6
-8
-10
-12
-14
-16
0
5
10
15
20
25
30

Figure 6.7:

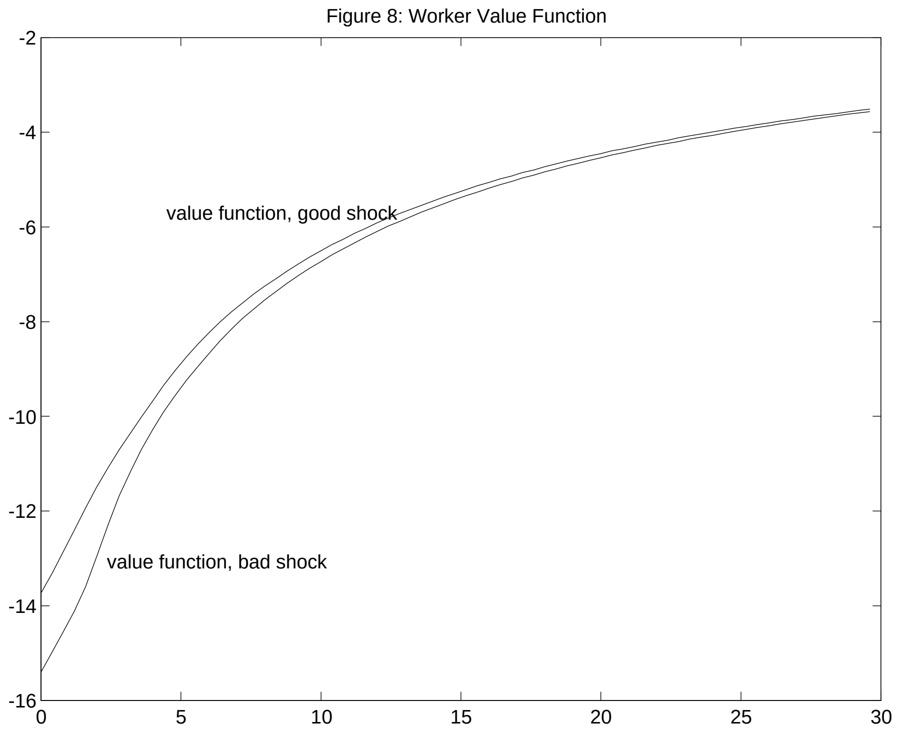


Figure 8: Worker Value Function
value function, good shock
value function, bad shock
-2
-4
-6
-8
-10
-12
-14
-16
0
5
10
15
20
25
30

Figure 6.8:

