Credit Market Frictions and the Allocation of Resources over the Business Cycle*

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Abstract

In a seminal paper, Davis and Haltiwanger (1990) demonstrated that recessions are associated with an increase in job reallocation, at least in the manufacturing sector. The conventional view has interpreted this as evidence of "cleansing": less productive jobs are destroyed in recessions, and resources are reallocated towards more productive uses. But empirical evidence has failed to find evidence that resources are reallocated towards more producive uses during recessions. This paper provides an explanation for why certain less efficient projects might be able to survive recessions even if their more efficient counterparts do not. Building on a model of Acemoglu (1998), it generates selection of less efficient projects as an equilibrium outcome, and provides some empirical support for the claim that more efficient production arrangements will be more vulnerable to credit market constraints.

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Introduction

Recent empirical work by Davis and Haltiwanger (1990) has renewed interest among economists in how business cycles affect the allocation of resources. Davis and Haltiwanger find that job reallocation, even within narrowly defined industries, tends to be more concentrated in recessions. This suggests business cycles might play an important role in determining how scarce resources in the economy are allocated across different uses. In explaining why this might be the case, various authors have argued that increased reallocation during recessions provides evidence in favor of the old Schumpeterian view that recessions promote a more efficient allocation of resources. One version of this hypothesis, which is advanced in Caballero and Hammour (1994, 1996) and Mortensen and Pissarides (1994), emphasizes that recessions drive out or "cleanse" all but the most efficient production units, since only these are sufficiently profitable to survive during hard times. Resources that are employed in less efficient uses prior to the recession will inevitably drift to the more superior arrangements that prevail. A distinct but related version of this hypothesis, advanced by Hall (1991, 2000), Cooper and Haltiwanger (1993), and Aghion and Saint Paul (1998), argues that recessions encourage agents to engage in efficiency-enhancing activities instead of production because the return to the latter activity declines during recessions. If efficiency-enhancing activities include seeking out more productive uses for resources, recessions will lead to a more efficient allocation of resources. While these explanations do not necessarily imply that there is inherent virtue in bad times, as some have concluded from this theory, they do identify recessions as ameliorating rather than exacerbating the misallocation of employed resources.

Despite the growing consensus in favor of this explanation for the increase in job reallocation during recessions, empirical work that investigates which jobs survive downturns has failed to find evidence in support of this view. For example, Griliches and Regev (1995) and Bailey, Bartelsman, and Haltiwanger (1998) examine a panel dataset of manufacturing plants in Israel and the U.S., respectively. For each plant, they use output per worker as a measure of how productive resources are at that site. Their findings provide only weak support for the claim that changes in the composition of employment across plants act to increase aggregate productivity in downturns, and in some industries the effect goes in the wrong direction. Barlevy (1999) likewise fails to find support for the claim that jobs which survive recessions tend to be more productive using wage data to identify productivity as an alternative to average output per worker. Adopting a more historical perspective, Bresnahan and Raff (1991) and Bertin, Bresnahan, and Raff (1996) examine which plants survive the Great Depression in particular industries. In both the automobile and the blast furnace industry, they find no evidence that among those establishments which survive through the Depression, those who were more productive tended to attract more resources. Moreover, in the blast furnace industry, they find no correlation between productivity and the propensity for firms to shut down. Although they do find that more productive plants in the automobile industry were more likely to survive the Depression, Bresnahan and Raff (1998) subsequently argue that these plants shut down because of avoidable costs rather than because they were less productive.[1] Even over longer horizons, there is little evidence that reallocation in recessions is associated with improved productive potential. Schuh and Triest (1998) compare growth in total factor productivity in the five years after a recession with growth in the same industry in the five years before a recession. They find no obvious relationship between the extent of reallocation during the recession and subsequent productivity growth across industries.

The above findings suggest we need an alternative explanation for increased job reallocation during recessions that does not predict only the most efficient production arrangements survive recessions. This paper offers one such explanation which relies on credit market frictions. I begin with a simple example which illustrates the role credit market imperfections could play in reversing the cleansing pattern described in previous work. The example shows the reason previous models imply a cleansing pattern is because they assume agents are governed only by participation constraints. This assumption implies that the decision to produce hinges on whether there is enough surplus to keep agents interested in production. Consequently, participation constraints bind first for those projects which generate the least amount of surplus, so that recessions select the most efficient projects which generate the most surplus. But the same intuition need not hold if we introduce other constraints into the model. For example, there is no analogous argument that incentive constraints necessarily bind first for projects that generate less surplus; projects which generate more surplus might also offer participants greater incentives to deviate, making them more fragile. I illustrate this in a model where imperfect enforceability of loan contracts gives agents an incentive to default on their loans. The departure from the standard cleansing pattern in this example is analogous to the mechanism which explains why cockroaches are more likely to survive harsh climactic episodes than other animals. Specifically, although cockroaches are arguably neither more efficient at finding food nor more productive at generating offspring than other animals, they require very little resources

[1] In the same spirit of using historical case studies, Baden-Fuller (1989) examines exits in the British steel castings industry during the 1980 recession. He considers plant profitability rather than productivity, and finds that some of the less profitable plants were among those which survived.

to sustain themselves. When food becomes scarce, animals which require very little of it are more likely to survive, independently of efficiency considerations. Credit in my model acts like food in that regard; during recessions, it is hard to find lenders willing to extend large amounts of credit, and so the projects that require less credit survive regardless of their underlying efficiency. Since there is no *a priori* reason for why more efficient production arrangements will rely on either more or less credit, inefficient projects could in principle survive recessions while more efficient projects do not. Building on this example, I develop a general equilibrium model in which the surplus associated with different uses of resources is determined endogenously. The model generates an endogenous relationship between the efficiency of different projects and the amount of credit they require. In particular, less efficient projects require smaller amounts of credit in equilibrium, implying they will have an advantage in surviving downturns. The final section of the paper presents some preliminary evidence which suggests firms that borrow more resources do in fact appear to be more productive as the model predicts, at least when productivity is measured in terms of output per worker.

I should note that although there is already a large literature on both credit market frictions and on the role of incentive constraints in models of resource allocation, it does not address the issues raised in this paper. On the one hand, many of the current models of credit market frictions such as Kiyotaki and Moore (1997) abstract from heterogeneity in productive efficiency across entrepreneurs, focusing instead on the role of heterogeneity in net worth among entrepreneurs that have access to the same technology. Hence, most models that study credit market frictions are silent on whether production arrangements that fall prey to financing constraints represent more efficient uses of resources. In fact, the one model in this literature that assumes heterogeneity in productivity, Bernanke and Gertler (1989), imposes technological assumptions that imply the opposite correlation between the amount of borrowing and productive efficiency, so that credit market frictions continue to select the most efficient uses of resources. Similarly, existing work that introduces incentive constraints into models of resource allocation, including most recently Ramey and Watson (1997) and Caballero and Hammour (1998), have not investigated the potential of such constraints to reverse the cleansing pattern described above. Instead, they invoke moral hazard to argue that jobs which generate positive surplus may nevertheless be destroyed during recessions because agents cannot credibly commit not to deviate on their obligations. But these models continue to imply only the most efficient production arrangements remain active in recessions. Put another way, these models use incentive constraints to generate excessive "cleansing" during recessions – recessions throw out some babies along with the bathwater – but they still predict recessions are associated with cleansing in these sense that all but the most efficient uses of resources are shut down. By contrast, this paper argues recessions could strike at the more efficient uses of resources and leave intact less efficient forms of production. This distinction is potentially important. For example, welfare calculations based on the assumption that only the most efficient uses of resources survive recessions would underestimate the true costs of recessions when, as appears to be the case in the data, some of the relatively less efficient uses of resources survive instead. Likewise, policy recommendations that seek to protect jobs which emerge during recessions may inadvertently foster the misallocation of resources rather than promoting their efficient use.

The paper is organized as follows. Section 1 constructs a simple example which illustrates why incentive constraints need not imply the same cleansing pattern as models that only allow for participation constraints. Section 2 develops a general equilibrium model that generates the assumption which insure the selection of less efficient projects during recessions as an endogenous equilibrium outcome. Section 3 discusses empirical evidence on the role of credit markets in generating the selection of less efficient projects. Section 4 concludes.

1. A Simple Example

I begin with a simple example that conveys the intuition for why credit market frictions can reverse the cleansing pattern described above. Consider an economy with a continuum of agents. Half are endowed with an arbitrarily large amount of a consumption good. The other half, whom I will refer to as entrepreneurs, have no consumption goods at their disposal, but have access to a technology that can produce consumption goods. This technology can only be carried out in indivisible units, and each agent can operate at most one project. However, not all agents have access to the same technology. Instead, there are two types of projects, indexed by $j \in \{0, 1\}$, and each entrepreneur has access to only one type of project. Project j requires a fixed input of k_j units of the consumption good, and yields p_j units of the consumption good as output. This production structure is common knowledge among all of the agents in the economy. Moreover, everyone can observe what technology each agent has access to.

Since entrepreneurs are not endowed with consumption goods, they will have to borrow inputs from those agents who are. Suppose initially that loan contracts are perfectly enforceable, so borrowers can be compelled to repay their debts. Competition will drive down the profits on loans to zero, so that entrepreneurs who wish to produce need only promise to repay the same amount k_j which they borrow. The profits to an entrepreneur who produces using technology j are $p_j - k_j$, and an entrepreneur will borrow funds and produce if and only if

$$p_j - k_j \geq 0 \tag{1.1}$$

Condition (1.1) is just a standard participation constraint. It is analogous to the participation constraints employed in previous models which study the allocation of resources across jobs, although these models typically allow for matching processes in which more there are participation constraints for all parties involved in production rather than just one.

The surplus from each project over the alternative option of not producing is just the net output of the project $p_j - k_j$. I will refer to a project that yields more surplus as a more efficient project, since we can always engineer a Pareto improvement by giving an entrepreneur access to a technology that yields higher net output. Put another way, such a project involves a more efficient use of scarce entrepreneurial resources.[2] Without loss of generality, suppose

$$p_1 - k_1 \geq p_0 - k_0 \tag{1.2}$$

so that project 1 is weakly more efficient. To determine what type of projects are more likely to survive recessions, suppose the parameters of the two production technologies are such that entrepreneurs engage in production for only one type of project $j \in \{0, 1\}$. Since an entrepreneur will employ resources for production if and only if the participation constraint (1.1) holds, it follows that only one project will be carried out if one project yields positive net output and the other yields negative output. Applying (1.2), it follows that

$$p_1 - k_1 \geq 0 \geq p_0 - k_0$$

Generically, then, it must be the case that if only certain production arrangements survive recessions, it will be those which are more efficient. The reason is straightforward: since production decisions are governed only by participation constraints, a project will survive if and only if it generates enough surplus to encourage the entrepreneur to participate in the project.

[2] This raises an important point about using productivity to measure underlying efficiency. As noted in the Introduction, empirical applications typically use productivity measures to proxy for the efficiency of a given production arrangement. But it is important to use the correct measure of productivity, namely the productivity of the scarce input that limits the scale of production. In this particular example, there is a limited number of entrepreneurs but an excess supply of consumption inputs. Hence, more efficient projects are those which yield more output per unit of entrepreneurial effort rather than per unit of consumption input, i.e. allocative efficiency is measured by how well the scarce resource is employed.

Although the intuition that only the most efficient projects survive seems almost tautological, it does not necessarily hold once we allow for additional constraints on the production process. To illustrate this, consider the case where loans are no longer perfectly enforceable. Instead, suppose there is only limited enforceability: an entrepreneur can be compelled to pay back his loan only if he undertakes production, in which case a third party can take control of the project and insure proper repayment of the loan. However, there is nothing to preclude the entrepreneur from running away with the output he borrows and directly consume it (or more generally a fraction of the output he borrows if we assume diversion is costly). Under this scenario, an entrepreneur will go ahead with a project if and only if it nets him more output than the amount he borrows. Formally, the entrepreneur will produce if and only if the incentive constraint

$$p_j - k_j \geq k_j \tag{1.3}$$

is satisfied. Note that since $k_j \geq 0$, (1.3) implies (1.1). If we again consider the case in which only one project j survives, then for $i \neq j$, we have

$$p_j - 2k_j \geq 0 \geq p_i - 2k_i$$

In contrast with the previous case, condition (1.2) is no longer enough to establish that $j = 1$. A simple calculation confirms that if

$$k_1 - k_0 < p_1 - p_0 < 2(k_1 - k_0) \tag{1.4}$$

project 1 will be more efficient, in line with (1.2), but only project 0 will satisfy the incentive constraint. The first inequality in (1.4) insures project 1 is more efficient, while the second inequality in (1.4) insures the less efficient projects will be those which satisfy the incentive constraint. Intuitively, the second inequality requires $k_1 - k_0$ to be sufficiently large, i.e. it requires that the more efficient project depends on a larger amount of borrowed funds. Since the incentive for agents to default on loans is increasing with loan size, this feature implies less efficient projects will be more likely to survive.

It should be emphasized that the above example does not rely crucially on the assumption of limited enforcement. Rather, the key feature behind this example is that projects which require more borrowing are more vulnerable to incentive constraints. Other frictions in the credit market could likewise generate the result that tight credit constrains first affect those projects which borrow larger amounts of resources. For example, Bernanke and Gertler (1989) generate this same pattern in a costly state verification model; larger amounts of credit offer agents greater incentive to misrepresent their earnings, and are therefore associated with larger expected agency costs for lenders. Likewise, Kiyotaki and Moore (1997) generate this pattern in a model where borrowers cannot commit to not renegotiate loan contracts and are limited by the amount of collateral they can offer. Hence, as long as projects which require more borrowing also happen to generate more surplus, standard incentive problems in the credit market can reverse the conventional prediction that recessions shake out all but the most efficient uses of resources. However, the example above only illustrates a theoretical possibility, one which relies on a seemingly arbitrary restriction on technological parameters given by (1.4). At this stage, it difficult to assess the plausibility of the hypothesis that increased reallocation during recessions could select less efficient projects instead of cleansing out all but the most efficient. Towards this end, the next section develops a model in which the surplus of different projects is determined endogenously and yields condition (1.4) as an equilibrium outcome, while Section 3 presents empirical evidence that provides some support for the condition (1.4).

As a final remark, this example readily illustrates the differences between this paper and previous work cited in the Introduction that incorporates incentive constraints in models of resource allocation. Translated into the notation of this example, both Ramey and Watson (1997) and Caballero and Hammour (1998) assume a constant cost k for all projects while maintaining the assumption that some projects generate more output than others. This specification is inconsistent with the second inequality in (1.4), and therefore rules out the possibility that more efficient projects are more likely to survive.[3] In fact, condition (1.4) can only be satisfied if both the costs of a project k_j and the output of a project p_j are different across projects. Since existing models adopt the convenient assumption that either input costs or productivity are constant across projects, they obscure the fact that introducing incentive constraints can overturn the prediction that only the most efficient projects survive recessions. This is fine, since both Ramey and Watson and Caballero and Hammour emphasize a different aspect of incentive constraints, namely that a project might be destroyed even when it yields positive net output, i.e. (1.3) might be violated for projects with strictly positive net output, i.e. $p_j - k > 0$. This prediction is also a feature of the example above, since a project has to generate enough surplus to satisfy the incentive constraint (1.3). But the novel contribution of this paper lies in demonstrating that recessions could destroy more efficient uses of resources while leaving less

[3] In a similar vein, Bernanke and Gertler (1989) assume enterpreneurs have access to projects that yield an identical amount of output $p \equiv 1$, but some projects are more efficient than others becuase they require fewer inputs to produce this unit of output, i.e. $k_1 < k_0$. This specification again precludes the second inequality in (1.4), and thus predicts that the most efficient projects will survive in downturns.

efficient uses intact, not in demonstrating that recessions can be associated with an inefficiently high productivity threshold that jobs must satisfy.

2. A General Equilibrium Model

The example in the previous section explains why it is *possible* for less efficient projects to survive even as more efficient projects do not. However, the example suffers on two counts in providing a useful model for understanding the nature of resource allocation over the business cycle. First, there is nothing in the example that relates selection to aggregate economic conditions. Second, the prediction that more efficient projects are less likely to survive hinges on a seemingly arbitrary restriction on the production technology, namely that efficient projects happen to be those which require more credit. To address these issues in a more satisfactory way, I now develop a general equilibrium model in which the only primitive assumption is that different projects require different amounts of borrowing. Agents choose which project to carry out, and the level of surplus associated with each project is determined in equilibrium given the choices of all relevant economic agents. The model illustrates two mechanisms that generate condition (1.4) as an equilibrium outcome rather than as a restriction on production technology; the first channel relies on binding incentive constraints, while the second relies on holdup problems due to bargaining frictions. To gain some insights on the role economic conditions play in determining the allocation of resources, I examine the effects of changes in the level of aggregate productivity on the allocation of resources across the different types of projects. A lower level of aggregate productivity tightens the incentive constraints on projects which borrow more funds, forcing resources to be reallocated out of these more efficient projects and into other less efficient uses. Thus, recessions will be associated with a reallocation of resources, but this reallocation will not select the most efficient uses of resources as previous authors have argued.

2.1. Binding Constraints

To retain comparability with the previous section, I consider a static model in which all decisions occur within a period. It is straightforward to recast the model as a dynamic overlapping generations economy in which productivity fluctuates over time, along the lines described in Bernanke and Gertler (1989), but this would not add much insight beyond the static model. The model is similar to Acemoglu (1998) in the way it models the endogenous determination of surplus, which in turn borrows from earlier work by Pissarides (1994). The economy is populated by a continuum of agents of mass 2. Half of the agents are endowed with an arbitrarily large amount of consumption goods, in a sense to be made precise below. Agents who are not endowed with consumption goods nevertheless have access to a production technology and will be referred to as entrepreneurs. The technology entrepreneurs have access to converts consumption goods into one of two types of intermediate goods, indexed by $j \in \{0, 1\}$. The intermediate goods they produce can subsequently be converted into final consumption goods using a constant returns to scale CES production function

$$f(y_0, y_1) = z\left(y_0^\rho + y_1^\rho\right)^{\frac{1}{\rho}}$$

where y_j is the amount of intermediate good of type j used, z is a measure of aggregate productivity, and $\rho \in (0, 1)$ is the elasticity of substitution between the two intermediate goods. This latter technology is readily available to all agents in the economy. Since the technology for producing consumption goods exhibits constant returns to scale, and since profits will be zero in equilibrium, I can assume without loss of generality that final goods are produced by one single agent. I normalize the price of the final good to equal 1, and denote the price of intermediate good j by p_j.

The production of intermediate goods is as follows. Producing one unit of intermediate good j requires a fixed cost of k_j units of the consumption good. Agents can choose which intermediate good to produce, but each agent has enough entrepreneurial resources (i.e. attention span) to produce no more than one unit of one intermediate good. The key assumption is that different types of projects require different amounts of initial resources, i.e. k_j is not identical for the two intermediate goods. To remain consistent with the notation in the previous section, I assume project 1 requires more resources, i.e. $k_1 > k_0$. It will prove useful in what follows to assume that the difference between the two is proportional to z, i.e. $k_1 = k_0 + zk$ for some constant k. This assumption is deliberately ad-hoc. It can be derived from first principles by assuming that the process of converting a unit of intermediate good 0 into a unit of intermediate good 1 requires a fixed k' units of intermediate goods rather than a fixed amount of the consumption good. In this case, the difference in costs for the two types of capital will be equal to $(p_0 + p_1)\,k'$, which is proportional to z in equilibrium as long as no constraints are binding.[4] But this modification

[4]This is because in equilibrium, the price p_j is equal to the marginal product of intermediate good j, $\partial f/\partial y_j$. If z is sufficiently large to satisfy all relevant constraints, in a sense made precise in Proposition 1, the sum of these derivatives evaluated at the equlibrium quantities y_0 and y_1 will be proportional to z. In other words, there exists a z^* and a k and such that $(p_0 + p_1)\,k' = zk$ if $z > z^*$.

would introduce unnecessarily complicated notation and detail. As will become clear further below, this assumption is useful in ruling out spurious changes in the allocation of resources that arise from changes in relative prices and costs between the two intermediate goods as aggregate productivity z changes. The essential results depend on differences in costs across the two projects and would be unaffected by assuming such differences do not depend on z.

Agents who wish to produce need to borrow the consumption goods necessary to initiate production. Since the previous example establishes that incentive constraints are essential for generating a reversal of the cleansing pattern, I need to introduce incentive problems into this framework. I therefore maintain the assumption of imperfect enforceability in the credit market as described in the previous section, i.e. agents can always run away with the funds they borrow instead of using it to produce. However, I need to be more specific about the nature of loan markets than in the previous section in order to characterize an equilibrium outcome. It is convenient to focus on the case where entrepreneurs borrow funds sequentially, i.e. those who wish to borrow resources for production must assemble in a line. When his turn arrives, an entrepreneur can turn to any individual in the economy who is endowed with consumption goods in order to obtain credit. Once an entrepreneur obtains credit, he immediately decides whether to produce an intermediate good or to run off with the funds. After this decision is made, the next entrepreneur in line gets his turn to borrow. All agents can observe previous history: that is, when an entrepreneur's turn arrives to secure a loan, both he and his creditors know how much the entrepreneurs before him borrowed, as well as whether they produced or ran off with the funds they borrowed. This insures creditors can form reasonable expectations about the supply of intermediate goods that will be eventually sold to the final goods producer. After all agents get their turn to borrow funds and production decisions are made, markets for intermediate goods open in which the goods produced by entrepreneurs are sold to the final goods producer, and prices are set by a Walrasian auctioneer so that the markets for these intermediate goods clear. Each agent who produced intermediate good j receives the equilibrium price p_j in the respective market, at which point he must pay back his debt. Any revenue the entrepreneur has left over after repaying his debt can be used to purchase consumption goods. The assumption that credit markets operate sequentially is not essential for the results. I could have alternatively allowed borrowing and production decisions to be determined simultaneously, but this would have required additional assumptions to ration the production of particular intermediate goods when constraints are binding.[5] By contrast, rationing is naturally resolved in

[5] For example, suppose entrepreneurs submit simultaneous loan requests, and then creditors offer contracts

the sequential formulation since more profitable projects are rationed in equilibrium to those who come first in line.

As noted above, I assume the total amount of consumption goods available at the beginning of the period is sufficiently large. More specifically, I assume it exceeds the maximum credit demands of all the entrepreneurs $\int_0^1 k_1 = k_1$. Competition and excess supply of credit insures any agent who lends funds to finance production will earn zero profits on his loan. An entrepreneur will not extend the necessary credit to produce good j unless he anticipates the agent has incentive to go ahead with production, i.e. if

$$p_j - k_j \geq k_j$$

In principle, a lender who extends an amount k_1 might worry that the agent he lends to deviates and produces good 0 instead. However, since the returns from a project can always be seized, the agent will only be able to consume whatever funds he saves from not operating the more costly project, i.e. $k_1 - k_0 < k_1$. This strategy is obviously dominated by running away with all of the borrowed funds, which allows the agent to consume k_1 units of output. Hence, the incentive constraint above is sufficient to determine whether lenders will trust entrepreneurs enough to extend credit to produce good j.

Since there is a mass 1 of entrepreneurs, we can order them according to their turn in line and index them by $i \in [0, 1]$. A subgame perfect equilibrium for this economy is a set of quantities of intermediate goods $\{y_0, y_1\}$ and a set of prices for each intermediate good $\{p_0, p_1\}$ such that

1. In the final stage, the market for intermediate goods is in equilibrium, i.e.

that specify the interest rate at which they will supply the amount requested by a given entrepreneur. For certain parameters, any pair of market clearing prices which satisfy incentive constraints imply unequal profits and consequently excess demand for credit to finance one type of intermediate good. One way to ration credit in this case would be to allow for randomization. Specifically, since creditors make zero profits on loans in equilibrium, they are indifferent about extending credit. Thus, we can suppose they extend credit to only a fraction of those who apply for credit for a particular intermediate good; which entrepreneurs ultimately receive credit is determined at random. Knowing the odds of receiving credit if they request a particular amount, entrepreneurs choose which good to request financing for. An interesting feature of this rationing rule is that it involves wasteful rent-seeking when constraints are binding, i.e. more entrepreneurs apply for credit to finance certain projects than will be approved, so some are bound to remain idle. Negative shocks in this specification would induce both a reallocation of resources and an increase in the fraction of entrepreneurial resources that are left idle.

a. The final goods producer demands y_0 and y_1 given prices $\{p_0, p_1\}$ by solving the maximization problem

$$\max_{y_0, y_1} \; f(y_0, y_1) - p_{1t}y_1 - p_0 y_0 \tag{2.1}$$

b. The market for intermediate goods clears, i.e.

$$y_j = \int_0^1 1_{ij} \; di \tag{2.2}$$

where 1_{ij} is an indicator that equals 1 if agent i produces intermediate good j and 0 otherwise.

2. The subgame perfect optimal strategies of entrepreneurs are defined recursively starting with the very last agent: given the optimal strategies of those who come after him, agent i can compute the equilibrium prices p_j in the continuation subgame given previous history and his own decision. For every history of decisions by agents $[0, i)$, agent i chooses to produce the most profitable project, subject to the constraint that at the prices which prevail in the continuation equilibrium subgame, the creditor is willing to extend credit to the entrepreneur. That is, i solves

$$\max_{j \in \{0,1\}} \; p_j - k_j \tag{2.3}$$

$$\text{s.t.} \quad p_j - k_j \geq k_j \tag{2.4}$$

where p_j is the equilibrium price in the continuation subgame given all previous decisions and where agent i chooses to produce good j and is a function of the history of decisions up to agent i.

To solve for a subgame perfect equilibrium of this economy, we work backwards by first examining the equilibrium in the market for intermediate goods. Given the CES production function and the restriction that $\rho \in (0, 1)$, it must be the case that any equilibrium with production will be an interior equilibrium in which both goods are produced. This is established formally in the next lemma, whose proof is contained in the Appendix.

Lemma: In any subgame perfect equilibrium where new consumption goods are produced, both intermediate goods must be produced. That is, $y_0 + y_1 > 0$ implies $y_j > 0$ for $j \in \{0, 1\}$.

The above lemma only applies to an equilibrium in which new consumption goods are produced. Whether such an equilibrium exists depends on the level of aggregate productivity z. When z is very low, the production technology essentially requires more consumption goods as input than it yields as output, and so no production will take place. Conversely, for z sufficiently large, the technology will be productive enough to induce some wealthy agents to lend resources to entrepreneurs and some output will be produced. Hence, the nature of production will depend on the level of aggregate productivity. We can use this observation to gain some insights as to how aggregate fluctuations affect the allocation of resources across different uses, at least through the direct channel of changing the profitability of production. The next Proposition characterizes the subgame perfect equilibrium of this economy, which allows us to determine whether the different intermediate goods are associated with different levels of surplus in equilibrium, and the role aggregate productivity plays in determining the allocation of resources across different projects.

Proposition 1: There exist two cutoffs $z' < z'' \leq \infty$ such that

1. If $z < z'$, no production is the unique subgame perfect equilibrium outcome.
2. If $z' < z < z''$, there exists a unique subgame perfect equilibrium. In this equilibrium, the incentive constraint will be strictly binding for good 1 and not binding for good 0, i.e. $p_0 - 2k_0 > 0 = p_1 - 2k_1$. In addition, good 1 will be associated with greater surplus, i.e. $p_1 - k_1 > p_0 - k_0 > 0$. Finally, the equilibrium output y_0 decreases with z and y_1 increases with z. Hence, lower levels of aggregate productivity will be associated with a shift of resources towards the production of goods that generate less surplus.
3. If $z > z''$, there is a unique subgame perfect equilibrium. In this equilibrium, neither incentive constraint is binding, i.e. $p_j - 2k_j > 0$ for both values of j. The surplus associated with both projects is the same, i.e. $p_1 - k_1 = p_0 - k_0$, and the equilibrium quantities y_0 and y_1 do not vary with z. The cutoff z'' is finite if and only if $k < k^*$ for a finite constant k^*.

The equilibrium in Proposition 1 can be broken down into three cases, depending on the level of aggregate productivity z. For low values of aggregate productivity, i.e. when $0 \leq z < z'$, the fact that the production of intermediate goods requires a fixed cost that is bounded strictly away from zero implies production will cease altogether. As previous authors have noted in similar contexts, this no production equilibrium can be inefficient, since no production is the unique equilibrium outcome even when projects are inherently profitable, i.e. when there exist market-clearing prices p_0 and p_1 such that all agents could profitably produce intermediate goods if they were able commit not to run away with the funds they borrow. As illustrated formally in the Appendix, any pair of prices that satisfies market-clearing will violate the incentive constraint for at least one intermediate good, encouraging the entrepreneurs who produce that good to default. Anticipating this in advance, lenders will refuse to extend credit to entrepreneurs to carry out production in the first place.

For higher levels of aggregate productivity, i.e. when $z > z'$, the productivity of each intermediate good is sufficiently high to insure market-clearing equilibrium prices satisfy the incentive constraints for both goods. However, as long as aggregate productivity is not too high, i.e. $z < z''$, incentive constraints (2.4) will just bind at the equilibrium market-clearing prices. Since the incentive to default is strictly increasing in the amount of resources borrowed, the incentive constraint will bind only for the good which requires a larger amount of borrowing, namely good 1. For this constraint to be satisfied, good 1 must be in relatively low supply in order to keep its price up to a level which discourages default. This implies that not enough of the projects which require a larger amount of borrowing will be carried out in equilibrium. Hence, such production arrangements will be associated with greater surplus in equilibrium: on the margin, the production of another unit of good 1 would generate more final goods from the same entrepreneurial effort than another unit of good 0.[6] Since greater surplus from production corresponds to higher net output for the entrepreneur, all entrepreneurs would want to produce good 1. But the sequential structure of the game implicitly rations the more profitable projects to agents who come early; entrepreneurs who arrive later in line want to produce good 1, but creditors know that given the amount of good 1 already produced, any additional production would drive the price of this good down to the point that they will prefer to default. Late agents can only borrow to produce good 0, and given they can still make a positive profit producing this good, this is precisely what they do. As the value of z declines within this region (z', z''), a smaller fraction of entrepreneurs will be able to produce good 1 without violating the incentive constraint (2.4). This is because as z falls, the only way to maintain a price at which entrepreneurs producing good 1 will not default is if fewer entrepreneurs produce this good. Hence, within this region, lower aggregate productivity will be associated with a shift of resources from more efficient (re: undersupplied) projects where incentive constraints are binding to less efficient projects where they are not. The model thus generates condition (1.4) as an endogenous equilibrium outcome, as well as the prediction that at low levels of aggregate

[6] Alternatively, a central planner not governed by incentive constraints who faces the same technology would produce consumption goods using more intermediate good 1 and less intermediate good 0 relative to the subgame perfect equilibrium outcome.

productivity, resources will be reallocated from projects which generate more surplus to those which generate less.

Finally, for sufficiently large values of z, i.e. for $z > z''$, incentive constraints cease to bind in equilibrium. Given the lemma above, both intermediate goods will be produced, and since entrepreneurs are free to choose which intermediate good to produce, profits from both goods must be equal. Since profits represent all of the surplus from production, it follows that both goods will be associated with the same level of surplus in equilibrium. Hence, any reallocation of resources induced by changes in z in this range is spurious in the sense that resources shift across projects that are equally productive. It is convenient to rule out this type of reallocation altogether, which is why I introduce the assumption that the difference in costs between the two projects $k_1 - k_0$ is proportional to z. As evident from the last part of Proposition 1, this assumption yields the desired result that changes in z have no effect on the equilibrium allocation of resources between the two types of projects when incentive constraints no longer bind.

Note that the cutoff z'' in Proposition 1 will be infinite when k is sufficiently large, i.e. the incentive constraint for good 1 will always bind in equilibrium. This is because the debt requirement for good 1 rises with z at a rate determined by k; hence, as aggregate productivity rises, so does the amount of resources entrepreneurs could steal if they borrow to produce good 1. For k large, the temptation to steal rises at a fast enough rate to insure entrepreneurs are always tempted to run off with the funds they borrow. Bernanke, Gertler, and Gilchrist (1996) argue in favor of models where borrowing constraints bind at low values of productivity but not at high values. This is because such models imply an asymmetry in the effects of macroeconomic shocks, which they argue is apparent in the data. In the context of job reallocation, such an asymmetry could potentially explain why positive shocks do not trigger increased reallocation of resources while negative shocks do. As such, we might want to focus on parameter restrictions on k that generate a finite cutoff z''. The problem with this approach is that if, as this model implies, differences in surplus across production arrangements arise from binding constraints, heterogeneity in the efficiency of different production arrangements should disappear during booms. This prediction is unrealistic, suggesting we might want to look for alternative sources of heterogeneity that prevail even when credit constraints are not binding. This task is taken up in the next subsection. It illustrates an alternative source of heterogeneity in surplus that persists when incentive constraints no longer bind, but which continues to imply condition (1.4) as an equilibrium outcome.

2.2. Holdup Problems

Consider the following modification to the model above. To produce one unit of intermediate good j, an entrepreneur needs k_j units of the consumption good along with one unit of labor, i.e. production of intermediate goods is Leontieff in labor and consumption good inputs. To allow for labor supply in the model, suppose there is an additional group of agents in the economy of mass 1 who are each endowed with one unit of labor and nothing else. If labor is priced competitively, the model would be the same as before, except that the cost of production $k_j + w$ now includes labor payments. But if labor is not priced competitively because of some underlying frictions in the labor market, the level of surplus associated with different intermediate goods could differ. In what follows, I explore frictions that arise from bilateral bargaining in the absence of binding wage contracts. The model implies that projects that require more inputs will be associated with higher levels of surplus in equilibrium if inputs are already sunk at the time labor is hired. This generates an endogenous relationship between the amount of inputs that go into production and the level of surplus associated with production even when incentive constraints are not binding.[7] Since the model assumes all producers have the same net worth, projects that require more initial inputs will also require more debt. Hence, this explanation implies projects that require more credit will also be more efficient in equilibrium, but only among producers with similar levels of net worth.[8]

As before, suppose producers stand in a line and obtain credit sequentially. Once they obtain credit, they must instantly decide whether to invest the funds they borrow before the next producer arrives to obtain credit. Once entrepreneurs commit to production, i.e. once the resources they are sunk, the entrepreneur is paired with a worker. Assuming renegotiation is always possible, entrepreneurs cannot commit to wage payments to their workers; instead, wage payments will be determined through bilateral bargaining over the surplus after the intermediate

[7]This result relies on both the absence of binding wage contracts and the assumption that inputs are sunk before labor is hired. However, these assumptions only insure that projects which borrow more resources represent more efficient uses of resources even when incentive constraints are no longer binding. If either condition is relaxed, the model would predict identical wages for workers producing the two types of goods, in which case the model is equivalent to the previous subsection but with a cost of production of $k_j + w$. Modifying either assumption would therefore not generate the opposite relationship between the amount of credit a project requires and the amount of surplus it generates.

[8]Similarly, for the model in the previous subsection, the prediction that entrepreneurs who borrow more funds are more efficient holds only among entrepreneurs with similar levels of net worth. Agents with more net worth might would presumably find it easier to carry out projects which are undersupplied in equilibrium without having to borrow more resources.

good is produced. After all entrepreneur-worker pairs commence production, their intermediate goods are sold to final goods producers at market clearing prices announced by a Walrasian auctioneer. The worker and producer receive the revenue p_j earned on intermediate good j and must agree on how to divide this revenue. The revenue p_j is equivalent to the total available surplus the parties can share as long as producers have enough resources to repay their debt even if they fail to reach an agreement, i.e. as long as the input cost k_j is treated as sunk by the parties. For example, suppose entrepreneurs receive an amount K of consumption goods after all production has commenced. As long as $K > k_j$, producers can always be compelled to repay their debt out of this endowment, and the parties will treat k_j as a sunk cost when considering the outside option of not reaching agreement on how to divide the revenue. I henceforth maintain the assumption that there exists a punishment mechanism that can garnish alternative sources of income from those entrepreneurs who engage in production but do not repay their loans, i.e. producers cannot use failure to reach agreement with their workers as a way to get out of repaying their debts.[9] As is standard in the literature, I assume the two parties get to make alternating offers which the other party can accept or reject. Binmore, Rubinstein, and Wolinsky (1985) show that in the unique equilibrium of this bargaining game, the worker receives a share α of the surplus, where α depends on the underlying rules of the game such as the amount of time that transpires between offers or the probability that a breakdown in bargaining occurs. This implies the producer can expect to earn $(1 - \alpha) p_j - k_j$ in profits from production, while the worker can expect to receive a wage of ap_j.

As already pointed out in a similar model by Acemoglu (1998), the fact that inputs are sunk before labor is hired and that entrepreneurs cannot commit to wage contracts creates a holdup problem which causes the more costly intermediate good to be undersupplied in equilibrium. The reason is that according to the lemma above, both intermediate goods must be produced in equilibrium. Since producers are free to choose which good to produce, it must be the case that the profits from producing the two goods are the same. However, the fact that good 1 is more costly to produce requires that the revenue from producing good 1 in equilibrium be higher. This gives workers greater power in holding up production on projects with larger sunk costs. Intuitively, the worker's contribution is more valuable on projects which generate more revenue since withholding labor services would incur a greater loss to the entrepreneur. This allows workers to extract a greater wage when producing this intermediate good, i.e. the wage on jobs producing good 1 will be higher than the wage on jobs producing good 0. Consequently, the

[9] Again, relaxing this assumption would imply workers receive the same wage regardless of which good they help to produce, in which case the model is equivalent to that of the previous subsection.

total surplus from producing intermediate good j over the alternative of no production, which is just the sum of profits and wages, will be higher for intermediate good 1: profits for producers will be the same, but wages will be higher for workers who help to produce good 1. The fact that production of intermediate good 1 yields greater surplus has the same interpretation as before, i.e. we can generate a Pareto improvement by shifting some of the resources used to produce good 0 into producing good 1. Intuitively, the holdup problem creates an externality that leads to an inefficient allocation of resources: an entrepreneur's decision regarding which intermediate good to produce has an effect on the worker he is paired with, but the entrepreneur will not take this into account when he makes his choice. Consequently, goods with greater sunk costs will be undersupplied in equilibrium and thus associated with greater total surplus. Since all entrepreneurs are assumed to have the same net worth, it follows that those projects which require more borrowing will also be those which are more efficient. This is formalized in the next Proposition, which characterizes the subgame perfect equilibrium of the economy with bargaining frictions:

Proposition 2: There exist two cutoffs $z' < z'' \leq \infty$ such that

1. If $z < z'$, no production is the unique subgame perfect equilibrium outcome.
2. If $z < z''$, there exists a unique subgame perfect equilibrium. In this equilibrium, the incentive constraint will be strictly binding for good 1 and not binding for good 0, i.e. $(1-\alpha)\,p_0 - 2k_0 > 0 = (1-\alpha)\,p_1 - 2k_1$. Good 1 will be associated with a larger surplus, i.e. $p_1 - k_1 > p_0 - k_0 > 0$. Finally, the equilibrium output y_0 decreases with z and y_1 increases with z. Hence, lower levels of aggregate productivity will be associated with a shift of resources towards projects that generate less surplus.
3. If $z > z''$, there is a unique subgame perfect equilibrium. In this equilibrium, neither incentive constraint is binding, , i.e. $p_j - 2k_j > 0$ for both values of j. The surplus associated with good 1 will be larger, i.e. $p_1 - k_1 > p_0 - k_0$, and the equilibrium output y_0 and y_1 do not vary with z. There exists a finite cutoff k^* such that $z'' < \infty$ if and only if $k < k^*$.

This model continues to generate condition (1.4) as an endogenous equilibrium outcome rather than as an assumption on the production technology. The equilibrium in Proposition 2 is identical to the one in the previous subsection, except that even when $z > z''$ and incentive constraints are no longer binding, projects which require more resources as input will continue to be associated with greater levels of surplus. Since holdup problems do not depend on the presence of incentive constraints, heterogeneity in surplus across different production arrangements will continue to prevail even at high levels of aggregate productivity.

To summarize, the example in Section 1 demonstrated that if projects which generate more surplus also require more credit, incentive constraints could lead to the reallocation of resources that runs counter to the traditional Schumpeterian view in which recessions shake out all but the most efficient production arrangements. The two models presented above generate a relationship between the amount of credit an entrepreneur with a given net worth undertakes and the efficiency of the production arrangement he undertakes endogenously, and illustrates that entrepreneurs who require more credit will generate more surplus in equilibrium. This occurs either because projects which borrow more resources are more likely to be constrained and thus undersupplied, or because projects which borrow more resources are likely to be associated with holdup problems and for this reason undersupplied. Before turning to empirical evidence to verify whether credit demands are in fact correlated with underlying efficiency as the model predicts, I end with a few observations about some of the particular features of the model advanced in this section. First, the model investigates the effects of changes in aggregate productivity on resource allocation, i.e. on the allocation of workers across uses. However, the data on reallocation over the cycle described in Davis and Haltiwanger (1990) concerns job reallocation, i.e. the allocation of resources across physical locations such as plants or establishments. The fact that resources are shifted into different uses does not necessarily imply a shift across locations; employers can switch to different production methods using the same resources, in which case resources will be reallocated to new uses without having to destroy any jobs. But it is not difficult to introduce assumptions that will equate changes in the allocation of resources with changes in the physical location where resources are employed; for example, if conversion costs are sufficiently high relative to the costs of creating a job at a new location, resource reallocation will be achieved through job reallocation across plants rather than reallocation within plants. However, modelling this formally would require a dynamic rather than static framework in which jobs exist for at least two periods.

While the static nature of the model precludes a rigorous discussion of job reallocation *per se*, it also rules out other important considerations that could arise under dynamic environments. As noted previously, one could introduce some dynamics by reinterpreting the model as an overlapping generations economy in which production occurs in one period of life, just as in the model of Bernanke and Gertler (1989). The analysis would remain essentially unchanged, but the dynamic structure would allow us to study the propagation of shocks over time. Allowing for production in more than one period would substantially complicate the analysis by introducing a richer dynamic contracting problem agents face. Such dynamic contracting problems have been studied by Gertler (1992), Albuquerque and Hopenhayn (1997), and Monge (1999), among others. Gertler (1992) emphasizes that many of the qualitative results of one period models can extend to optimal dynamic contracts in multi-period settings, and under certain assumptions, it is possible to insure that borrowers are always financially constrained as part of the optimal dynamic contract. Although hardly a trivial exercise, the prediction of this model that projects which require more credit will be undersupplied in equilibrium because they hit against the incentive constraint is likely to extend to multi-period settings, implying these projects will yield greater surplus. The analysis of these more complicated but more realistic models is left for future research.

Finally, although the model establishes that recessions select less efficient projects since these are less dependent on credit, one should not take away the message that recessions will select only the least efficient projects. Such a prediction would not be consistent with the empirical evidence described in the Introduction, which suggests recessions are associated with increased job reallocation that does not favor either less productive or more productive uses of resources. The model instead illustrates one mechanism that can explain why certain less efficient projects might be selected. If in addition to this channel, some producers in the economy are somehow constrained to using less efficient technologies, e.g. they are prevented from using better production techniques because of patents or by prohibitive costs of adopting such technologies, a decline in aggregate productivity might render their technologies unproductive and force them to shut down or upgrade, as consistent with the cleansing hypothesis. In reality, both channels are likely to operate. The message of this paper, then, is not that recessions necessarily foster only inefficient production arrangements; instead, it is that recessions could discourage some entrepreneurs from engaging in certain highly productive uses of resources without precluding their ability to engage in other, less productive arrangements. This point, which emerges quite naturally out of the model above, seems to have been lost among the recent theoretical models in which it is always the least efficient uses of resources which are destroyed in recessions and only the most efficient uses of resources survive.

3. Empirical Evidence

As the example in Section 1 illustrates, the prediction that recessions select less rather than more efficient uses of resources relies on the premise that projects which borrow more resources — and are therefore more vulnerable to incentive constraints — represent more efficient uses of resources. While the model in Section 2 provides a theoretical justification for why this could occur as an equilibrium outcome, this is ultimately an empirical question: among firms with similar levels of net worth, is it the case that firms which borrow more funds tend to employ resources in a more efficient manner? Moreover, is it the case that firms which borrow more funds are more severely affected by recessions, so that downturns induce a reallocation of at least some resources into less efficient uses? This section reviews existing empirical evidence that bears upon these questions, and presents new evidence on whether firms which borrow more funds also tend to employ resources more productively.

Turning first to the question of whether firms which borrow more funds are more constrained during recessions, various authors have already examined whether lenders appear to favor particular types of borrowers in recessions. A nice survey of this literature is contained in a recent paper by Bernanke, Gertler, and Gilchrist (1996). As they point out, this work has focused on the question of whether there is a flight to safety during recessions, i.e. whether downturns are associated with a shift towards borrowers who are objectively less likely to default on their loans.[10] For example, Lang and Nakamura (1995) construct a panel dataset of commercial bank loans from the Federal Reserve Survey of Terms of Bank Lending and find that the fraction of loans made to customers at a markup of 1% over the prime rate or less increases during recessions. If the markup over the prime rate reflects risk premia for the probability of default, this would indicate a shift away from financing risky projects during recessions. Additional evidence comes from Kashyap, Stein, and Wilcox (1993), who find that the ratio of commercial paper to bank loans is countercyclical. Since high-grade borrowers are more likely to be able to issue commercial paper, this too can be seen as evidence of a flight to safety during recessions. Finally, Gertler and Gilchrist (1993, 1994) argue that the ratio of bank loans to small manufacturing firms relative to large manufacturing firms declines during contractions. Since the latter can offer more collateral and are less likely to default, this too appears to confirm a

[10] Previous literature has typically referred to this phenomenon as a flight to quality. This term is somewhat unfortunate, since the whole premise of this paper is that safe projects that reflect high quality from the perspective of creditors are also associated with less efficient production arrangements and thus represent low quality uses of resources from society's perspective. I maintain the term flight to safety to minimize confusion.

flight to safety in downturns.

At first glance, the evidence on the flight to safety seems at odds with the claim that recessions shift resources towards production arrangements that rely on smaller amounts of credit; after all, recessions induce a flight towards large firms that presumably borrow more funds. However, one has to be careful in interpreting this pattern as evidence against the mechanism outlined in the model. Recall that the model implies a shift towards smaller loans among borrowers with a similar level of net worth. Since large firms are likely to have higher net worth, a shift towards large firms does not necessarily contradict the claim that credit during recessions is reallocated towards uses that require fewer funds *among otherwise similar entrepreneurs*. Even if the composition of credit shifts in favor of larger firms, it could still shift in favor of those large firms which require smaller amounts of credit. Evidence in support of this interpretation is provided in a recent paper by Asea and Blomberg (1998). Using the same Survey of Terms of Bank Lending, they explore the evolution of various bank lending practices over the business cycle, including average loan size. They find that average loan size declines with aggregate economic conditions as measured by aggregate unemployment.[11] This implies that the flight to large firms during recessions is consistent with a flight to small loans; in their quest for safety, banks appear to seek out firms that require only small amounts of funds, or at least cut back credit to the firms they ultimately lend to.

The fact that recessions appear to favor smaller loans raises the question of whether reduced borrowing is associated with less efficient uses of resources as the model predicts. In principle, we should be able to resolve this by looking at the relationship between loan size and productive efficiency in a cross section of firms, controlling for the net worth of each firm. However, establishing this in a satisfactory way proves to be a rather daunting task. First, it requires detailed financial data for a representative sample of firms along with data that can be used to identify the efficiency of production at that firm. Obtaining such data is difficult, since firms jealously guard the sensitive financial information that is necessary for carrying out this analysis, and data sources such as administrative records which record financial data typically provide either aggregated data or else fail to include necessary information in order to maintain confidentiality. Abstracting from issues of data availability, measuring the efficiency associated

[11] Asea and Blomberg estimate a more sophisticated two-state Markov switching model in which the sensitivity of lending to aggregate unemployment can differ across two states. An increase in unemployment is associated with a bigger decline in average loan size when unemployment is high, but the effect is significant only in the regime where unemployment is declining.

with different firms is in itself quite difficult. The notion that output per worker is a useful proxy for efficiency, as some previous authors have assumed, is only warranted under certain auxiliary assumptions. A compelling empirical case that safe projects also represent less efficient uses of resources would require tests of auxiliary assumptions that insure higher output per worker reflects more efficient production. This is beyond the scope of this paper. Instead, I take a modest first step by taking the relevance of output per worker for granted, and showing that within narrowly defined industry categories, firms that borrow more resources appear to have higher output per worker. While this does not establish that recessions select less efficient uses of resources as the model purports, it could at the very least explain why, as described in the Introduction, previous researchers have failed to find a pronounced shift of resources during recessions towards establishments with high output per worker; firms with higher output per worker appear to have larger credit demands, and are therefore potentially more vulnerable to credit constraints than firms with lower output per worker.

In assembling data to study the relationship between output per worker and borrowing across firms, I draw on the Compustat database. Compustat provides detailed information on all publicly listed companies in the United States between 1950 to 1998. Since listed companies are bound by public disclosure laws, they are required to provide sensitive financial data that is typically kept confidential. Moreover, Compustat has the advantage that it contains information on sales, inventories, and employment for each firm that can be used to estimate output per worker. This makes it preferable to other data sources such as the Quarterly Financial Report of Manufacturing Firms which does not provide the necessary employment data. However, the same feature of the Compustat database which makes it attractive poses its biggest problem: since only publicly listed firms are included in the Compustat database, it is not a representative sample. Quite to the contrary, it contains those firms which are least likely to encounter credit constraints. Firms in the Compustat database are typically quite large with enough net worth to offer as collateral in the case of default. The mere fact that firms are publicly listed implies they have alternative sources of financing other than debt. I try to correct for this by examining whether the results are more pronounced when restricting the sample to smaller firms within the Compustat population, since these are more likely to have difficulty borrowing. Still, even these smaller firms are fairly large, and may present a distorted picture of the role of credit as an input for productivity for the typical small firm.[12]

[12] In addition, since even small firms in the Compustat database are quite large, they are less likely to depend

Given that production and financing evolve over time and over the course of a firm's life cycle, I limit my analysis to a panel of firms that covers only 10 years in order to minimize the possibility of picking up spurious time effects.[13] To maximize the size of my sample, I focus on the most recent 10 year period which contains data on a relatively larger number of firms. Since price deflators by industry are available from the NBER productivity database only up to 1994, this limits the sample to the period between 1984-1994. To retain comparability with the studies reported in the Introduction, I restrict attention to firms in the manufacturing sector. I further limit the sample to nondurable manufacturing firms, i.e. those whose four digit industry classification codes range between 2000-2999; the production decisions of durable goods producers are more likely to incorporate dynamic considerations, and static measures of productivity such as current output per worker may inadequately characterize the underlying efficiency of production. After deleting observations in which data were unavailable, I constructed a sample of roughly 1000 observations per year, with a slightly larger fraction of the observations coming from the last two years of the sample.

For each observation, I computed nominal output as the sum of sales (item 12) and the change in inventories (item 2) from the previous year. Observations in which this implied output measure was zero or negative were dropped. To arrive at a measure of real output, I use industry price deflators from the NBER productivity dataset.[14] I then divided this figure by the number of employees in each firm (item 29) to arrive at a measure of real output per worker. There are several discrepancies between this productivity measure and the measures that have been used by previous authors that should be pointed out. First, some of the work in the Introduction uses output per hours worked or per production employees, in contrast to my measure which reports output divided by the total employment within the firm. However, Bailey, Bartelsman,

on banks for credit. This again makes the Compustat dataset less than ideal in relating its results to the findings of Asea and Blomberg (1998) concerning changes in bank loan practices over time. However, as long as the flight to safety is common to all forms of debt rather than just bank loans, the same patterns should appear for more general categories of debt.

[13] I also experimented with estimating the relationship between credit and productivity year by year, as well as with using the full 1959-94 period for which price deflators are available from the NBER. Estimates on a year by year basis were generally consistent with the 10 year sample, particularly for the specifications that use log output per worker, although the point estimates were volatile and statistically significant in only some of the years. For the entire 35 year sample, the point estimates were again quite comparable to those from only the 10 year sample.

[14] In those cases where the Compustat industry classification corresponded to a 3 digit SIC code that was coarser than that provided by the NBER dataset, I computed an average price deflator using the value of shipments as weights across the different 4 digit SIC codes.

and Haltiwanger (1998) report that output per worker and output per hour yield very similar results in their dataset, so the absence of more specific employment data in the Compustat database should not be a severe limitation. A more crucial difference is that previous work reflects output per worker by plant, whereas the present work measures output per worker by firm. However, to the extent that smaller establishments are more likely to operate only a single plant, discrepancies due to this difference could be ameliorated when I restrict the sample to smaller firms. As is conventional in work involving the Compustat dataset, I trimmed 1% of the observations which had the highest value of output per worker to minimize the possibility that results are driven by outliers or data entry mistakes. Including these outliers does not seem to affect the direction of the estimates, but it does affect the precision and magnitudes for some of the specifications. The observations that were removed came nearly uniformly from the 10 different years, although a slightly larger share came from the last two years of the sample.

For my measure of net worth, I use the difference between assets (item 6) and liabilities (item 181) deflated by the producer price index. Since the model assumes credit is used to purchase of inputs, this would seem to be the relevant price with which to deflate net worth. Arguably, the true input price index will vary by industry. However, since I limit my analysis to a 10 year period in which inflation was moderate, using a different price deflator should not substantially affect the results. As a measure of new debt a firm undertakes each year, I use the sum of current debt liabilities (item 34), which represents the amount of debt a firm has that is due in one year, and the change in long term total debt (item 9) from the previous year. If the firm did not take on any new debt in the current year and paid its debt on schedule, this measure will equal zero: the decline in long-term debt will be reflected one-for-one in increased current debt liabilities. If the firm decided to repay its debt ahead of schedule, this measure will be negative. However, since the predictions of the model only concern the role of additional debt, whenever I included observations in which the firm did not take on new debt, I made no distinction between a firm that retires its debt on schedule and one that retires it ahead of the schedule by assigning both zero new debt. This is not important for the results I present below, since these focus only on those observations in which a firm took on a positive amount of debt. I deflated debt once again by the producer price index to arrive at a real measure that is comparable over time.

Table 1 reports summary statistics for debt, net worth, output, employment, and output per worker in the sample of firms that I use in my subsequent analysis. In particular, the statistics in Table 1 are based on a sample which excludes observations that rank in the top 1% in terms of real output per worker. Moreover, since firms which take on zero additional debt could either be severely constrained or not dependent on debt at all, I focus only on observations where the firm reported taking on a positive amount of debt; accordingly, the statistics in Table 1 exclude observations in which the firm did not take on any additional debt within that year. One of the striking features of the table is how large the typical firm in the Compustat database is. The average firm employs more than 11,500 workers and produces almost $2 billion (measured in 1987 dollars) worth of output. These numbers are not driven by a few disproportionately large outliers; more than 50% of the sample employ at least 1,700 workers and had at least $188 million in sales. Since I eventually restrict my analysis to smaller firms, I also report sample moments for smaller firms, where I follow Gertler and Gilchrist (1993, 1994) in classifying firm size according to asset holdings. The cutoffs of $500 million and $50 million in assets (in 1987 dollars) are somewhat arbitrary, but are chosen roughly to remove the top third and two thirds of the sample, respectively.[15] Firms with smaller asset holdings are smaller along all of the dimensions described in Table 1, although they are still relatively large: nearly 60% of all observations in the bottom third of asset ownership (i.e. with assets of no more than $50 million) employ at least 100 workers, and all but 10% produce at least $1 million worth of output.

Having assembled the data, I now turn to the question of whether firms with similar initial levels of net worth that borrow more funds appear to be associated with higher output per worker. Since output per worker might differ systematically across industries and over time for reasons that are unrelated to the issues addressed by the model, I look for this relationship within industry-year cells. That is, I regress output per worker on the amount of debt the firm undertook in the same year, controlling for net worth in the previous year and a set of industry-year dummy variables. It is important to emphasize that these regressions should not be interpreted as reduced-form estimates, since the model is too stylized to suggest functional forms on how output per worker will depend on the amount borrowed. Instead, these regressions should be viewed as a tool for computing partial correlations between debt and productivity. The results are reported in Table 2. Since timing is an issue, I also considered the correlation between productivity and lagged debt, consequently controlling for net worth lagged by two years rather than one. This specification is reported in Table 3, and yields point estimates that

[15] For robustness, I also experimented with removing firms which ever had assets that exceeded 500 or 50 million dollars. The results were similar, confirming that my results are not affected by firms which straddle both sides of the cutoffs over time. Gertler and Gilchrist (1993, 1994) classify firms as small if their asset holdings fall below a cutoff that lies somewhere between $100 and 250 million in 1987 dollars.

are quite similar to those in Table 2. Estimates are based on only those observations in which firms took on positive debt; including those observations where firms did not take on new debt yield somewhat smaller point estimates for the coefficient on debt than those reported Table 2, but with roughly the same magnitude and similar standard errors.

The first column in both Table 2 and Table 3 reports the coefficients on debt and net worth using all of the observations in which the firm took on additional debt. The results fail to support the main prediction of the model: although the coefficient on the debt variable is positive, output per worker within industries does not appear to be significantly correlated with the amount of funds borrowed. This is not entirely surprising, since many of the large firms in the sample are unlikely to be debt constrained, and so we should not expect to see a correlation between the debt they take on and their productivity. But as the second column in the table illustrates, removing the firms with the third largest asset holdings reveals a statistically significant partial correlation between the level of debt and output per worker. This correlation is even more pronounced among the firms with asset holdings of $50 million or less, which is reported in the third column of Table 2. The point estimates imply that among firms with a common net worth level within a particular industry year cell, an additional $1000 worth of borrowing is associated with an additional $2.43 in output per worker per year. To the extent that output per worker reflects the efficiency of production, then, the results appear consistent with the claim that entrepreneurs who borrow more funds are more efficient, at least when we restrict attention to smaller firms that are likely to be financially constrained.

To assess whether the estimates above are robust to alternative functional forms, the last three columns in Tables 2 and 3 repeat these regressions using the log of output per worker and debt instead of levels. This specification has several advantages. First, the coefficient on debt can be interpreted as an elasticity and is therefore scale-independent. Second, the log specification is less sensitive to measurement error in price deflators, since these would just enter as constants for each industry-year cell and thus would be absorbed in with the fixed effect. The log specification reveals a statistically significant correlation between the amount of debt and output per worker even for the entire sample. Once again, the coefficient on new debt is bigger and more significant when I restrict the sample to smaller firms. For observations where asset values lie below $50 million, the data suggests that a firm which takes on 10% more debt than comparable firms within the same industry and with a similar initial level of net worth is associated with output per worker that is roughly 1% higher.[16]

There are several other noteworthy features about the regressions in Tables 2 and 3. First, as the sample is restricted to smaller and smaller firms, the role of credit becomes more pronounced while the role of lagged net worth becomes less important. For firms with assets of 50 million or less, output per worker is not significantly correlated with net worth; for most of the specifications, in fact, the coefficient on net worth is negative, although not statistically significant. Second, in restricting the sample to smaller firms, variation in output per worker across industries and over time plays an increasingly less important role. For observations with asset holdings of $50 million or less, industry-year dummies provide almost no explanatory power, as illustrated by the low value of the between R^2 statistic. In other words, systematic differences in output per worker across industries-year cells come only from firms with large asset holdings. Among smaller firms, little of the variation in output per worker is due to differences over time (for this particular 10 year period) or across industry. The fact that new debt is the only variable that remains significantly correlated with output per worker among small firms is strongly suggestive that this correlation is not due to spurious factors such as firm size, age, or sources of credit: these characteristics are likely to differ across industries, and thus should be captured by the industry-year dummies. Hence, although these empirical results are based on a highly selected sample of firms and should be confirmed once data for a more representative sample of firms becomes available, they do appear to provide support for the notion that more efficient production arrangements are potentially more vulnerable to credit market frictions, at least among small firms, and thus less likely to survive credit tightening during recessions.

4. Conclusion

Since the essential insights of the paper are already laid out in the discussion above, I dispense with the usual summary of the results and conclude instead with a few remarks on how this model relates to the existing literature. Previous work on credit market frictions has already pointed out that in the presence of imperfections in the market for loanable funds, a decline in aggregate economic conditions could cause incentive constraints on borrowers to tighten, limiting the extent of economic activity that can be carried out. It is also well understood that

[16] I also experimented with log-level and level-log specifications. These again yield a statistically significant positive correlation between amount of debt and output per worker, although these specifications provide worse fits in terms of R^2 than the level-level and log-log specifications in Tables 2 and 3.

this tightening will generally be inefficient, since it implies productive uses of resources will not be carried out. The point of the paper is not to rehash this familiar territory. Instead, it addresses the more specific question of which production arrangements are likely to fall victim to incentive constraints during recessions. Contrary to conventional wisdom which argues that only the most efficient uses of resources survive during downturns, this paper illustrates that it is possible, arguably even likely, that recessions will have a more severe impact on some of the more efficient uses of resources while sparing those which are relatively less efficient. In other words, the presence of credit market frictions implies that the ability to survive a recession need not point to inherent efficiency as conventional wisdom dictates.

The fact that it is relatively easy to generate examples in which the reallocation of resources during recessions violates the cleansing effect should not diminish from the contribution of this paper. First, existing literature has thus far failed to appreciate the possibility that recessions could hurt less efficient production arrangements while sparing those which are less efficient. For example, the literature on credit constraints has largely ignored this issue, and if anything the most prominent models in this literature have helped to propagate the opposite notion. Even the terminology in this literature evokes the notion that credit market frictions select projects which are more efficient; after all, the claim that there is a "flight to quality" during recessions hardly sounds like a rebuke of the claim that recessions "cleanse" out inefficient modes of production. Likewise, among researchers who try to explain the increase in job reallocation during recession, even models which have incorporated incentive constraints into models of reallocation have effectively ruled out the case in which more efficient projects are more likely to survive incentive constraints. As such, even the simple example in Section 1 represents a significant departure from current thinking about what increased job reallocation during recessions represents. However, what makes the argument against cleansing developed in this paper more compelling is that one could derive this pattern not just from ad-hoc assumptions on the nature of production but as an endogenous equilibrium outcome in models where the surplus associated with different uses of resources is determined endogenously. Moreover, the preliminary empirical evidence is consistent with the necessary condition to generate this pattern, namely that projects which borrow more funds are associated with higher productivity, at least when measured in terms of output per worker.

The notion of inefficient reorganization during recessions advanced in this paper has at least two important implications in the study of reallocation over the business cycle. First, previous work that has attempted to calibrate the costs of recessions, including Ramey and Watson

(1997), den Haan, Ramey and Watson (1997), and Caballero and Hammour (1998), are based on the assumption that recessions destroy marginal firms, i.e. those which generate the least amount of surplus and are therefore on the margin of destruction. These models therefore minimize the amount of output lost because of increased destruction during recessions since by assumption it is the less productive uses of resources that are scrapped. However, introducing assumptions under which recessions strike at some of the more efficient uses of would lead to larger costs of recessions, potentially by a significant amount. This is more than just a theoretical possibility; as noted in the Introduction, empirical work confirms that some of the firms which survive recessions are in fact less productive and less profitable than those which are destroyed, suggesting that existing models are in fact likely to understate the true impact of recessions. While the model developed here is too stylized to calibrate and compute more a sensible cost of recessions, incorporating the elements it highlights in more realistic models and calibrating them could lead to larger costs of recessions than those computed by previous authors.

Finally, the notion that recessions generate reallocation which favors some of the less efficient production arrangements could have important implications for policymakers. The conventional Schumpeterian view which argues that only the most efficient production arrangements survive during recessions lends itself to policy implications that these production arrangements should be encouraged. In particular, there might be temptation for policymakers to save firms which have proven themselves "too good to fail" by maintaining production during aggregate contractions. However, if production arrangements which survive recessions represent less efficient uses of resources that would be threatened once aggregate conditions improve, such an intervention might protect inefficient uses of resources that are simply less vulnerable to incentive constraints that bind during recessions. The fact that it is not necessarily true that only the best survive during recessions should make us more reluctant to adopt policies which subsidize and protect the creation of new matches during recessions.

References

[1] Acemoglu, Daron, 1998. "Good Jobs versus Bad Jobs: Theory and Some Evidence" Mimeo, MIT.

[2] Aghion, Phillippe and Gilles Saint Paul, 1998. "Virtues of Bad Times: Interaction between Productivity Growth and Economic Fluctuations" *Macroeconomic Dynamics*, September, 2(3), p322-44.

[3] Albuquerque, Rui and Hugo Hopenhayn, 1997. "Optimal Dynamic Lending Contracts with Imperfect Enforceability" Mimeo, University of Rochester.

[4] Asea, Patrick and Brock Blomberg, 1998. "Lending Cycles" *Journal of Econometrics*, 83(1-2), March-April, p89-128.

[5] Baden-Fuller, Charles, 1989. "Exits From Declining Industries and the Case of Steel Castings" *Economic Journal*, December, 99(398), p949–61.

[6] Bailey, Martin, Eric Bartelsman, and John Haltiwanger, 1998. "Labor Productivity: Structural Change and Cyclical Dynamics" Mimeo, University of Maryland.

[7] Barlevy, Gadi, 1999. "Is There a Cleansing Effect of Recessions? Evidence from Wage Data" Mimeo, Northwestern University.

[8] Bertin, Amy, Tim Bresnahan, and Daniel Raff, 1996. "Localized Competition and the Aggregation of Plant-Level Increasing Returns: Blast Furnaces, 1929-1935" *Journal of Political Economy*, April, 104(2), p241-66.

[9] Bernanke, Ben and Mark Gertler, 1989. "Agency Costs, Net Worth, and Business Fluctuations" *American Economic Review*, March, 79(1), p14-31.

[10] Bernanke, Ben, Mark Gertler, and Simon Gilchrist, 1996. "The Financial Accelerator and the Flight to Quality" *Review of Economics and Statistics*, 78(1), February, p1-15.

[11] Binmore, Kenneth, Ariel Rubinstein, and Asher Wolinsky, 1986. "The Nash Bargaining Solution in Economic Modelling" *Rand Journal of Economics*, Summer , 17(2), p176-88.

[12] Bresnahan, Tim and Daniel Raff, 1991. "Intra-industry Heterogeneity and the Great Depression: The American Motor Vehicles Industry, 1929-1935" *Journal of Economic History*, June, 51(2), p317-31.

[13] Bresnahan, Tim and Daniel Raff, 1998. "Plant Shutdown Behavior During the Great Depression and the Structure of the American Motor Vehicle Industry" Working Paper, The Wharton School, and forthcoming, *Journal of Economic History.*

[14] Caballero, Ricardo and Mohamad Hammour, 1994. "The Cleansing Effect of Recessions" *American Economic Review*, December, 84(5), p1350-68.

[15] Caballero, Ricardo and Mohamad Hammour, 1996. "On the Timing and Efficiency of Creative Destruction" *Quarterly Journal of Economics*, August, 111(3), p805-52.

[16] Caballero, Ricardo and Mohamad Hammour, 1998. "Improper Churn: Social Costs and Macroeconomic Consequences" Mimeo, MIT.

[17] Cooper, Russel and John Haltiwanger, 1993. "The Aggregate Implications of Machine Replacement: Theory and Evidence" *American Economic Review*, June, 83(3), p181-186.

[18] Davis, Steven and John Haltiwanger, 1990. "Gross Job Creation and Destruction: Microeconomic Evidence and Macroeconomic Implications." *NBER Macroeconomics Annual.* Cambridge, Mass: MIT Press.

[19] den Haan, Wouter, Garey Ramey, and Joel Watson, 1997. "Job Destruction and Propagation of Shocks" Mimeo, UCSD.

[20] Gertler, Mark, 1992. "Financial Capacity and Output Fluctuations in an Economy with Multi-Period Financial Relationships" *Review of Economic Studies*, 59(3), p455-472.

[21] Gertler, Mark and Simon Gilchrist, 1993. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence" *Scandinavian Journal of Economics*, 95(1), p43-64.

[22] Gertler, Mark and Simon Gilchrist, 1994. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms" *Quarterly Journal of Economics*, 109(2), May, p309-40.

[23] Griliches, Zvi and Haim Regev, 1995. "Firm Productivity in Israeli Industry: 1979-1988" *Journal of Econometrics*, January, 65(1), p175-203.

[24] Hall, Robert, 1991. "Labor Demand, Labor Supply, and Employment Volatility" *NBER Macroeconomics Annual.* Cambridge, Mass: MIT Press.

[25] Hall, Robert, 2000. "Reorganization" *Carnegie Rochester Conference on Public Policy.*

[26] Kashyap, Anil, Jeremey Stein, and David Wilcox, 1993. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance" *American Economic Review*, 83(1), March, p78-98.

[27] Kiyotaki, Nobuhiro and John Moore, 1997. "Credit Cycles" *Journal of Political Economy*, April, 105(2), p211-248.

[28] Lang, William and Leonard Nakamura, 1995. "'Flight to Quality' in Banking and Economic Activity" *Journal of Monetary Economics*, December, 36(1), p145-64.

[29] Monge, Alexander, 1999. "Financial Markets, Creation and Liquidation of Firms, and Aggregate Dynamics" PhD Thesis, University of Chicago.

[30] Mortensen, Dale and Christopher Pissarides, 1994. "Job Creation and Job Destruction in the Theory of Unemployment" *Review of Economic Studies*, July, 61(3), p397-415.

[31] Pissarides, Christopher, 1994. "Search Unemployment with On-the-Job Search" *Review of Economic Studies*, July, 61(3), p457-75.

[32] Ramey, Garey and Joel Watson, 1997. "Contractual Fragility, Job Destruction, and Business Cycles" *Quarterly Journal of Economics*, 112(3), August, p873-911.

[33] Rubinstein, Ariel, 1982. "Perfect Equilibrium in a Bargaining Model" *Econometrica*, January, 50(1), p97-109.

[34] Schuh, Scott and Robert Triest, 1998. "Job Reallocation and the Business Cycle: New Facts for an Old Debate" in *Beyond Shocks: What Causes Business Cycles*, eds. Fuhrer, Jeffrey and Scott Schuh, Federal Reserve Bank of Boston Conference Series, June, 42, p271-337.

Table 1: Sample Means

	Variable		Mean	Median	SD
All firms, 1984-94	Total:	9,362			
	Debt > 0:	6,696			
	Net Worth $_{t-1}$ (millions)		766.12	51.70	2,813.33
	New Debt (millions)		181.55	8.96	684.68
	Output (millions)		2,006.46	188.07	6,497.05
	Employees		11,523	1,745	28,702
	Output/Worker		158,209	120,610	138,452
Assets < 500	Total:	6,620			
	Debt > 0:	4,468			
	Net Worth $_{t-1}$ (millions)		41.88	18.66	59.08
	New Debt (millions)		11.42	3.13	24.32
	Output (millions)		150.38	57.49	233.18
	Employees		1,462	504	2,198
	Output/Worker		131,768	104,189	111,872
Assets < 50	Total:	3,530			
	Debt > 0:	2,294			
	Net Worth $_{t-1}$ (millions)		7.86	4.69	9.41
	New Debt (millions)		2.51	1.11	3.88
	Output (millions)		23.22	13.85	27.25
	Employees		278	140	385
	Output/Worker		116,972	90,000	107,168

The sample includes all observations from Compustat for which data was available, omitting the observations with the top 100 values of output per worker. The bottom two panels limit this sample to firms with asset values (deflated by the Producer Price Index to 1987 dollars) below the specified range. Summary statistics are reported only for observations where the firm took on a positive amount of new debt in the current period. Net worth and new debt are deflated by the PPI, while output is deflated by an industry specific shipment deflator from the NBER productivity database. Net worth reported above is lagged by one period, since lagged net worth is used in the subsequent regressions.

Table 2: Regression Results

	Debt > 0	Debt > 0 Assets < 500	Debt > 0 Assets < 50	Debt > 0	Debt > 0 Assets < 500	Debt > 0 Assets < 50
Dependent Variable	Y/L	Y/L	Y/L	ln(Y/L)	ln(Y/L)	ln(Y/L)
New Debt	0.0020	0.2610	2.4237			
	0.0024	0.0661	0.5752			
ln(New Debt)				0.0565	0.0619	0.0796
				0.0038	0.0067	0.0124
Net Worth $_{t-1}$	0.0074	0.0558	0.0885	0.00002	0.0006	-0.0004
	0.0006	0.0282	0.2246	0.000004	0.0002	0.0023
Years	1984-94	1984-94	1984-94	1984-94	1984-94	1984-94
N	6696	4468	2294	6696	4468	2294
Number of Industry/Years	868	816	638	868	816	638
R squared within	0.042	0.008	0.011	0.052	0.031	0.025
between	0.267	0.011	0.001	0.186	0.040	0.000
overall	0.171	0.012	0.009	0.132	0.048	0.028

Columns 1-3 report the coefficients from a regression of output per worker on new debt, lagged net worth, and industry year dummy variables (the number of industry-year categories is reported in the table). The samples correspond to the samples reported in Table 1, i.e. excluding observations with the top 100 values of output per worker and observations where the firm did not take on a positive amount of debt in the current year. Variables have been scaled so that debt and net worth are measured in terms of $1000 in 1987 dollars. Column 2 restricts the sample to observations with real asset values of no more than 500 million in 1987 dollars, and column 3 to reall asset values of no more than 50 million. Columns 4-6 are similar, excpet that the dependent variable is log output per worker, and the debt variable is replaced with log debt.

Table 3: Regression Results

	Debt > 0	Debt > 0 Assets < 500	Debt > 0 Assets < 50	Debt > 0	Debt > 0 Assets < 500	Debt > 0 Assets < 50
Dependent Variable	Y/L	Y/L	Y/L	ln(Y/L)	ln(Y/L)	ln(Y/L)
New Debt $_{t-1}$	0.0045	0.3624	2.2851			
	0.0025	0.0663	0.5859			
ln(New Debt $_{t-1}$)				0.0549	0.0658	0.0868
				0.0038	0.0069	0.0133
Net Worth $_{t-2}$	0.0066	0.0050	-0.0804	0.00001	0.0003	-0.0026
	0.0006	0.0307	0.2487	0.000004	0.0003	0.0024
Years	1984-94	1984-94	1984-94	1984-94	1984-94	1984-94
N	6078	3975	1967	6078	3975	1967
Number of Industry/Years	863	809	611	863	809	611
R squared within	0.040	0.011	0.011	0.052	0.034	0.030
between	0.276	0.011	0.002	0.199	0.030	0.000
overall	0.188	0.015	0.007	0.141	0.047	0.034

Table 3 is identical to Table 2 except for the timing assumptions; specifically, debt and log debt are replaced with lagged debt and log of lagged debt, while lagged net worth is replaced with net worth lagged by two periods. For additional information, see the notes associated with Table 2.

Appendix

Proof of Lemma: For ease of notation, I suppress time subscripts unless necessary. Suppose the lemma does not hold, i.e. $y_j = 0$ but $y_i > 0$ for $i \neq j$. Since y_0 and y_1 must solve the maximization problem for the final goods producer, it follows that

$$\frac{\partial f}{\partial y_j} \leq p_j \tag{4.1}$$

with equality if $y_j > 0$. Differentiating f with respect to y_j yields

$$\frac{\partial f}{\partial y_j} = z\left(y_i^{\rho} + y_j^{\rho}\right)^{\frac{1-\rho}{\rho}} y_j^{\rho-1}$$

Since $\rho < 1$, $\dfrac{\partial f}{\partial y_j} = \infty$. Hence, $p_j = \infty$. Since $y_i > 0$, $p_i = \dfrac{\partial f}{\partial y_i} = z < \infty$. This implies an entrepreneur could earn infinite profits from producing good j but only finite profits from producing good i. All entrepreneurs will therefore produce good j, which implies $y_j > 0$, a contradiction.

Proof of Proposition 1: The proof proceeds in several steps. First, I show there exists a z' such that $y_j = 0$ is part of a subgame perfect equilibrium if and only if $z \leq z'$. I then demonstrate that this is the unique subgame perfect equilibrium outcome when $z < z'$. Finally, I characterize the equilibrium when $z > z'$.

No production is a subgame perfect equilibrium if (1) there exist prices of intermediate goods p_j in the final stage game such that incentive constraints in neither sector are satisfied, i.e.

$$p_j - k_j \leq k_j$$

in which case by backwards induction no entrepreneur will produce either interemediate goods, and (2) at these prices, $y_0 = y_1 = 0$ solves the maximization problem of the final goods producer. Since the profit function for the final goods producer is globally concave, the latter will be true if and only if there does not exist a $(y_0, y_1) \in R_+^2$ such that

$$\frac{\partial f(y_0, y_1)}{\partial y_j} - p_j \geq 0$$

for both j with strict inequality for at least one j. Substituting in for the derivative of f and combining the two constraints implies that a no-production equilibrium exists if and only if there is no pair $(y_0, y_1) \in R_+^2$ such that

$$z\left(1+\left(\frac{y_0}{y_1}\right)^{\rho}\right)^{\frac{1-\rho}{\rho}} \geq 2k_1 \tag{4.2}$$

$$z\left(1+\left(\frac{y_1}{y_0}\right)^{\rho}\right)^{\frac{1-\rho}{\rho}} \geq 2k_0 \tag{4.3}$$

with strict equality for both j. Let $\theta = \frac{y_1}{y_0}$, and define $x_j = \frac{\partial f(y_0, y_1)}{\partial y_j}$. Consider the graph $\Gamma(z) = \{(x_0, x_1) \mid \theta \in (0, \infty)\}$ defined for a given z. This graph traces a downward sloping curve Γ, since

$$\frac{dx_1}{dx_0} = \frac{dx_1/d\theta}{dx_0/d\theta} = -\left(\frac{1+\theta^{-\rho}}{1+\theta^{\rho}}\right)^{\frac{1}{\rho}} < 0$$

Define $K(z) = [0, 2k_0] \times [0, 2k_1]$. A no-production equilibrium exists if and only if $K \cap \Gamma \neq \emptyset$. To see this, note that if this intersection is non-empty, we can pick a point (x_0^*, x_1^*) from the set $K \cap \Gamma$ and set $p_j = x_j^*$. Since Γ is downward sloping, then for any $(x_0, x_1) \in \Gamma$ where $(x_0, x_1) \neq (x_0^*, x_1^*)$, there exists a j such that $x_j \leq x_j^* = p_j$. Hence, there is no pair $(y_0, y_1) \in R_+^2$ for which $x_j \geq k_j$ for both values of j. But (4.2) and (4.3) above establish that insures $y_0 = y_1 = 0$ is optimal for the final goods producer. Hence, if the intersection is non-empty, there exists an equilibrium in which no final goods are produced. Conversely, suppose this intersection is empty. Conditions (4.2) and (4.3) imply that $y_0 = y_1 = 0$ is optimal for the final goods producer only if for any $(x_0, x_1) \in \Gamma$, $x_j \leq p_j$ for both j. But since $K \cap \Gamma = \emptyset$, it follows that for any $(x_0, x_1) \in \Gamma$, there exists a j such that $x_j > k_j$. Hence, at these equilibrium prices, there exists a j for which $p_j - k_j \geq x_j - k_j > 0$. But by backwards induction, this implies every entrepreneur will want to produce good j, which implies $Y_j = y_j > 0$, which contradicts the original assumption that we have

Next, I show that there exists a z' such that $K \cap \Gamma(z) = \emptyset$ if and only if $z \geq z'$. Note that the set $K \cap \Gamma$ is isomorphic to the set

$$\Theta(z) = \{\theta \mid (x_0(\theta), x_1(\theta)) \in K\}$$

so that $K \cap \Gamma = \emptyset$ if and only if $\Theta = \emptyset$. The set Θ is a compact interval $\left[\underline{\theta}, \overline{\theta}\right]$, where the endpoints of the interval are given by the solutions to the two equations

$$\begin{aligned} x_1(\overline{\theta}) &= 2(k_0 + zk) \\ x_0(\underline{\theta}) &= 2k_0 \end{aligned}$$

if these solutions exist; otherwise $\underline{\theta} = 0$ and $\overline{\theta} = \infty$ if no solution exists. If $\underline{\theta}(z) > \overline{\theta}(z)$, then $\Theta = \emptyset$. These two equations can be rewritten as

$$z\left(1 + \overline{\theta}^{-\rho}\right)^{\frac{1-\rho}{\rho}} = 2(k_0 + zk) \tag{4.4}$$

$$z\left(1 + \underline{\theta}^{\rho}\right)^{\frac{1-\rho}{\rho}} = 2k_0 \tag{4.5}$$

Since $\rho \in (0, 1)$, the LHS in the first equation is decreasing in $\underline{\theta}$, while the LHS in the second equation is increasing in $\overline{\theta}$. Hence, $\underline{\theta}(z)$ is decreasing in z and $\overline{\theta}(z)$ is increasing in z. Thus, if $K \cap \Gamma \neq \emptyset$ for some

z', then $K \cap \Gamma \neq \emptyset$ for any $z < z'$. This establishes z' is unique. It remains to show that z' exists. To see this, note that as $z \to 0$, $\underline{\theta} \to \infty$ and $\overline{\theta} \to 0$. But for $z = 2k_0$, $\underline{\theta} = 0$ while $\overline{\theta} > 0$. Since both $\underline{\theta}(z)$ and $\overline{\theta}(z)$ are continuous in z, there exists a z' such that $\underline{\theta}(z') = \overline{\theta}(z')$, and hence a no production subgame perfect equilibrium exists if and only if $z \leq z'$.

Next, I argue no production is the unique subgame perfect equilibrium when $z < z'$. From the lemma, we know that either $y_j = 0$ for both j or $y_j > 0$ for both j. So I only need to rule out the case where $y_j > 0$ for both j. To do this, note that from the first order conditions of the final goods producer, $y_j > 0$ implies $p_j = \dfrac{\partial f}{\partial y_j}$. Define $K'(z) = [2k_0, \infty) \times [2k_1, \infty)$. A subgame perfect equilibrium with $y_j > 0$ occurs only if $K' \cap \Gamma \neq \emptyset$, or else entrepreneurs would not be willing to supply both intermediate goods. But since Γ is downward sloping, $K \cap \Gamma \neq \emptyset$ implies $K' \cap \Gamma = \emptyset$. So there is no equilibrium with production for $z < z'$.

Finally, we turn to the case where $z > z'$. The previous argument establishes no production is not a subgame perfect equilibrium. Furthermore, from the lemma, any subgame perfect equilibrium with some production requires that both goods be produced. Hence, $y_j > 0$ for both j, so $p_j = \dfrac{\partial f}{\partial y_j} \equiv x_j$ for both j in equilibrium. To satisfy both incentive constraints, it must be the case that $x_j = p_j > 2k_j > k_j$, so profits are strictly positive in equilibrium for both goods. By backwards induction, all entrepreneurs will choose to produce some intermediate good, so that $Y_0 + Y_1 = 1$.

Consider the fraction ϕ of entrepreneurs producing good 1 which insures the profits from producing either good are equal, i.e.

$$p_1 - p_0 = k_1 - k_0$$

Substituting in the equilibrium conditions $p_j = \dfrac{\partial f}{\partial y_j}$, $Y_0 + Y_1 = 1$, and $y_1 = \phi(Y_0 + Y_1)$ yields the following equation

$$\frac{\phi^{\rho-1} - (1-\phi)^{\rho-1}}{\left(\phi^{\rho} + (1-\phi)^{\rho}\right)^{\frac{\rho-1}{\rho}}} = k$$

which is independent of z_t. The LHS of the above equation is monotonic in ϕ, is unbounded at $\phi \to 0$, and equals 0 when $\phi = \frac{1}{2}$. Hence, there exists a unique ratio $\theta = \frac{\phi}{1-\phi}$ at which profits are equal for the two goods. If $\frac{\phi}{1-\phi} \in \left[\underline{\theta}(z), \overline{\theta}(z)\right] \equiv \Theta(z)$, the unique subgame perfect equilibrium outcome will be for a fraction ϕ of entrepreneurs to produce good 1 and the remaining to produce good 0. It is easy to construct strategies to support this equilibrium outcome. Any other production pattern will not be an equilibrium, since if a fraction $\phi' \neq \phi$ produce good 1 profits will be unequal. Hence, there exists a good j which yields lower profits. Consider the last enterpreneur who produces this good in equilibrium. He could do better by producing good $i \neq j$: regardless of what the entrepreneurs who come later do in the equilbrium subgame, the minimum profits he could receive are given $x_i\left(\phi'\right) - k_i$; if all the entrepreneurs who follows him continues to produce good i, this will exactly describe his profits, and if any of them choose not to produce good i, the equilibrium price of good i will be even higher. If the original outcome was an equilibrium, the incentive constraint must have been satisfied for good i, so that the entrepreneur could obtain a loan to produce good i. But this deviation yields higher profits to the entrepreneur, proving the original outcome was not an equilibrium. The remaining issue is to determine whether $\frac{\phi}{1-\phi} \in \left[\underline{\theta}(z), \overline{\theta}(z)\right]$, and what the subgame perfect equilibrium outcome will be when this condition is not met.

From (4.5) we know that $\underline{\theta}(z) = 0$ for $z > 2k_0$, and as $z \to \infty$,

$$\overline{\theta}(z) \to \begin{cases} \infty & \text{if } k \leq \frac{1}{2} \\ \left[(2k)^{\frac{\rho}{1-\rho}} - 1\right]^{-\frac{1}{\rho}} & \text{if } k > \frac{1}{2} \end{cases}$$

If $\frac{\phi}{1-\phi} < \left[(2k)^{\frac{\rho}{1-\rho}} - 1\right]^{-\frac{1}{\rho}}$, then there exists a finite z'' such that $\frac{\phi}{1-\phi} \in \Theta(z)$ for $z \geq z''$. From the discussion above, it follows that the unique subgame perfect equilibrium outcome when $z > z''$ is $y_1 = \phi$ and $y_0 = 1-\phi$, and profits $p_j - k_j$ are equal by definition. This estalishes the last part of the Proposition. To characterize the cutoff z'', note that at $z = z'$, $K \cap \Gamma = (2k_0, 2k_1)$, i.e. the set K and the curve Γ are tangent and their intersection contains only one point, i.e. $\Theta(z) = \left[\underline{\theta}, \overline{\theta}\right] = \{\theta\}$ is a singleton. At this value of θ, the incentive constraints just bind, i.e. $x_j(\theta) = k_j$, and equilibrium profits are given by

$$x_j(\theta) - k_j = 2k_j - k_j = k_j$$

Since $k_1 > k_0$,it follows that profits are not equal for the two goods, and so $\frac{\phi}{1-\phi} \notin \Theta(z')$, or more specifically $\underline{\theta}(z') = \overline{\theta}(z') < \frac{\phi}{1-\phi}$ since profits for good 1 are decreasing in θ. This implies $z'' > z'$. Since the upper bound $\lim_{z\to\infty} \overline{\theta}(z) = \left[(2k)^{\frac{\rho}{1-\rho}} - 1\right]^{-\frac{1}{\rho}}$ is decreasing in k, z'' exists (i.e. is finite) only if k is sufficiently small.

Lastly, consider the case where $z \in (z', z'')$ so that $\frac{\phi}{1-\phi} > \overline{\theta}(z)$. I now show that the unique subgame perfect equilibrium outcome is that the first ϕ_z entrepreneurs borrow to produce good 1 and the last $1-\phi_z$ borrow to produce good 0, where $\frac{\phi_z}{1-\phi_z} = \overline{\theta}(z)$, i.e. ϕ_z solves

$$z\left(1+\left(\frac{\phi_z}{1-\phi_z}\right)^{-\rho}\right)^{\frac{1-\rho}{\rho}} = 2\left(k_0 + kz\right)$$

Consider the strategy of each agent. Given the history of play and applying backwards induction, agents can compute the ratio $\frac{y_1}{y_0}$ that would prevail once all entrepreneurs produce. If this ratio exceeds $\frac{\phi}{1-\phi}$, the entrepreneur will prefer to produce good 0, while if this ratio falls below this cutoff he will prefer to produce good 1, i.e. $p_1 - k_1 > p_0 - k_0$. Since $z > z'$, by definition profits will be strictly positive from producing the more preferred good, so agents would want to produce the more profitable good if they could. However, an entrepreneur will be able to borrow to produce good 1 only if $\frac{y_1}{y_0} \leq \frac{\phi_z}{1-\phi_z} < \frac{\phi}{1-\phi}$. Along the equilibrium path, the ratio $\frac{y_1}{y_0}$ cannot exceed $\frac{\phi_z}{1-\phi_z}$ in equilibrium, since any of the entrepreneurs who produce good 1 would recognize that they are better off defaulting instead, in which case the actual production of good 1 would equal 0, which is a contradiction. Since $\frac{\phi_z}{1-\phi_z} < \frac{\phi}{1-\phi}$, it follows that along the equilibrium path, all entrepreneurs would employ the following recursively defined strategy: produce good 1 if given the history up to now and that all subsequent agents behave optimally, the ratio $\frac{y_1}{y_0}$ after all entrepreneurs produce is less than or equal to $\frac{\phi_z}{1-\phi_z}$; otherwise, produce good 0. From this, it is easy to see that this implies only the first ϕ_z entrepreneurs will produce good 1, and all subsequent entrepreneurs produce good 0. By the definition of ϕ_z, the incentive constraint will strictly bind for good 1, i.e. $p_1 - 2k_1 = 0$. For $z > z'$, $\overline{\theta}(z) > \underline{\theta}(z)$, and since the incentive constraint for good 0 does not bind as long as $\theta > \underline{\theta}(z)$, it follows that in equilibrium $p_0 - 2k_0 > 0$. Finally, since $\theta(z)$ is increasing in z, so is ϕ_z, which yields the second part of Proposition 1.

Proof of Proposition 2: The proof of Proposition 2 is similar to that of Proposition 1, except that profits from producing good j are given by

$$(1-\alpha)\, p_j - k_j$$

Since the incentive constraint can be rewritten as $p_j > 2k'_j = 2k_j(1-\alpha)$, and so the analysis of the subgame perfect equilibrium will be identical to that of Proposition 1: there exist cutoffs z' and z'' such that profits are equal in equilibrium for $z > z''$, but not for $z' < z < z''$. In the latter case, profits will be higher for good 1 in equlilibrium, and agents follow the strategy of producing this more good if possible. The only difference is that profits $(1-\alpha)p_j - k_j$ are no longer equal to surplus $p_j - k_j$. To characterize the latter, I solve for the condition which characterizes equal profits in the two sectors, i.e.

$$p_1 - p_0 = \frac{\phi^{\rho-1} - (1-\phi)^{\rho-1}}{\left(\phi^{\rho} + (1-\phi)^{\rho}\right)^{\frac{\rho-1}{\rho}}} = \frac{k}{1-\alpha}$$

This implies that in equilibrium, $p_1 > p_0$, or $\phi < \frac{1}{2}$. Using the fact that profits from producing good 1 are greater than or equal to the profits from producing good 0 for all $z > z'$, which follows from the proof of Proposition 1, it follows that

$$\alpha p_1 + (1-\alpha)p_1 - k_1 \geq \alpha p_0 + (1-\alpha)p_0 - k_0$$

which establishes the desired claim.