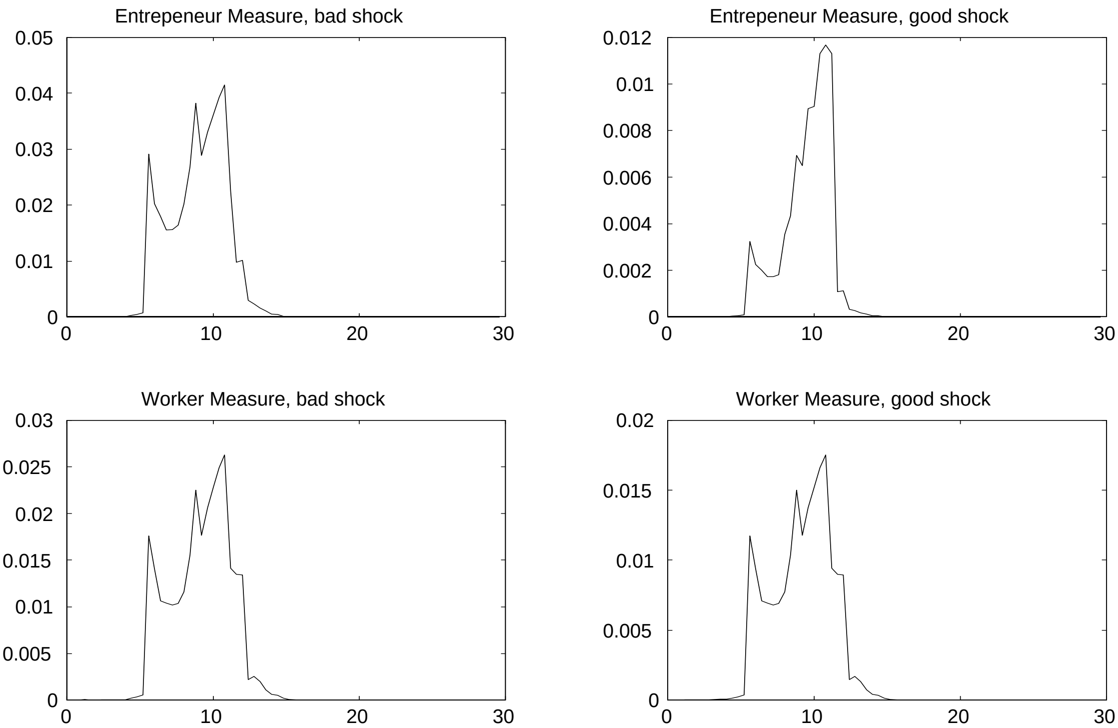
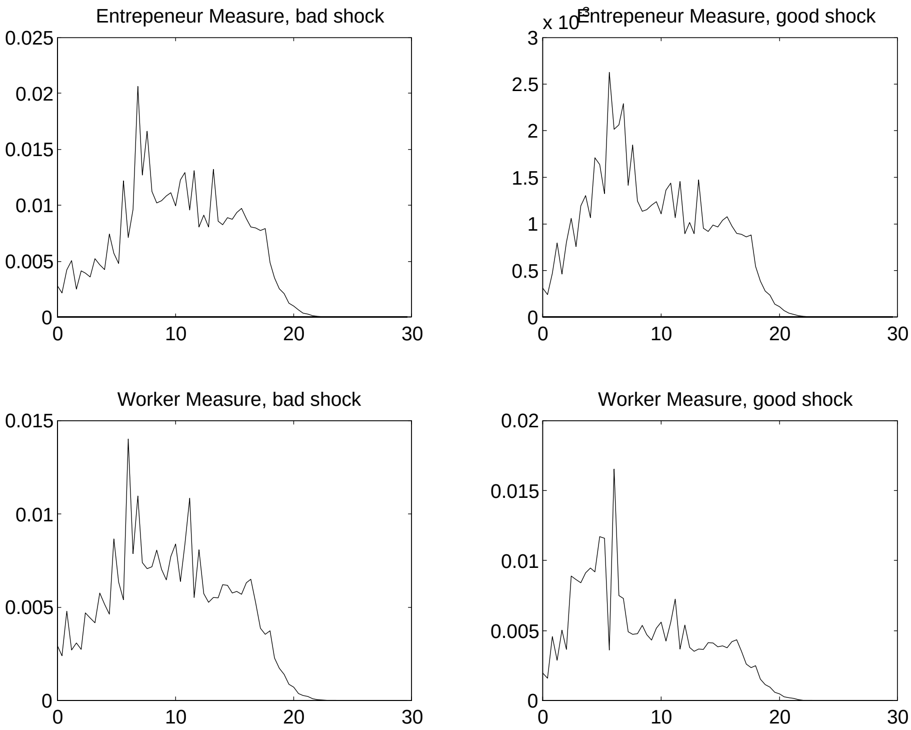

Entrepeneur Measure, bad shock
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
Entrepeneur Measure, good shock
0.012
0.01
0.008
0.006
0.004
0.002
0
0
10
20
30
Worker Measure, bad shock
0.03
0.025
0.02
0.015
0.01
0.005
0
0
10
20
30
Worker Measure, good shock
0.02
0.015
0.01
0.005
0
0
10
20
30

Figure 6.9:



Entrepeneur Measure, bad shock
0.025
0.02
0.015
0.01
0.005
0
0
10
20
30
x 10
-3
Entrepeneur Measure, good shock
3
2.5
2
1.5
1
0.5
0
0
10
20
30
Worker Measure, bad shock
0.015
0.01
0.005
0
0
10
20
30
Worker Measure, good shock
0.02
0.015
0.01
0.005
0
0
10
20
30

Figure 6.10: