Production in Entrepreneurial Firms: The Effects of Financial Constraints on Labor and Capital

Mark J. Garmaise
UCLA Anderson

I model the contrasting capital-labor decisions of financially constrained and unconstrained firms. I show that financially restricted firms use relatively more labor than physical capital because informed employees provide more efficient financing than uninformed capital suppliers. I demonstrate that constrained firms cannot easily attract new employees to replace existing staff. Their greater employee retention aligns owner-worker incentives and encourages workers to make firm-specific investments. Constrained firms, however, gradually suffer from their inability to replace low-quality workers, such that their relative labor productivity decreases over time. Empirical tests utilizing instrumental variables confirm several implications of the theory. (*JEL* G32, L26)

Introduction

Small entrepreneurial firms and larger companies have very different labor management policies. One important distinction is that small firms are much more labor intensive in their production processes. For example, the large firms in the Compustat dataset in 1998 had a median total assets–employee ratio of $189,628 while the median ratio for the small firms in the 1998 Survey of Small Business Finance (SSBF) was $18,520.[1] A second disparity is that survey and anecdotal evidence consistently show that entrepreneurial work environments are more cooperative.[2] What explains these different uses of labor in small and large firms? Is there a connection between small firms' heavy reliance on labor and their collaborative modes of production? In this paper, I argue that it is the financially constrained status of many small firms that drives both their relatively high employment levels and their enlistment of employee firm-specific investments.

I have benefited from the suggestions and comments of Tony Bernardo, Matthias Kahl, Kjell Nyborg, Robert L. McDonald (the editor), an anonymous referee, and seminar participants at the University of Southern California, Tel Aviv University, and Hebrew University. I gratefully acknowledge the support of the Harold and Pauline Price Center for Entrepreneurial Studies at UCLA. Address correspondence to Mark Garmaise, UCLA Anderson, 110 Westwood Plaza, Los Angeles, CA 90095, USA: telephone: (310) 794-4118: e-mail: mark.garmaise@anderson.ucla.edu.

[1] The Compustat firms had a median of 600 employees, while the SSBF firms had a median of five employees.

[2] Examples include Wilkinson (1999) and "Nine to Five—No Comparison: Having worked for both large and small companies, these executives have come to the same conclusion: Small is better," *Wall Street Journal*, May 22, 1997, p. R 10.

doi:10.1093/rfs/hhm081 Advance Access publication December 13, 2007

I develop a model in which there are both constrained and unconstrained entrepreneurs. Financially restricted firms must seek vendor financing from their suppliers. I presume that the supplier of labor (i.e., a worker) learns about the firm in the course of production, while the supplier of physical capital (e.g., a vendor or a bank leasing equipment to the entrepreneur) does not receive information until production is complete. The worker's ability to learn in the course of performing his duties enables him to exploit the real option to quit the firm if the entrepreneur's quality (e.g., the innovativeness of his project or the depth of his management skill) is revealed to be low. Workers are, thus, willing to join risky new businesses, even without an initial compensatory payment, because they will remain only with successful ventures. Suppliers of capital do not learn the entrepreneur's quality as quickly as workers do, and hence can only rent out their assets to firms with the resources to offer some fee in advance. Constrained firms' inability to offer their suppliers cash in advance thus leads them to make greater use of labor rather than capital in production.

I then demonstrate that even financially restricted firms that become successful find it hard to attract new employees (and thereby replace existing staff), and hence, current workers can expect to receive a larger share of future firm profits in these firms. This has the implication that in a constrained firm, a worker has incentives that are better aligned with the owner, with the result that the employee is more willing to make firm-specific investments. These investments benefit the firm, such that constrained firms will exhibit strong performance early in their lives. Unconstrained firms, however, benefit as they age from their ability to replace low-quality workers. My model, thus, predicts that the labor productivity of financially constrained firms relative to unconstrained firms will decrease over time.

I test several of the implications of the model. Measuring the effects of financial constraints on a firm's production and employment strategies requires a reasonable proxy for having limited access to credit. Using data from the 1998 Survey of Small Business Finance, I analyze the owner and firm characteristics that are associated with loan rejections and then consider the capital-labor ratios of firms that are more likely to have loan applications denied. I do not simply regress capital-labor ratios on whether a firm's application was denied, because firms with little capital to serve as collateral might be more likely to be rejected, thereby generating an endogenous relationship. Instead, I show that local bank concentration, the owner's home equity, net worth, and ethnic status, and the firm's credit score are all good predictors of bank loan application rejection and hence serve as good instruments for financial constraints. I then show, in a two-stage least squares analysis, that the instruments for bank loan rejection are associated with low capital-labor ratios, controlling for firm size, age, and industry, as predicted by my theory.

I further test the implication of the model that the relative productivity of constrained firms will decrease with firm age. This is confirmed in empirical

results that show that financially restricted firms experience slower productivity growth, controlling for the level and type of assets and the number of employees in the firm. I also provide evidence, using data from the 1996–1997 National Organizations Survey, that is consistent with my theoretical prediction that workers in constrained firms are more likely to make firm-specific investments.

My theory and empirical work suggest that financial constraints can have a substantial impact on the investment decisions and growth trajectories of entrepreneurial firms. Small firms (those with fewer than 500 employees) are responsible for roughly 58% of US private employment (Headd, 2000) and 50% of private, nonfarm GDP (Joel Popkin and Company, 2001). Given this importance, their strategies for setting employment levels and deploying capital have crucial implications for the overall allocation and organization of human and physical capital in the economy.

The paper is organized as follows. Section 1 provides a literature review. I introduce the basic model in Section 2 and provide results on the optimal capital-labor choices of financially constrained and unconstrained firms. In Section 3, I extend the model to analyze the effects of financial constraints on the firm-specific investment decisions made by employees, and I examine the relative productivities of constrained and unconstrained firms over time. Section 4 describes empirical tests that examine the relationship between financial constraints and capital-labor ratios and productivity growth. In Section 5, I provide empirical work linking financial constraints to firm-specific investments by workers. I conclude the paper in Section 6. Formal proofs of the results are given in the Appendix.

1. Literature Review

This paper relates to several different streams of the literature. Hanka (1998), Ofek (1993), Kang and Shivdasani (1997), and Bronars and Deere (1991) link firms' capital structures to their labor negotiations strategies and firing policies. The thrust of these papers is that firms with substantial debt facing severe financial constraints lay off workers more frequently. The capital-labor decision is not the focus of this work.

Michelacci and Quadrini (2005) relate financial constraints to employee wages and claim, as I do, that employees can be a good source of financing for constrained firms. They do not, however, study the informational advantage of labor over physical capital, and I show that financially constrained firms will grow more slowly, while Michelacci and Quadrini argue the opposite. In my empirical work, I present an explicit measure of financial constraints and find evidence consistent with my theory.

Peek and Rosengren (2000), Cetorelli and Gambera (2001), Klein, Peek, and Rosengren (2002), and Burgess and Pande (2003), in work on financial market imperfections, have emphasized the broad damage that poorly functioning national or local credit markets can cause to investment and growth. I study

how financial constraints can distort one particular investment decision, the capital-labor choice, and, extending this approach, I provide a theoretical analysis of the costs of financial constraints.

Eisfeldt and Rampini (2005a, b) show that constraints can influence the type of capital used by a firm. These papers demonstrate that constrained firms exhibit preferences for used capital (versus new) and for leasing (rather than buying). Several previous studies have explored the effects of the financing environment on the success of entrepreneurial firms and evaluated the comparative advantages of bank and venture capital finance (Black and Gilson, 1998; Black and Strahan, 2002; Inderst and Muller, 2004; and Ueda, 2004). These studies consider aspects of the capital choices made by firms. My central focus is on the optimal labor/capital strategies for firms to undertake, given that they find it difficult to obtain credit.

This paper complements other work that considers both the labor and the capital strategies of firms. Several studies show that production in small firms is typically less capital intensive (Oi, 1983, Kimura, 2001, and Dupuy and de Grip, 2003). Small firms are more likely constrained than their larger counterparts, so these findings relate to my argument that financially restricted firms employ less capital. My empirical work, however, studies the effects of financial constraints on investment and growth, with the analysis controlling for firm size.

2. Theoretical Model

2.1 Model setup

I begin by describing the setup of the model.

2.1.1 Production in a firm. I model an entrepreneur with a new business idea. Production takes place over two periods, and it requires either labor or physical capital, which I will assume for simplicity to be perfect substitutes. The entrepreneur chooses the mode of production (labor or capital) prior to the beginning of each period. The idea of the entrepreneur and the input are then used to generate output.

The productiveness of the firm (as determined by the quality of the entrepreneur's idea or management skill) is given by f. If labor is hired, the quality of the match between the labor and the firm is q. If capital is hired or purchased, the quality of the match between the capital and the firm is r. For convenience, I assume that f, q, and r are positive random variables with full support over some bounded intervals. Total firm output π in a period is given by

$$\pi(f, q, r) = \begin{cases} f + q & \text{if labor is hired} \\ f + r & \text{if capital is hired.} \end{cases} \tag{1}$$

The entrepreneur must secure an input supplier for the second period before the first-period production is complete. At the conclusion of second-period production, the business is closed down and all assets have no further value. For simplicity, I set the discount rate equal to zero.

2.1.2 The informational advantage of labor. The key distinction between labor and capital in the model is that the supplier of labor (i.e., a worker) is capable of learning about the firm in the course of production, while the supplier of capital (e.g., someone leasing a piece of machinery to the entrepreneur) does not receive information until production is complete. Before the first period, the entrepreneur and the suppliers of labor and capital are equally ignorant of their specific qualities. In the course of the first-period production, prior to the point at which second-period arrangements must be made, however, f and either q or r (depending on whether labor or capital is hired) are revealed to the entrepreneur. If labor is hired, the worker also views f and q before making a decision about the second period. If, however, capital is hired, the supplier of capital only views f and r when first-period production is complete, after second-period arrangements have been finalized.

2.1.3 Inputs: Hiring or purchasing. I assume for realism that labor may be hired, but capital may be either purchased or rented.[3] Hiring (or renting) the input differs from purchasing it in two ways. First, if the input is hired, either party may terminate the relationship at the end of the first period. Purchased capital, on the other hand, belongs to the entrepreneur for as long as he wishes. Second, if the capital is purchased, all output belongs to the entrepreneur. If, on the contrary, the labor or capital input is hired, the supplier of the input acquires some bargaining power over the entrepreneur; I will assume that the output is not verifiable, so contracting is not possible and bargaining takes place over the division of the nonverifiable output.[4]

Since both the input and the entrepreneur are necessary for production, I will assume, as is standard in the incomplete contracting literature (e.g., Hart and Moore, 1994), that the entrepreneur receives a fraction $1 - \theta$ of the output, where $\theta \in (0, 1)$, with the remainder going to the input supplier (Binmore, Rubinstein, and Wolinsky, 1986). Both labor and capital have opportunity costs, which I denote by $\epsilon > 0$ for labor and $\zeta > 0$ for capital. Any labor or capital not employed by the entrepreneur in a given period receives its opportunity cost as payoff for that period. Capital may be purchased or sold for 2ζ before the first period and for ζ before the second period.

I assume that the entrepreneurial venture is risky and, on average, not profitable for the suppliers of the inputs (see, for example, Hamilton, 2000, and

[3] None of the results change if capital can only be rented.

[4] The robustness of the results to complete contracting is discussed in Section 3.3.4.

Moskowitz and Vissing-Jorgensen, 2002).[5] Specifically, I assume that

$$\theta\left(\bar{f}+\bar{q}\right)<\epsilon \tag{2}$$

and

$$\theta\left(\bar{f}+\bar{r}\right)<\zeta, \tag{3}$$

where I denote the mean of a variable x by $\bar{x}$.

2.1.4 Second-period input supply. If the relationship between the entrepreneur and the input supplier is terminated in the first period, the entrepreneur may seek a new input for second-period production. All outsiders (those who have not participated in the firm) observe the age of the firm and whether any separations have occurred. Outsiders, however, cannot distinguish between separations initiated by the entrepreneur and those initiated by the input supplier (Lane, Isaac, and Stevens, 1996).

2.1.5 Constrained and unconstrained entrepreneurs. I distinguish between two types of entrepreneurs. Financially constrained entrepreneurs have no wealth with which to pay suppliers of capital or labor. Financially unconstrained entrepreneurs have limitless wealth at their disposal and may offer advance payments to input suppliers. I assume that the financial status of an entrepreneur is public knowledge.[6]

The timing of the model is summarized in Figure 1.

2.2 Results: The capital-labor decision and financial constraints

I now consider differences in the capital-labor decisions of constrained and unconstrained entrepreneurs. I seek perfect Bayesian equilibria of the game described above. (All subsequent references to equilibria are to perfect Bayesian equilibria.)

RESULT 1. There is no equilibrium in which financially constrained entrepreneurs hire or buy capital. A necessary condition for the existence of an equilibrium in which financially constrained entrepreneurs hire labor is

$$\theta(\bar{f}+\bar{q})+E[\max\{\theta(q+f),\epsilon\}]\geq 2\epsilon. \tag{4}$$

A proof of Result 1 is given in the Appendix.

---

[5] In my risk-neutral model, I assume that entrepreneurial ventures are not profitable on average, but in a model with risk-averse agents, it would be enough to assume that they are insufficiently profitable to compensate agents for their substantial risk. Strictly speaking, the references I cite describe the low profitability of projects for entrepreneurs, but I presume that input providers also receive low payoffs when supplying entrepreneurial firms.

[6] Several determinants of financial constraints, such as local banking market concentration and entrepreneur ethnicity, may be easily observed. Others are less easily observed, and I discuss the robustness of my results to this assumption in Section 3.3.3.

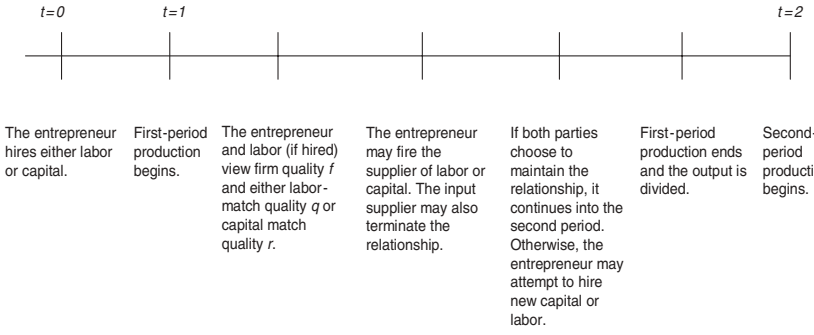

Figure 1
Timing in the basic model

It is clear that the purchase of capital is outside the means of the constrained entrepreneur, but Result 1 shows that constrained firms cannot rent capital, either. The intuition for the result is as follows. Suppose that a constrained entrepreneur could rent capital in the first period. Capital suppliers do not observe firm quality, so if a firm separates from its first-period capital supplier, it is deemed to be an average-quality firm by the market (i.e., the separation conveys no information). Assumption (3), that the one-period average returns to capital are less than the reservation rental price, implies that no supplier will be willing to offer new capital to a firm in the second period without an advance payment, which the constrained firm cannot offer. As a result, constrained entrepreneurs who rent capital in the first period will always retain the capital for both periods. Assumption (3) then shows that first-period suppliers of capital will not earn their reservation payoffs over the two periods. It must, therefore, be that capital can only be rented with an advance charge, which implies that constrained entrepreneurs cannot rent capital in equilibrium.

Why can constrained firms hire labor? Labor differs from capital in that the first-period employees can observe the firm's quality f and the quality q of their labor match before making second-period arrangements. If the sum of the firm- and labor-match qualities is too low, then the employees will leave the firm. This real option to remain only with a successful venture enhances the two-period payoff of labor hired in the first period from $2\theta(\bar{f} + \bar{q})$ to $\theta(\bar{f} + \bar{q}) + E[\max\{\theta(q + f), \epsilon\}]$, and if Inequality (4) holds, then constrained firms can hire labor with no initial signing payment. The basic intuition is that a worker may be willing essentially to finance the firm by accepting low initial wages, because if he learns that the entrepreneur is of poor quality, then he can simply leave. The ability of workers to learn about a firm's prospects and hence remain only with successful ventures generates a real option that enables them to join risky new businesses, even without an initial compensatory payment.

Suppliers of capital do not learn as quickly as workers do, and hence can only rent out their assets to firms with the ability to offer some fee in advance.

Result 2 shows that unconstrained entrepreneurs may hire capital.

RESULT 2. Unconstrained entrepreneurs may produce output in equilibrium with either labor or capital. The unconstrained entrepreneur's choice of input is determined by the relative productivities and costs of labor and capital.

A proof of Result 2 is given in the Appendix.

Unconstrained entrepreneurs have sufficient cash to simply buy physical capital when that is the input they prefer. Unconstrained entrepreneurs do not need financing, so their choice of input is, thus, solely governed by the productivities and costs of labor and capital, without reference to the fact that labor may be rented without an advance payment.

While, in practice, the differences between the two entrepreneurs will not be quite as stark as depicted in the theoretical findings, the clear empirical implication of Results 1 and 2 is that constrained firms will rely more heavily on labor, while unconstrained firms will make more use of capital. I will test this prediction in Section 4.

3. Model Extension: Firm-Specific Investments and Growth

3.1 Model extension setup

I now introduce a more comprehensive model of labor production that allows for an analysis of firm-specific investment by the worker. As my focus in this section will be on the strategy of the worker, I will analyze the case in which both constrained and unconstrained entrepreneurs hire labor, not capital. (It is sufficient, for example, to assume that the conditions given in the proofs of Results 1 and 2 for labor-hiring equilibria hold.)

Each period, after having viewed the firm- and labor-match qualities, the worker decides whether or not to make a firm-specific investment. This investment requires some effort by the worker, in exchange for which he becomes more productive within the firm. For example, the employee may exert himself to master the firm's internal systems. This skill enables the employee to produce more while working with the entrepreneur, but does not increase his value to other employers.

I presume that if the employee exerts effort, he pays a personal cost of g, and the quality of his labor match permanently improves from q to $q + \lambda$. If the worker fails to exert effort, no gains are realized. I assume that firm-specific investment is essentially a long-term investment; it is only profitable to the worker when he expects to enjoy the benefits over both periods. Specifically,

$$g > \theta\lambda > 0 \tag{5}$$

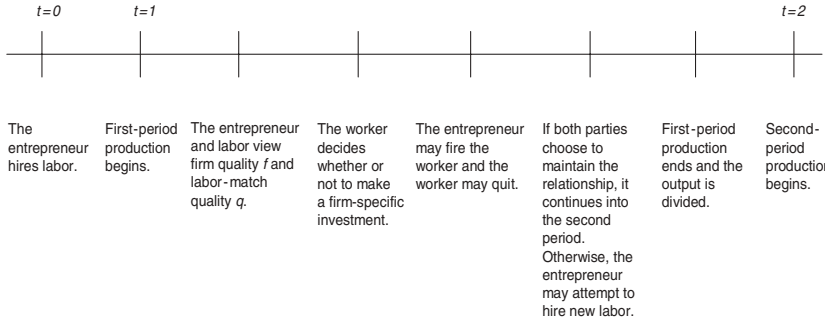

Figure 2
Timing in the extended model (labor-hiring equilibrium)

and

$$2\theta\lambda > g. \tag{6}$$

The timing of the extended model (for the case of the labor-hiring equilibrium) is summarized in Figure 2.

3.2 Results: Firm-specific investment, growth, and financial constraints

I now describe the equilibrium firm-specific investment decisions of workers in constrained and unconstrained firms and analyze the impact of these choices on firm growth.

The second-period firm-specific investment decision of the worker is straightforward. Inequality (5) shows that the optimal second-period strategy for workers at both constrained and unconstrained firms is to not exert effort.

In the first period, a worker will be willing to make a firm-specific investment only if he expects to be retained in the second period, and if he expects to reap some benefit from the investment in the second period. Lemma 1 gives a condition under which a constrained entrepreneur will retain a worker.

LEMMA 1. *If worker quality $\hat{q}$ at the end of the first period satisfies*

$$\theta(f + \hat{q}) \geq \epsilon, \tag{7}$$

then the worker will be retained by a constrained entrepreneur.

A proof of Lemma 1 is given in the Appendix.

The following is the intuition for Lemma 1. If a constrained firm seeks a new worker after the first period, this is regarded as a weakly negative signal about the firm by the market, because the first-period separation may have arisen

from a firing or a quitting (or both), and none of these indicates good news about the firm. Condition (2), that even average firms insufficiently compensate employees, thus guarantees that no new worker will join the constrained firm without an advance payment, which the firm cannot provide. As a consequence, whenever the firm is able to retain its first-period employee (i.e., whenever Inequality (7) holds), it will do so. This generates an implicit retention guarantee for employees of successful constrained firms.

I emphasize that the overall probability of retention need not be higher in constrained firms. Constrained firms may be forced, due to lack of resources or complete firm failure, to lay off their employees. When Inequality (7) fails, only unconstrained entrepreneurs can retain their employees. The essential point is that when the firm is successful (i.e., when Inequality (7) holds), constrained firms are more likely to retain their employees than unconstrained firms, but the opposite is true when the firm is struggling.

RESULT 3. If a worker in an unconstrained firm makes a firm-specific investment, then a worker in a constrained firm makes a firm-specific investment. The converse does not hold.

Retention alone is not sufficient to induce the worker to exert effort; he must also realize a benefit from his effort to improve his productivity. If Inequality (7) fails, the worker may quit, be fired, or be offered a retention payment to stay, but in all cases, he will simply receive a net payment of his reservation value ϵ. Employees do not benefit from being retained by poorly performing firms, and the prospect of being retained by such a firm will not encourage them to make a firm-specific investment. If Inequality (7) holds, the worker will receive a share of the output that he has increased. It is, thus, an implication of Lemma 1 that constrained firms retain workers precisely when it is in the interest of the workers to make firm-specific investments, and workers understand this. The practice of retention by successful constrained firms is the reason that entrepreneur and worker incentives are better aligned in constrained rather than unconstrained firms, despite the greater survival probability of the latter. As a consequence, Result 3 predicts that workers should be more willing to invest in skills specific to the firm when working for financially restricted entrepreneurs.

Result 3 shows that successful constrained entrepreneurs induce employee investment in their firms by offering implicit retention guarantees to workers. Constrained entrepreneurs, however, also suffer from the fact that they cannot dismiss poor-quality workers. This argument suggests that constrained entrepreneurs will have relatively high first-period output (due to firm-specific investments by workers), but relatively low second-period output (because they have lower-quality workers). Result 4 formalizes this idea. I denote the constrained firm's output in period $i = 1, 2$ by $\pi^{i,c}$, and $\pi^{i,u}$ is defined similarly for unconstrained firms.

RESULT 4. Constrained firms experience relatively high first-period output and relatively low second-period output:

$$E\left[\pi^{1,c}\right] \geq E\left[\pi^{1,u}\right] \tag{8}$$

and

$$E\left[\pi^{2,c}\right] \leq E\left[\pi^{2,u}\right]. \tag{9}$$

Moreover, conditional on first-period output, unconstrained firms have higher expected second-period output than constrained firms. Formally, for all $x \geq 0$,

$$E\left[\pi^{2,u} \left| \pi^{1,u} = x\right.\right] \geq E\left[\pi^{2,c} \left| \pi^{1,c} = x\right.\right]. \tag{10}$$

Result 4 states that constrained firms will have lower output growth than unconstrained firms. In the model, the firm's assets and number of employees do not vary over time, so Result 4 essentially predicts lower labor productivity growth for constrained firms. This result complements some of the findings in the literature that link financial constraints to slower growth due to reduced physical capital investment (Demirguc-Kunt and Maksimovic, 1998, Carlin and Mayer, 2003, and Almeida and Campello, 2005). In contrast, Result 4 focuses on human capital: constrained firms benefit from greater firm-specific investment by their workers, but gradually suffer from a negative selection effect in the quality of their employees that arises from their limited ability to fire. Result 4 predicts that constrained firms will perform relatively well early in their lives and relatively poorly later for reasons that are completely independent of their physical capital investment policies.[7]

3.3 Robustness

I now consider the effects on the theory's implications of relaxing several modeling assumptions.

3.3.1 Correlation between firm quality and financial status. One possible extension to the model would be to allow for positive correlation between firm quality f and unconstrained status. That is, better entrepreneurs may be wealthier. In this case, ability to pay input suppliers in the second period would now signal firm quality f and the relative advantage of unconstrained entrepreneurs in second-period hiring described in the base model would be

[7] Result 4 leaves open the question of the overall impact of financial constraints on total output. Can the benefits of firm-specific investment outweigh the costs of retaining poor-quality workers? An example provided in a previous draft showed that if the worker is of moderately less than average quality and the gains from firm-specific investment are large, then constrained entrepreneurs can have a higher two-period expected payoff than unconstrained entrepreneurs. The thrust of this example is not to suggest that entrepreneurs are better off if they are financially constrained, but rather to argue that the relative benefits of being financially unrestricted are the smallest when current employees are only slightly subpar and firm-specific investment yields large gains.

enhanced. Since this relative hiring advantage drives the results, the main findings of the paper would continue to hold.

3.3.2 First-period payoffs realized before inputs secured for second period. A second possible extension would be to have first-period payoffs realized by the entrepreneur before second-period arrangements are made. In such a setting, some very successful constrained firms would switch to unconstrained status, which would moderate the distinction between initially constrained and unconstrained entrepreneurs. Nonetheless, ability to pay in the second period would signal firm quality in this extension as well, and the relative hiring advantage of unconstrained entrepreneurs would be maintained. Thus, the central implications of the paper are robust to this extension as well.

3.3.3 Financial status is private information. A third extension would require that financial status be unknown to potential investors and employees. A pooling equilibrium in which all entrepreneurs rent capital would require that no initial payments for capital be made (because the constrained entrepreneurs cannot make these payments), but the argument underlying Result 1 indicates that such an equilibrium cannot exist. As a result, constrained entrepreneurs would be unable to rent capital in this model as well, and Results 1 and 2 would continue to hold. Results 3 and 4, however, do require that employees be informed about the financial status of the entrepreneur when making their firm-specific investment decisions. Results 3 and 4, thus, require that employees be able to learn about the entrepreneur's financial condition in the course of employment. Results 1 and 2 are robust to this assumption, as well.

3.3.4 Complete contracts. A final variation on the base model would be to allow for full verifiability of firm cash flows and complete contracts. For example, the employee could be offered a fixed or contingent wage, and the physical capital supplier might be awarded a debt or equity claim. This variation would have little effect on the capital-labor decision analyzed in Section 2. The central issues in that section are the information disadvantage of capital relative to labor and the desire of the entrepreneur to continue the project even if it is not profitable for the input supplier. An unconstrained entrepreneur can always purchase capital, while a constrained entrepreneur will be unable to rent capital, irrespective of the contract he offers, because the project is on average not worthwhile. A worker, by contrast, may join a constrained firm because of his ability to leave if project quality is revealed to be low.

The verifiability of cash flows would, however, affect Results 3 and 4. The intuition for these results is that financially constrained status essentially serves as a commitment device on the part of the entrepreneur to retain the worker because successful constrained entrepreneurs do not replace their employees, while successful unconstrained entrepreneurs may do so. This implicit commitment to retain their employees induces them to invest in the firm in the

first period. In the presence of verifiable cash flows, however, contracts may be used by unconstrained entrepreneurs to make an explicit retention promise. This suggests that the model of firm-specific investment described in Section 3 is the most appropriate for firms in which cash flows are quite costly or hard to verify. This condition is likely to apply to many entrepreneurial ventures for which the use of external cash flow monitors is simply impractical.[8]

4. Empirical Tests: Capital-Labor Ratios, Productivity Growth, and Financial Constraints

In this section, I provide empirical tests of Results 1, 2, and 4. Section 5 provides tests of Result 3.

4.1 Data

The data source for these tests is the 1998 Survey of Small Business Finance (SSBF) conducted by the Board of Governors of the Federal Reserve System. This survey, which has been used by a number of researchers (e.g., Moskowitz and Vissing-Jorgensen, 2002, and Petersen and Rajan, 2002) collects information on owner demographics, financing characteristics, balance sheets, and other attributes of small businesses (which are defined to be firms with fewer than 500 employees).

There are 3561 US firms in the dataset. Firms report the book value of assets and the number of employees they employ. The value of assets includes capital that is rented in the form of capitalized leases or secured with collateralized loans, but excludes operating leases. Data are also provided on sales revenue, the total cost of conducting business, profit margin (i.e., profits divided by sales), firm age, the Dun and Bradstreet firm credit score (a 1–5 scale), and whether the firm is located in an MSA (Metropolitan Statistical Area). A bank competition index from one to three is given that describes the commercial bank deposit Herfindahl measure of the firm's MSA (if it is in an MSA) or county. (The firm's location, however, is not revealed.) The firms also report financial information, including whether their most recent loan application was rejected and whether they have applied for a loan in the last three years.

Detailed data on the owner are provided, such as the value of home equity, net wealth (excluding both home equity and the value of the firm), ethnicity, gender, and education (on a 1–7 scale). The seven firms with negative asset levels and the one firm without a reported bank Herfindahl index are excluded from the dataset. Summary statistics, including means (all variables) and medians and standard deviations (all nonbinary variables), are given in Table 1. (The summary statistics reported weight each observation equally; they are not calculated using the SSBF survey weights.)

[8] The assumption of privately observed cash flows is found in many settings, including Harris and Raviv (1995), Gromb (1999), and DeMarzo and Fishman (2002).

Table 1
Summary statistics

Survey of Small Business Finance variable distribution characteristics

Nonbinary variables	Mean	Median	Std Dev	Binary variables	Mean
Employees	25.5	5	54.52	MSA	0.78
Assets	1,463,454	95,756	5,330,001	Female	0.22
Depreciable assets	419,825	17,577	2,114,480	African-American	0.08
Sales	3,436,004	250,000	14,993,484	Hispanic	0.07
Total costs	3,046,484	195,000	13,882,678	Applied for a loan	0.27
Assets per employee	57,014	18,503	262,462	Applied for a loan and rejected	0.05
Profit margin	–0.03	0.13	4.89		
Bank Herf index	2.47	3	0.59		
Home equity	147,677	80,000	323,491		
Net worth—home equity	786,430	180,000	3,425,042		
DBscore	3.03	3	1.04		
Education	4.65	6	1.96		
Firm age	14.45	11	12.12		

This table reports means (all variables), medians, and standard deviations (all nonbinary variables) for each variable in the 1998 Survey of Small Business Finance. Employees, assets, depreciable assets (including depletable and intangible assets), sales, total costs of conducting business, assets per employee, firm age, profit margin (profits divided by sales), and DBscore (Dun and Bradstreet credit score on a 1–5 scale) are measured at the firm level. Home equity, net worth (excluding the value of the firm and the value of home equity), education (on a 1–7 scale), gender, and ethnicity are given for the firm's primary owner. MSA is a dummy for whether the firm is located in a Metropolitan Statistical Area, and Bank Herf index is a measure (from 1 to 3) of the deposit concentration of the local MSA or county commercial bank market. Applied for a loan is a dummy for whether the firm made one or more loan applications in the past three years, and applied for a loan and rejected is a dummy for whether the firm's most recent loan application (if any) was rejected.

4.2 Empirical tests: The capital-labor decision and financial constraints

4.2.1 Theoretical hypothesis and econometric strategy. Results 1 and 2 suggest that constrained entrepreneurs will make relatively greater use of labor in production, while unconstrained entrepreneurs will rely more heavily on capital. To test this hypothesis, I estimate the following equation:

$$\begin{aligned} \textit{capital to labor ratio}_i = \alpha + \beta * (\textit{financially constrained}_i) \\ + \gamma * \textit{controls}_i + \epsilon_i, \end{aligned} \tag{11}$$

where $capital\,to\,labor\,ratio_i$ is set equal to $\log\left(1 + \frac{value\ of\ assets_i}{number\ of\ employees_i}\right)$, $financially\ constrained_i$ is a proxy for the probability that an entrepreneur is constrained, $controls_i$ is a vector of controls containing firm and owner attributes, and ϵ_i is an error term. The implication of Results 1 and 2 is that $\beta < 0$: financially constrained firms have lower capital-labor ratios.

The SSBF dataset of small firms is appropriate for testing the theory, because the issues highlighted in the model, in particular individual employee contributions that have a significant effect on firmwide outcomes, the large risk of bankruptcy, and asymmetric information about the firm's quality, are most germane in smaller firms.

4.2.2 Instruments for financial constraints. Estimating Equation (11) requires a reasonable proxy for the probability $financially\ constrained_i$ that a

given firm i is financially constrained. A clear indication of financially constrained status is that a firm's loan application is denied, and I use loan application denial as my measure of *financially constrained*. Loan application denials are only informative about firms that make a loan application, so I restrict the data to the 960 firms that made applications (and that meet the data requirements described earlier).

It is reasonable to consider that firms with small capital-labor ratios may have very few assets with which to secure a loan, and that this lack of collateral may cause their loan applications to be denied, rather than the converse. That is, the relationship between a loan denial (i.e., *financially constrained*) and a low capital-labor ratio may be endogenous. I will, therefore, provide instruments for loan denial and use these instruments as measures of financial constraints.[9]

I propose the following eight instruments for whether a firm has its loan application denied: firm presence in a concentrated local banking market, the entrepreneur's home equity, the entrepreneur's net worth (excluding the value of the firm and the value of home equity), the entrepreneur's education level, gender, and African American or Hispanic ethnicity, and the firm's Dun and Bradstreet credit score. The rationale for these instruments is as follows. Concentrated banking markets, small entrepreneurial wealth (and hence, little collateral), low education level, female gender, minority status, and poor firm credit ratings are all variables that may plausibly make it more likely that an entrepreneurial applicant will be denied a loan. On the other hand, I presume that these variables will not have a direct effect on firm capital-labor ratios.[10] I assume, for example, that in the absence of financial constraints, African American entrepreneurs would not choose capital-labor ratios that differ systematically from those of other entrepreneurs.

In the main model, I presumed that the entrepreneur's financial status was public information, and that is a reasonable description of the following instruments: local banking market concentration, entrepreneur education, gender, and ethnicity, and firm credit score. The entrepreneur's home equity and other wealth are less easily observed. In Section 3.3.3, I argue that the results in the model are robust to assuming that workers can learn the entrepreneur's financial status after being employed for some time. Therefore, all I need to assume is that workers can learn about the entrepreneur's home equity and other wealth in the course of their employment.[11]

---

[9] In addition, it may be the prospect of having a future loan request denied, rather than the actual denial itself, that weighs the heaviest on most constrained firms.

[10] In the model, unconstrained entrepreneurs have limitless cash, so even if, for example, the cost of borrowing is higher in more concentrated banking markets, unconstrained entrepreneurs can simply buy physical capital outright and bypass the banking market. As a result, local banking market competition will not have an effect on the capital-labor ratio of unconstrained entrepreneurs.

[11] Workers will learn where the owner lives, what car he drives, where he vacations, etc. As Section 3.3.3 makes clear, Results 1 and 2 are also robust to assuming that financial status is unobservable, but Results 3 and 4 require that workers know something about the firm's financial status after having been employed for a period.

My central strategy will be to estimate a two-stage least squares (2SLS) regression in which the first-stage equation is given by

$$financially\ constrained_i = F(instruments_i, controls_i, \nu_i), \qquad (12)$$

where $financially\ constrained_i$ is a binary variable set equal to one if the firm has been denied a loan, F is a linear function, $instruments_i$ is a vector of the eight instruments described above, $controls_i$ is a vector of controls containing firm and owner attributes, and ν_i is an error term. The second-stage equation is (11). That is, even though my first stage-dependent variable is binary, I estimate 2SLS using a linear form in the first state, as recommended by Angrist (2001). I estimate Equations (11) and (12) via a cross-sectional 2SLS regression, which assumes that errors are independent across firms but potentially heteroskedastic.

A second potential proxy for *financially constrained* that I do not utilize is an indicator for whether or not the firm made any loan applications in the last three years. I do not make use of this proxy because not applying for a loan may indicate either constrained status or unconstrained status, or neither:

- Constrained firms may be so unlikely to receive financing that they are discouraged from applying. In this case, not having applied for a loan would be associated with constrained status.
- Unconstrained firms may have sufficient internal capital or long-term loans, such that they need not apply for new debt. In this case, it is the unconstrained firms that do not apply.
- It may also be that filing a loan application is relatively low cost, so that it is done by both constrained and unconstrained firms.

4.2.3 Testing the instruments. I begin by evaluating whether the instruments are associated with my measure of financial constraints. In the first column of Table 2, I report results from regressing a dummy variable for whether the firm's most recent loan application was rejected on the instruments and a set of controls. The controls with reported coefficients are log of one plus sales, log of one plus firm age, profit margin, and an indicator for firm location in an MSA. Additional controls with coefficients unreported for brevity include a constant, industry dummies at the 2-digit SIC level, census region dummies, the log of one plus the owner's experience in managing a business, the log of the owner's age, the ownership share of the primary owner, a dummy for whether the firm is managed by the owner, a dummy for firms with zero sales in the previous year, a dummy for new firms, a dummy for firms subject to corporate income tax, and a dummy for family-owned firms. The estimation is via ordinary least squares (OLS), with t-statistics reported in parentheses using robust "sandwich" (White) standard errors.

I find that several instruments enter Equation (12) with statistically significant coefficients. Firms are significantly ($t = 2.76$) more likely to be denied a

Table 2
The capital–labor decision and financial constraints

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Loan appl. rejected?	Capital–labor ratio	Capital–labor ratio	Capital–labor ratio	Capital–labor ratio	Capital–labor ratio
No. of Obs.	960	960	960	436	524	960
Bank Herf index	0.051**					−0.222**
	(2.76)					(−2.40)
Log(home equity)	−0.016**					0.047**
	(−3.96)					(2.83)
Log(net worth–home equity)	−0.009**					0.050**
	(−1.97)					(2.71)
Education	−0.010					0.044
	(−1.54)					(1.54)
Female	0.021					−0.273*
	(0.59)					(−1.77)
African-American	0.304**					−0.672**
	(5.41)					(−2.50)
Hispanic	0.161**					−0.018
	(2.88)					(−0.09)
DBscore	−0.018*					0.083**
	(−1.91)					(1.98)
Log(1 + sales)	−0.020**	0.145**	0.111*	0.237**	0.138**	0.188**
	(−3.00)	(3.01)	(1.93)	(3.64)	(2.23)	(3.88)
Log(1 + firm age)	−0.010	0.101	0.080	−0.109	0.256	0.135
	(−0.51)	(0.95)	(0.69)	(−0.47)	(1.26)	(1.35)
Profit margin	−0.019**	−0.100**	−0.116**	−0.104**	0.099	−0.039
	(−4.55)	(−2.84)	(−2.89)	(−3.19)	(0.69)	(−1.30)
MSA?	0.062**	0.087	0.138	0.051	0.080	−0.150
	(2.25)	(0.66)	(0.93)	(0.31)	(0.39)	(−1.21)
Financially Constrained (Instrumented)		−2.756**		−1.332	−2.696**	
		(−4.74)		(−1.22)	(−4.63)	
Financially Constrained (Instrumented')			−3.642**			
			(−3.79)			
Estimation method	OLS	2SLS	2SLS	2SLS	2SLS	OLS
Subsample?	NA	NA	NA	Old firms	Young firms	NA
R^2	0.26					0.32

Results from the regressions of whether the firm had a loan application declined in the last three years (first column) and the log of one plus the ratio of assets to employees (second through sixth columns) on measures of financial constraints. The regressors with reported coefficients are an index of the local banking market Herfindahl measure, the log of one plus the firm owner's home equity, the log of one plus the owner's net worth excluding his home equity, a ranking of the firm owner's education, dummies for the firm owner being female, African American or Hispanic, the firm's credit score as obtained from Dun and Bradstreet, the log of one plus annual sales, the log of one plus firm age, the firm's profits to sales ratio (profit margin), a dummy for the location of the firm within an MSA (Metropolitan Statistical Area), and an instrumented estimate of the probability of the firm's having a loan application declined. The instruments are the first eight variables listed for the regressions in columns 2, 4, and 5, and the first three variables listed for the regression in column 3. Additional regressors with unreported coefficients include a constant, industry dummies at the 2-digit SIC level, census region dummies, the log of one plus the owner's experience in managing a business, the log of the owner's age, the ownership share of the primary owner, a dummy for owner-managed firms, a dummy for firms with zero sales in the previous year, a dummy for new firms (except column 4), a dummy for firms subject to corporate income tax, and a dummy for family-owned firms. The data source is the 1998 Survey of Small Business Finance. The regressions are estimated via ordinary least squares (OLS) or two-stage least squares (2SLS), as described, with t-statistics reported in parentheses using robust standard errors.
*,** indicate significance at the 10% and 5% levels, respectively.

loan in concentrated local banking markets.[12] Owners with less home equity ($t = -3.96$) and other wealth ($t = -1.97$), African Americans ($t = 5.41$), and Hispanics ($t = 2.88$) are all significantly more likely to have their loan applications rejected. Firms with better Dun and Bradstreet credit scores are also weakly ($t = -1.91$) less likely to have their applications rejected. Entrepreneur education and gender do not have a significant effect on loan denials. Taken together, however, the results in the first column of Table 2 support the use of the proposed instruments.[13]

4.2.4 Empirical findings: Capital-labor ratios and financial constraints. Results 1 and 2 imply that financially constrained firms will have low capital-labor ratios, and I test this hypothesis by estimating Equations (11) and (12) via 2SLS. In the second column of Table 2, I report results from the 2SLS regression of capital-labor ratios on whether the most recent loan application was declined. I make use of the eight instruments and all the controls previously described in Section 4.2.3. (The SSBF does not provide detailed firm locations or physical capital, or labor market variables, so the regressions do not include prices of physical capital or labor.) I find that financially constrained firms (i.e., those whose loan applications were declined) have substantially reduced capital-labor ratios, as predicted by Results 1 and 2. The t-statistic on loan denial is –4.74 (calculated with robust standard errors).[14] To evaluate the economic significance of this effect, I first calculate that the standard deviation of the predicted probability of being financially constrained (from the estimation of Equation (12)) is 0.1922. The regression results then show that, for a given firm, a one-standard-deviation increase in its predicted probability of being constrained decreases its capital-labor ratio by 5.3% of the mean.

Given that I have eight instruments and only one endogenous variable, I conduct a heteroskedasticity-robust test of overidentifying restrictions (Wooldridge, 2002, p. 123). This test assesses whether the proposed instruments are actually exogenous. I find a p-value of 0.41, suggesting no reason to reject the validity of the instruments.

In the third column of Table 2, I report results from repeating the previous regression, but making use of only the following three instruments: local banking market concentration, the log of the owner's home equity, and the log of the owner's net worth, because these are perhaps the most closely linked to the idea of financial constraints described in the theoretical model. The t-statistic on

[12] This finding is consistent with the evidence in Hannan (1997) and Berger, Rosen, and Udell (2001) that concentrated markets are less competitive. Black and Strahan (2002); and Cetorelli and Strahan (2004) show that banking concentration has an especially deleterious effect on small firms.

[13] Although the dependent variable measuring financial constraints is binary, I test the instruments using OLS because the first stage in the proposed 2SLS procedure is linear. A logit regression of the first-stage equation (12) yields similar results, with the same set of instruments entering significantly.

[14] A simple direct OLS regression of capital-labor ratios on whether the most recent loan application was denied also yields a negative and significant coefficient, but I find that the 2SLS results offer the clearest interpretation.

loan denial is –3.79 in this specification, and the p-value for the overidentifying restrictions is 0.68.

The idea underlying Results 1 and 2, that employees are quicker to learn firm quality than suppliers of physical capital, is likely most important for young firms. For older firms, input suppliers face less of an asymmetric information problem, so learning may be less important. To test this idea, I create subsamples of young (firm age less than or equal to 11) and old (firm age above 11) firms and repeat the eight-instrument 2SLS regression in each subsample. (The median firm age is 11.) The results, displayed in the fourth and fifth columns of Table 2, show that the coefficient on loan denial is significant ($t = -4.63$) in the young firms subsample, but insignificant ($t = -1.22$) in the old firms subsample. This is consistent with the argument of the model that constrained firms' lower capital-labor ratios are driven by the informational advantage of labor.

4.2.5 Robustness tests: The capital-labor ratio and financial constraints. As a robustness check for the results described in Section 4.2.4, I estimate Equation (11) via OLS using the instruments as proxies for *financially constrained*. That is, I estimate the reduced form of the model. This is not a formal 2SLS test, but it provides information on the effects of the different instruments on capital-labor ratios. If an instrument for financially constrained status were associated with higher capital-labor ratios, this would be a cause for concern. In the sixth column of Table 2, I report results from regressing capital-labor ratios on the eight instruments directly, and I include all the previous controls. Firms whose owners have more home equity ($t = 2.83$) and net wealth ($t = 2.71$) and firms with high credit scores ($t = 1.98$) have higher capital-labor ratios, while firms in banking markets with high Herfindahls ($t = -2.40$) and firms with African American owners ($t = -2.50$) or female owners ($t = -1.77$) have lower capital-labor ratios. The coefficients on education and Hispanic ethnicity are insignificant. The results depicted in the first column of Table 2 show that lower home equity, lower net wealth, lower firm credit scores, higher banking market concentration, and African American and Hispanic status of owners are all associated with financial constraints (loan denials), and I find that the first five of these variables are also linked in a statistically significant manner to lower capital-labor ratios, while the sixth exhibits an insignificant correlation. Overall, this provides broad support for the argument that the empirical effect of financial constraints on capital-labor ratios is consistent across instruments.

As an additional test, I drop all observations for which the capital-labor ratio is above its 95th percentile or below its 5th percentile, and find that this screening has only a minor effect on the regressions in Table 2 and does not change the statistical inferences.[15]

[15] For example, the coefficient on financial constraints in the 2SLS regression described in the secand column of Table 2 increases from -2.756 to -1.57 and the t-statistic increases from -4.74 to -3.68.

4.2.6 Robustness tests: The labor intensity of production and financial constraints. Results 1 and 2 have a direct implication for the relative capital-labor ratios of constrained firms, but they also have the more general implication that financially restricted firms will produce in a labor-intensive manner. In the model, the total cost of conducting business is the payment to the input supplier, so the theory predicts that the costs per employee will be lower in constrained firms as they hire more workers and use less physical capital. To test this broader implication, I relate the total costs of conducting business per employee to a firm's financial status. Specifically, I estimate the following equation:

$$y_i = \Phi + \Delta * (financially\ constrained_i) + \kappa * controls_i + \Sigma_i, \qquad (13)$$

where y_i is set equal to $\log\left(1 + \frac{total\ costs_i}{number\ of\ employees_i}\right)$, $financially\ constrained_i$ and $controls_i$ are defined as in Equation (11), and Σ_i is an error term. The total cost of conducting business includes rental costs on production facilities, the costs of all materials, and interest payments on purchased capital, so this specification allows for the possibility that constrained firms may make greater use of operating leases or purchase (rather than produce) materials. All these costs are incorporated in $\log\left(1 + \frac{total\ costs_i}{number\ of\ employees_i}\right)$, which is a measure of the labor intensity of production that thus controls for varying leasing or outsourcing strategies by different firms. (The SSBF does not provide data on the total wage bill of the firm.) The implication of Results 1 and 2 is that $\Delta < 0$: financially constrained firms have lower total costs-labor ratios. I jointly estimate Equations (12) and (13) using 2SLS.

In the first column of Table 3, I report results from the 2SLS regression of total cost-labor ratios on my measure of financial constraints (i.e., whether the most recent loan was declined). I make use of the eight instruments and all the controls previously described in Section 4.2.3, with the exception of the profit margin, since the total costs are used to compute the profit margin. The five firms with zero costs are excluded. I find that financially constrained firms have significantly ($t = -4.09$) lower total cost-labor ratios, as predicted by Results 1 and 2. For a given firm, a one-standard-deviation increase in its predicted probability of having a loan declined decreases its total costs-labor ratio by 2.0% of the mean. The p-value for the overidentifying restrictions is 0.92. The second column of Table 3 details the results from running the same regression, but making use of only local banking market concentration, the log of the owner's home equity, and the log of the owner's net worth as the instruments in Equation (12). I find similar results, with a negative and significant coefficient on financial constraints ($t = -2.76$) and an overidentifying restrictions p-value of 0.40.

I next consider the relationship between a firm's financial status, the number of its employees, and its depreciable, depletable, and intangible assets. (For simplicity, I refer to the latter class of assets, which are treated as a group in the

Table 3
The labor intensity of production and financial constraints—robustness tests

Dependent variable	(1) Total costs–labor ratio	(2) Total costs–labor ratio	(3) Depreciable assets–labor ratio	(4) Depreciable assets–labor ratio
No. of Obs.	955	955	959	959
Financially Constrained (Instrumented')	−1.136**		−3.201**	
	(−4.09)		(−3.06)	
Financially Constrained (Instrumented')		−1.348**		−4.908**
		(−2.76)		(−2.77)
Log(1 + sales)	0.273**	0.264**	0.202**	0.138
	(9.67)	(7.45)	(2.55)	(1.40)
Log(1 + firm age)	−0.089	−0.093	0.007	−0.034
	(−1.40)	(−1.42)	(0.04)	(−0.16)
Profit margin			−0.187**	−0.218**
			(−3.55)	(−3.57)
MSA?	0.168**	0.181**	−0.550*	−0.452
	(2.02)	(2.00)	(−1.89)	(−1.44)
Estimation method	2SLS	2SLS	2SLS	2SLS

Results from the regressions of the log of one plus the ratio of the total cost of conducting business to the number of employees (first and second columns) and the log of one plus the ratio of depreciable, depletable, or intangible assets to employees (third and fourth columns) on measures of financial constraints. The regressors with reported coefficients are instrumented estimates of the probability of the firm's having a loan application declined, the log of one plus annual sales, the log of one plus firm age, the firm's profits to sales ratio (profit margin) in columns 3 and 4, and a dummy for the location of the firm within an MSA (Metropolitan Statistical Area). The instruments are generated using an index of the local banking market Herfindahl measure, the log of one plus the firm owner's home equity, the log of one plus the owner's net worth excluding his home equity, a ranking of the firm owner's education, dummies for the firm owner being female, African American, or Hispanic, and the firm's credit score as obtained from Dun and Bradstreet for the regressions in columns 1 and 3, and are generated using the first three of these variables for the regressions in columns 2 and 4. Additional regressors with coefficients unreported for brevity include a constant, industry dummies at the 2-digit SIC level, census region dummies, the log of one plus the owner's experience in managing a business, the log of the owner's age, the ownership share of the primary owner, a dummy for whether the firm is managed by the owner, a dummy for firms with zero sales in the previous year, a dummy for new firms, a dummy for firms subject to corporate income tax, and a dummy for family-owned firms. The data source is the 1998 Survey of Small Business Finance. The regressions are estimated via ordinary least squares (OLS) or two-stage least squares (2SLS), as described, with t-statistics reported in parentheses using robust standard errors.
*,** indicate significance at the 10% and 5% levels, respectively.

SSBF, simply as the firm's depreciable assets.) As a second test of the effects of financial constraints on the labor intensity of production, I estimate Equation (13), setting y_i equal to $\log\left(1 + \frac{depreciable\ assets_i}{number\ of\ employees_i}\right)$. Depreciable assets may be more likely substitutes for labor than other assets, such as land or cash. As above, the implication of Results 1 and 2 is that $\Delta < 0$. I jointly estimate Equations (12) and (13) using 2SLS.

In the third column of Table 3, I report results from the 2SLS regression of depreciable asset–labor ratios on my measure of financial constraints. I utilize the eight instruments and all the controls previously described in Section 4.2.3. The one firm with negative depreciable assets is excluded. I find that financially constrained firms have significantly ($t = -3.06$) lower depreciable assets–labor ratios, as predicted by the model. For a given firm, a one-standard-deviation increase in its predicted probability of having a loan declined decreases its total depreciable assets–labor ratio by 8.2% of the mean. The p-value for the

overidentifying restrictions is 0.28. As shown in the fourth column of Table 3, the results from the regression using only local banking market concentration, the log of the owner's home equity, and the log of the owner's net worth are again consistent with the previous finding. I find a t-statistic of –2.77 on my measure of financial constraints, and the overidentifying restrictions p-value is 0.20.

The empirical findings in Tables 2 and 3, thus, together provide a variety of evidence in favor of the prediction of Results 1 and 2 linking financial constraints to lower capital-labor ratios, and to greater labor intensity of production more broadly.

4.3 Empirical tests: Firm productivity growth and financial constraints

4.3.1 Theoretical hypothesis and econometric strategy. Result 4 predicts that constrained firms will experience slower productivity growth than unconstrained firms, controlling for the level of physical capital and number of employees in the firm. To test this prediction, I estimate the following productivity equation:

$$\begin{aligned}\log(1 + sales_i) = {} & \psi_1 + \psi_2 * (financially\ constrained_i) \\ & + \rho * (financially\ constrained_i) * \log(1 + firm\ age_i) \\ & + \psi_3 * \log(1 + firm\ age_i) \\ & + \psi_4 * (firm\ productivity\ controls_i) + u_i, \end{aligned} \tag{14}$$

where $sales_i$ is the dollar value of firm i's sales, $firm\ age_i$ is the age of firm i in years, $firm\ productivity\ controls_i$ is an augmented vector of firm and entrepreneur attributes, and u_i is an error term. The implication of Result 4 is that $\rho < 0$: the relative productivity of constrained firms decreases over time.

I include in $firm\ productivity\ controls$ both the log of one plus assets and the log of employees interacted with industry dummies, and measures of firm assets in different categories (e.g., cash, land, inventory, etc.). This approach presumes that factor shares are constant within industries (Kahn and Lim, 1998), and I control for the use of different asset types by different firms. My accounting for asset levels and types helps to ensure that my productivity results are not driven by different levels of capital investment in constrained firms.

The results in the fourth and fifth columns of Table 2 indicate that the learning problems faced by input suppliers that are at the heart of the theoretical model are, as might be expected, most salient for young firms. This suggests that the decreasing relative productivity of constrained firms is most likely to be found in the sample of younger firms. As firms age, information asymmetries become less relevant, the assumptions underlying the model gradually fail to obtain, and the difference between the productivities of constrained and unconstrained

firms begins to narrow. Consequently, I separate the samples of old and young firms in my productivity analysis.

Ideally, I would test Result 4 by utilizing a panel dataset allowing time-varying productivity estimates for given firms over time, but the SSBF data do not provide the historical data required for that strategy. Instead, as described in Equation (14), I estimate productivity for a cross section of firms and analyze the interaction between financially constrained status and firm age.

4.3.2 Labor productivity versus total-factor productivity. Strictly speaking, Result 4 concerns labor productivity, not general productivity, so I interpret the coefficients on financially constrained status and its interaction with firm age as labor productivity effects of these variables. This follows the literature on labor productivity (e.g., Freeman and Kleiner, 2000, and Black and Lynch, 2001). As in any Cobb–Douglas-type specification, however, in Equation (14), I am actually estimating total-factor productivity, so it might be argued that any productivity differences I find between financially constrained and unconstrained firms actually arise from differences in asset productivity. Against this point, I note that I measure assets in dollar terms and control for the various types of assets used by the firm. Moreover, the prediction of Result 4 is that the relative productivity of constrained firms will fall over time. This interaction result would not be generated by any difference between the productivity of assets in constrained and unconstrained firms that is constant over time.[16] Result 4 is distinctive in that it predicts a time-series effect on the relative productivity of constrained firms.

4.3.3 Instrumental variables. To estimate Equation (14), I require a proxy for $financially\ constrained$. I do not make direct use of the indicator for whether a firm's loan application is denied, because this variable is endogenous in this setting as well; it may be that older firms are only denied a loan if they are especially unproductive. The analysis is somewhat complicated by the fact that both financially constrained status and the interaction between constrained status and firm age are endogenous. That implies that I must instrument for both variables using a form of nonlinear 2SLS.

I adopt the approach suggested in Angrist (2001) and Kelejian (1971) for nonlinear 2SLS. Specifically, I first estimate

$$financially\ constrained_i = G(instruments_i, firm\ productivity\ controls_i, \omega_i), \tag{15}$$

where $financially\ constrained_i$ is a binary variable set equal to one if the firm was denied a loan, G takes the logistic form, $instruments_i$ is the vector of the eight original instruments described in Section 4.2.2, and ω_i is an error

[16] In the Eisfeldt and Rampini (2005a, b) models, for example, each firm produces in only one period, so a given firm does not experience changing productivity over time.

term. I denote the predicted value of *financially constrained* generated by the estimation of Equation (15) by $\hat{fc}$.

I use this predicted variable to construct two new instruments, *ninstruments*: $\hat{fc}$ and $\hat{fc} * \log(1 + firm\ age)$. The variables *ninstruments* are used as instruments for financially constrained status and the interaction between financially constrained status and the log of firm age. I use *ninstruments* to perform 2SLS. The first-stage equations are

$$\begin{bmatrix} financially\ constrained_i \\ (financially\ constrained_i) * \log(1 + firm\ age) \end{bmatrix} = \Gamma \begin{bmatrix} constant \\ ninstruments_i \\ log(1 + firm\ age_i) \\ firm\ productivity\ controls_i \end{bmatrix} + v_i, \tag{16}$$

where Γ is a matrix of coefficients to be estimated and v_i is a vector of error terms. The second-stage equation is given by (14). I estimate Equations (14) and (16) via a cross-sectional 2SLS that assumes independent but potentially heteroskedastic errors across firms.

4.3.4 Empirical findings: Firm productivity and financial constraints. I begin by analyzing the effects of financial constraints on productivity in the sample of older firms. In the first column of Table 4, I report results from the regression of the log of one plus sales on financially constrained status, the interaction of financially constrained status and the log of one plus the firm age, the log of one plus the firm age, and the set of firm productivity controls. The firm productivity controls include all the variables used in the regressions in Table 2 (detailed in Section 4.2.3) and also include the log of one plus assets and the log of employees interacted with industry dummies, and the log of one plus the asset type for the following eight asset categories: cash, accounts receivable, inventory, other current assets, other investments, land, buildings plus equipment, and other assets. As additional controls, I use the geographic size of the firm's market (measured on a 1–5 scale) and a dummy for firms with zero sales. (Excluding firms with zero sales has no effect on the results.) The estimation is via 2SLS, using the two new instruments generated by the eight original instruments, as described in Section 4.3.3, with robust t-statistics.

The results in the first column of Table 4 show that in the sample of older firms, the estimated coefficient on the interaction between financial constraints (i.e., loan denial) and firm age is negative but insignificant. In the second column of Table 4, I report results from conducting the same regression on the sample of younger firms. For the set of younger firms, the coefficient on the interaction is negative and significant ($t = -1.97$), as predicted by Result 4.[17]

[17] A direct OLS regression of log of sales on whether the most recent loan application was denied interacted with firm age also yields a negative and significant coefficient, but I focus on the instrumented results.

Table 4
Productivity and financial constraints

	(1)	(2)	(3)	(4)
Dependent variable	Log(1 + sales)	Log(1 + sales)	Log(1 + sales)	Log(1+ sales)
No. of Obs.	436	524	436	524
Financially Constrained	0.514	0.431		
(Instrumented)	(0.42)	(0.73)		
Financially Constrained*	−0.389	−0.589**		
Log(1 + firm age) (Instrumented)	(−0.98)	(−1.97)		
Log(1 + firm age)	0.059	0.305**		
	(0.45)	(3.08)		
Financially Constrained			0.113	0.625
(Instrumented')			(0.07)	(1.06)
Financially Constrained*			−0.182	−0.664**
Log(1 + firm age) (Instrumented')			(−0.34)	(− 2.13)
Log(1 + firm age)			0.049	0.324**
			(0.38)	(3.28)
MSA?	0.222**	0.068	0.207**	0.066
	(2.70)	(0.75)	(2.51)	(0.72)
Log(1 + assets)* Industry dummies	Yes	Yes	Yes	Yes
Log(emp) * Industry dummies	Yes	Yes	Yes	Yes
Asset category controls	Yes	Yes	Yes	Yes
Estimation method	2SLS	2SLS	2SLS	2SLS
Subsample?	Old firms	Young firms	Old firms	Young firms

Results from the regressions of the log of annual sales on measures of financial constraints, interactions between financial constraints and firm age, and firm inputs. The regressors with reported coefficients are an instrumented estimate of the probability of the firm's having a loan application declined, the interaction of the instrumented estimate with the log of one plus the firm age, the log of one plus the firm age, and a dummy for the location of the firm within an MSA (Metropolitan Statistical Area). The instruments are generated using an index of the local banking market Herfindahl measure, the log of one plus the firm owner's home equity, the log of one plus the owner's net worth excluding his home equity, a ranking of the firm owner's education, dummies for the firm owner being female, African American, or Hispanic, and the firm's credit score as obtained from Dun and Bradstreet for the regressions in columns 1 and 2, and are generated using the first three of these variables for the regressions in columns 3 and 4. Additional regressors with coefficients unreported for brevity include a constant, industry dummies at the 2-digit SIC level, industry dummies interacted with both the log of one plus assets and the log of employees, the log of one plus the asset type for the following eight asset categories: cash, accounts receivable, inventory, other current assets, other investments, land, buildings plus equipment and other assets, census region dummies, the log of one plus the owner's experience in managing a business, the log of the owner's age, the ownership share of the primary owner, a dummy for whether the firm is managed by the owner, a dummy for firms subject to corporate income tax, a dummy for family-owned firms, a dummy for firms with no sales, and an index for the geographic size of the firm's market. The data source is the 1998 Survey of Small Business Finance. The regressions are estimated via two-stage least squares (2SLS), with t-statistics reported in parentheses using robust standard errors.
*,** indicate significance at the 10% and 5% levels, respectively.

The estimated coefficients indicate that a one-standard-deviation increase in the predicted probability of having a loan declined raises the log of sales by 0.03% of the mean for one-year-old firms, but lowers it by 1.6% of the mean for eleven-year-old firms, controlling for the level of assets and number of employees in the firm. As suggested by Result 4, within the group of firms for which information asymmetries are important, financial constraints are a greater disadvantage as firms age.

I also conduct these regressions exploiting only local banking market concentration, the log of the owner's home equity, and the log of the owner's net

worth as the instruments utilized in Equation (15) to generate the two new instruments *ninstruments*. The results shown in the third and fourth columns of Table 4 confirm my previous findings. The interaction between financial constraints and firm age is insignificant in the older firms sample, and negative and significant ($t = -2.13$) in the younger firms sample. Dropping observations for which sales is above its 95th percentile or below its 5th percentile has only a minor effect on the coefficient estimates and does not change the statistical inference for any of the regressions in Table 4.[18]

The results in Table 4 indicate that firm age has no significant effect on productivity for older firms of either the constrained or unconstrained types. Unconstrained younger firms, however, experience significant positive productivity improvements over time, while constrained younger firms do not experience any significant change. This finding is consistent with the mechanism in the model by which unconstrained firms can improve their productivity by firing poor employees and hiring new ones who are better on average, while constrained firms retain their existing workers and maintain a fairly stable level of productivity over time.[19] The empirical results described in Table 4, particularly those for young entrepreneurial firms, thus provide support for Result 4.

5. Empirical Tests: Firm-Specific Investments and Financial Constraints

In this section, I provide tests of Result 3.

5.1 Data

The data source for the tests of Result 3 is the 1996–1997 National Organizations Survey (Kalleberg, Knoke, and Marsden, 1996–1997). The National Organizations Survey (NOS) gathers data from US work establishments on their formal structures, internal labor markets, and use of hierarchies. There are 1002 organizations in the dataset. I make use of two variables in the NOS on organizational practices. The first is a dummy variable, indicating whether employees in the firm are involved in work teams when they do their job. The second is a summary measure of the average level at which decisions are made within the firm. To construct the second variable, I make use of data in NOS that describes who within the firm makes the final decision in the following eight areas: new employee hiring, the use of subcontractors, the use of temporary workers, worker evaluation, product or service improvement, worker schedules,

[18] For example, removing sales outliers from the regression described in the second column of Table 4 increases the coefficient on the interaction between financial constraints and log of firm age from -0.589 to -0.557 and decreases the t-statistic from -1.97 to -2.11.

[19] In unreported results, I find that the relative elasticity of output with respect to labor in constrained and unconstrained firms does not vary over time.

production targets, and the provision of training programs. For each area, the respondent indicates if the decision is made by the head of the organization (to which I assign a score of four), a middle manager (three), a supervisor (two), or someone below (one). For each firm, I then average the scores across all the areas for which data are available to generate the summary measure.

The NOS includes location data, which enables me to calculate the commercial bank deposit Herfindahl of the organization's MSA (if it is in an MSA) or county (otherwise) in 1996. The owner demographic and credit score variables I employ in Table 2 are not available in the NOS data. I restrict attention to organizations that are small firms. My requirements that organizations have 500 or fewer employers, have for-profit status, and provide the necessary organizational data are met by 241 firms in the dataset.

5.2 Theoretical hypotheses and econometric strategy

Result 3 shows that a worker will be more willing to make a firm-specific investment in a constrained firm than in an unconstrained firm. In order to generate empirical implications from Result 3, I must make the idea of a firm-specific investment concrete. In a previous draft (available from the author), I consider two examples of firm-specific investments: workers investing in cospecialization with fellow employees and workers choosing projects that generate firmwide benefits at some personal cost. My analysis of both these particular examples was driven by the intuition underlying Result 3, that employees in constrained firms are more willing to make firm-specific investments. I showed that constrained firms are more likely to produce in teams, because workers in constrained firms are more willing to make the cospecialization efforts that make team production efficient. I also showed that constrained entrepreneurs are more willing to grant their employees discretion in project selection, as employees in these firms are more likely to choose projects that generate firmwide benefits, even at some personal cost.[20]

This suggests two empirical implications of Result 3: firms owned by constrained entrepreneurs should more frequently produce in groups and should be more likely to grant their employees significant autonomy (i.e., allow decisions to be made at a lower level). To test these implications, I estimate the following equation:

$$z_i = H(financially\ constrained_i, controls_i, \eta_i), \tag{17}$$

where z_i is a description of an organizational practice (production in teams or level at which decisions are made), $financially\ constrained_i$ is proxied for by the local commercial bank deposit Herfindahl, $controls_i$ is a set of firm-level controls, and η_i is an error term. I estimate Equation (17) via cross-sectional logit (for the binary team-production variable) and OLS (for the decision-level

[20] Harris and Raviv (2002); Dessein and Santos (2003); Vayanos (2003); and Garicano (2000) provide other models of the optimal form of firm organization.

variable), assuming that errors are independent across firms, but potentially heteroskedastic.

5.3 Empirical findings: Firm-specific investments and financial constraints

I analyze a logit regression of a dummy variable indicating whether employees in the firm are involved in work teams on the concentration of the local banking market and controls for the number of employees, sales, age, and industry (at the 2-digit SIC level). Consistent with the first implication of Result 3, I find that firms located in concentrated banking markets are significantly more likely to have their core employees involved in work teams ($t = 2.59$). A one-standard-deviation increase in banking concentration increases the probability of work teams by 6.6%, when the other variables are evaluated at their medians.

I also regress, via OLS, the average level at which decisions are made on banking concentration and the controls described above. I find, consistent with Result 3, a significant negative coefficient ($t = -2.35$) on banking concentration. A one-standard-deviation increase in bank concentration reduces the level at which decisions are made by 2.2% of the mean.

These findings from the NOS data utilize only one proxy for financial constraints and draw on a relatively small dataset. The results, nonetheless, provide some empirical support for Result 3 and indicate that it has several clearly testable implications.

6. Conclusion

In this paper, I develop a model of the optimal capital and labor management strategies of financially constrained and unconstrained firms. I argue that workers are better informed than suppliers of physical capital, and therefore employees, but not capital providers, have the real option to abandon unsuccessful firms. As a result, employees are willing to work for firms without advance payments, while capital suppliers are not, and constrained firms (that cannot offer initial payments) consequently will have lower capital-labor ratios. I also demonstrate that successful constrained firms find it difficult to hire new employees, and thus, offer an implicit retention guarantee to their workers. As a result, employees in these firms will be likelier to make firm-specific investments. I further show that constrained firms will exhibit declining relative labor productivity over time. Empirical tests confirm the central predictions of the model and indicate that a firm's use of labor as an input in production can be affected considerably by the extent of its financial resources.

An interesting implication of the model is that firms that undergo a shift in their financial status will simultaneously alter their labor policies. For example, the advent of new sizable venture capital or bank financing may discourage employees from making firm-specific investments. In such a setting, encouraging employee initiative becomes less important, which should lead the firm to

institute a more formal hierarchy structure that concentrates decision-making power in the hands of senior managers. This may lead to a "professionalization" (Hellman and Puri, 2002) of the way the firm conducts business, that derives simply from the firm's new access to financing and that is independent of any actions or guidance on the part of the source of capital. Similarly, post-IPO firms should experience a significant change in their employee retention policies.

Appendix

A1 Proof of Result 1

For each variable x, I denote its minimum and maximum by $x_{\min}$ and $x_{\max}$, respectively. Suppose, for a contradiction, that there is an equilibrium in which the constrained entrepreneur hires capital in the first period. I begin by showing that the constrained entrepreneur will retain the supplier of capital after first-period production with probability one. It cannot be that the supplier of capital quits with probability one, since then Inequality (3) would show that this supplier would not supply the entrepreneur in the first period. So for any outcome of f and r, the supplier of capital chooses to remain with positive probability $p_s > 0$. (Recall that the supplier of capital cannot condition his strategy on f and r, since he does not view them until after making a decision.)

Suppose that for any given f and r with some positive probability, the entrepreneur fires the supplier of capital. It must then be that with some positive probability, there is a supplier of capital willing to rent to the entrepreneur in the second period or else, the entrepreneur would do strictly better to retain the first-period supplier of capital. This implies that if a separation is seen by the market, there is a probability $p_c > 0$ that new capital is supplied. For any f and r, the entrepreneur's payoff from retention is $(1-\theta)(f+r)$ and his payoff from firing the capital and attempting to rehire is $(1-\theta)(p_c(f+\bar{r}))$. In equilibrium, the entrepreneur will choose to fire if and only if

$$(1-\theta)(f+r) < (1-\theta)p_c(f+\bar{r}), \tag{A1}$$

i.e., $r < p_c\bar{r} - (1-p_c)f$. I define $D(f) = \min\{r_{\max}, p_c\bar{r} - (1-p_c)f\}$, a decreasing function of f. Separation can arise from either quitting or firing. I denote the densities and cumulative distribution functions of f, r, and q by h_f, h_r, and h_q, H_f, H_r, and H_q, respectively. It is the case that

$$E[f|separation] = \frac{p_s \int_{f_{\min}}^{f_{\max}} \int_{r_{\min}}^{D(f)} h_r(r)dr(f)h_f(f)df + (1-p_s)\bar{f}}{p_s \int_{f_{\min}}^{f_{\max}} \int_{r_{\min}}^{D(f)} h_r(r)drh_f(f)df + (1-p_s)}. \tag{A2}$$

I note that

$$\frac{\int_{f_{\min}}^{f_{\max}} \int_{r_{\min}}^{D(f)} h_r(r)dr(f)h_f(f)df}{\int_{f_{\min}}^{f_{\max}} \int_{r_{\min}}^{D(f)} h_r(r)drh_f(f)df} = \frac{\int_{f_{\min}}^{f_{\max}} H_r(D(f))(f)h_f(f)df}{\int_{f_{\min}}^{f_{\max}} H_r(D(f))h_f(f)df} \leq \bar{f}, \tag{A3}$$

since $\hat{h_f}(f) = \frac{H_r(D(f))h_f(f)}{\int_{f_{\min}}^{f_{\max}} H_r(D(f))h_f(f)df}$ is a probability density function for f, and it is dominated by h_e in the sense of the monotone likelihood ratio property and hence has a lower mean. (It is clear that $\frac{\hat{h_f}(f)}{h_f(f)} = \frac{H_r(D(f))}{\int_{f_{\min}}^{f_{\max}} H_r(D(f))h_f(f)df}$ is decreasing, since D is decreasing.) I conclude from Equation (A2) that

$$E[f|separation] \leq \bar{f}. \tag{A4}$$

No new capital will consent to join the firm, since the expected payoff from doing so is

$$\theta(\bar{r} + E[f|separation]) \leq \theta(\bar{r} + \bar{f}) < \zeta. \tag{A5}$$

This contradicts my earlier assumption. I conclude that with probability one, the entrepreneur retains the first-period supplier of capital. The two-period payoff to the first-period supplier of capital is given by

$$\theta(\bar{f} + \bar{r})(1 + p_s) + (1 - p_s)\zeta < 2\zeta. \tag{A6}$$

I conclude that no supplier of capital will be willing to provide capital to the constrained entrepreneur in the first period.

I now show that condition (4) is necessary for the existence of an equilibrium, in which financially constrained entrepreneurs hire labor. If, in equilibrium, labor is hired by the constrained entrepreneur in the first period, the worker will quit if

$$\theta(f + q) < \epsilon. \tag{A7}$$

I denote the probability that new labor can be hired without any advance cost by p_l. The entrepreneur will fire the worker if

$$(f + q) < p_l(f + \bar{q}). \tag{A8}$$

Separation, thus, occurs for

$$q < \max\left\{\frac{\epsilon}{\theta} - f,\, p_l(f + \bar{q}) - f\right\} := D_1(f), \tag{A9}$$

where the equality is a definition and D_1 is a decreasing function. I thus have

$$E[f|separation] = \frac{\int_{f_{\min}}^{f_{\max}} \int_{q_{\min}}^{D_1(f)} h_q(q)dq(f)h_f(f)df}{\int_{f_{\min}}^{f_{\max}} \int_{q_{\min}}^{D_1(f)} h_q(q)dq h_f(f)df}. \tag{A10}$$

As above, this shows that after separation, no new labor will be supplied to the constrained entrepreneur. Since no new labor can be hired in the second period, the first-period worker will remain with the constrained firm if and only if $\theta(q + f) \geq \epsilon$ (i.e., if it is in his own interest to do so). The two-period expected payoff to a worker hired by a constrained entrepreneur in the first period is

$$\theta(\bar{f} + \bar{q}) + \theta E\left[\max\left\{q + f, \frac{\epsilon}{\theta}\right\}\right] \geq 2\theta(\bar{f} + \bar{q}). \tag{A11}$$

If

$$\theta(\bar{f} + \bar{q}) + \theta E\left[\max\left\{q + f, \frac{\epsilon}{\theta}\right\}\right] \geq 2\epsilon, \tag{A12}$$

it is an equilibrium for a worker to join the firm in the first period, quit if $\theta(q + f) < \epsilon$, and remain otherwise. The entrepreneur never fires the worker. All off-equilibrium-path actions from the entrepreneur are assumed to come from entrepreneurs with $f = f_{\min}$ in the second period. Condition (A12) is, thus, necessary and sufficient for the existence of an equilibrium in which labor is hired, since if it fails, the worker will not agree to join the firm, and if it holds, he will.

A2 Proof of Result 2

To prove the result, I will exhibit a set of equilibria in which the unconstrained entrepreneur produces using capital and a second set of equilibria, in which he produces using labor. All references to an entrepreneur below are to an unconstrained entrepreneur.

First, I describe an equilibrium in which the entrepreneur produces using capital. I assume

$$\bar{r} > \text{Max}\left\{2\bar{q},\ \frac{\theta f_{\min}}{1-\theta} + \bar{q},\ \zeta + 2(1-\theta)\bar{q}\right\} \tag{A13}$$

and

$$\zeta - \theta(\bar{f} + \bar{r}) \in (0, \min\{\epsilon - \theta(\bar{f} + \bar{q}), \theta\bar{f}\}). \tag{A14}$$

These assumptions guarantee that capital is productive relative to labor (A13) and not too expensive (A14). I propose the following candidate equilibrium. Entrepreneurs hire capital in the first period and keep it if and only if $r \geq \bar{r}$. Otherwise, the existing capital is sold and new capital is purchased. All off-equilibrium-path bids from the entrepreneur are assumed to come from entrepreneurs with $f = f_{\min}$ and employees (who are never hired in equilibrium) expect not to be retained.

I now confirm that the above describes an equilibrium. Assumptions (A13) and (A14) show that $\bar{r} - \zeta \geq \bar{q} - \epsilon$, so hiring labor in the first round and then buying capital is dominated by buying capital in both rounds. Given the off-equilibrium-path beliefs about entrepreneurs who hire labor, a similar argument shows that if capital was hired in the first period, buying new capital is superior to hiring new labor in the second period. The off-equilibrium-path beliefs also make buying capital always cheaper than renting it. Condition (A13) shows that the entrepreneur does better to follow his equilibrium strategy rather than not producing.

I last consider the strategy of using labor in both periods. The expected first-period payoff from this strategy is $(1-\theta)(\bar{f} + \bar{q})$. If labor is retained and $\theta(f+q) > \epsilon$, then no retention payment is needed. If $(f+q) \in [\epsilon, \frac{\epsilon}{\theta})$, a retention payment of $k_l = \epsilon - \theta(f+q)$ will be required. The entrepreneur will never retain the labor if $(f+q) < \epsilon$, since he could only do so at a loss. This gives a net payoff to the entrepreneur choosing retention of

$$\text{Max}\{\text{Min}\{f + q - \epsilon, (1-\theta)(f+q)\}, 0\}. \tag{A15}$$

If the entrepreneur hires new labor, the off-equilibrium beliefs imply that only signing payments $s \geq \epsilon - \theta\bar{q} - \theta f_{\min}$ will be accepted. The expected payoff from hiring new labor is $(1-\theta)(f + \bar{q}) - (\epsilon - \theta\bar{q} - \theta f_{\min})$. The two-period expected payoff to the entrepreneur hiring labor is, thus,

$$\begin{aligned}
(1-\theta)(\bar{f} + \bar{q}) \;+\; & E[\text{Max}\{(1-\theta)f + \bar{q} - \epsilon + \theta f_{\min}, \\
& \quad \text{Min}\{f + q - \epsilon, (1-\theta)(f+q)\}\}] \leq (1-\theta)(\bar{f} + \bar{q}) \\
& + E[\text{Max}\{(1-\theta)f + \bar{r} - \zeta, (1-\theta)(f+q)\}] \\
& \leq 2(1-\theta)(\bar{f} + \bar{q}) + \bar{r} - \zeta \leq 2(\bar{f} + \bar{r} - \zeta) \\
& \leq 2(\bar{f} + \bar{r} - \zeta) + E[\text{Max}\{\bar{r} - r, 0\}],
\end{aligned} \tag{A16}$$

where the last term is the expected payoff from following the candidate equilibrium strategy of using capital in both periods. The first inequality follows from (A13) and (A14), the third from (A13), and the second and fourth follow from routine algebra. This verifies the candidate equilibrium.

I now describe an equilibrium in which the entrepreneur produces using labor. The necessary conditions are

$$\bar{q} > \text{Max}\left\{\epsilon,\ \frac{\theta f_{\min}}{1-\theta} + \bar{r},\ 2\bar{r},\ \frac{\theta\bar{f} + \bar{r} - \frac{\zeta}{2}}{1-\theta}\right\}, \tag{A17}$$

$$\epsilon - \theta(\bar{f} + \bar{q}) < \zeta - \theta(\bar{f} + \bar{r}), \tag{A18}$$

and

$$\epsilon - \theta(\bar{f} + \bar{q}) \in (0, E[\max\{\epsilon, \theta(f+q)I_{(1-\theta)q \geq \bar{q} - \epsilon + \theta f_{\min}}\}] - \epsilon). \tag{A19}$$

Condition (A19) implies Inequality (4).

I propose the following candidate equilibrium. Entrepreneurs hire labor at no cost in the first period. The retention payment to first-period labor is $k_l = Max\{\epsilon - \theta(f+q), 0\}$, and the signing payment to new second-period labor is $s = \epsilon - \theta\bar{q} - \theta f_{\min}$. First-period labor is retained by the entrepreneurs if and only if $Min\{f+q-\epsilon, (1-\theta)(f+q)\} \geq \max\{(1-\theta)f + \bar{q} - \epsilon + \theta f_{\min}, 0\}$; otherwise, new labor is hired (if the first argument of the maximum is larger) or the firm closes (if the second argument is larger). All off-equilibrium-path bids are assumed to come from entrepreneurs with $f = f_{\min}$ in the second period. The proof that this is an equilibrium is analogous to that given above for the physical capital equilibrium.

A3 Proof of Lemma 1

The entrepreneur at the end of the first period has three actions from which to choose:

1. σ_a —retain the employee:

$$\pi_E(f, \hat{q}, \sigma_a) = min\{(1-\theta)(f+\hat{q}), f + \hat{q} - \epsilon\}. \tag{A20}$$

2. σ_b —fire the employee and hire a replacement:

$$\pi_E(f, \hat{q}, \sigma_b) = (1-\theta)(f+\bar{q}) - s, \tag{A21}$$

   where s is the signing payment.
3. σ_c —fire the employee and leave the position open:

$$\pi_E(f, \hat{q}, \sigma_c) = 0. \tag{A22}$$

The proof of Result 1 shows that $E[f|separation] \leq \bar{f}$ for the constrained entrepreneur, which implies that the labor market will demand a positive signing payment $s > 0$ for joining the firm at the end of the first period. The constrained entrepreneur cannot pay this amount, so σ_b is unavailable to him. If $\theta(f+\hat{q}) > \epsilon$, then σ_a dominates σ_c.

A4 Proof of Result 3

I define R to be the indicator function for the retention of the worker: $R(f, \hat{q}) = 1$ if the worker is retained by the firm when firm productivity is given by f and end-of-first-period worker quality is given by $\hat{q}$, and $R(f, \hat{q}) = 0$ otherwise. R^c and R^u are the indicator functions for the constrained and unconstrained firms, respectively.

The worker may always choose to quit and receive ϵ, so for a given firmwide quality f and end-of-first-period worker quality $\hat{q}$, the expected second-period payoff of a worker in a constrained firm is given by

$$W^{2,c}(f, \hat{q}) = R^c(f, \hat{q}) \max\{\theta(f+\hat{q}), \epsilon\} + (1 - R^c(f, \hat{q}))\epsilon. \tag{A23}$$

The formula for $W^{2,u}(f, \hat{q})$ is analogous, with unconstrained retention functions replacing the constrained ones above.

The first statement in Result 3 is that if

$$W^{2,u}(f, q+\lambda) - W^{2,u}(f, q) \geq g - \theta\lambda, \tag{A24}$$

then

$$W^{2,c}(f, q+\lambda) - W^{2,c}(f, q) \geq g - \theta\lambda. \tag{A25}$$

First, suppose that $\theta(e+q+\lambda) \leq \epsilon$. This implies that $W^{2,u}(e, q+\lambda) = \epsilon = W^{2,u}(e, q)$, hence inequality (5) shows that Inequality (A24) fails and the result holds.

Now suppose that $\theta(e+q+\lambda) > \epsilon$. Lemma 1 shows that $R^{2,c}(e, q+\lambda) = 1$. I therefore have $W^{2,c}(e, q+\lambda) = \theta(e+q+\lambda)$ and $W^{2,u}(e, q+\lambda) \leq \theta(e+q+\lambda)$. If $\theta(e+q) \leq \epsilon$, then $W^{2,c}(e, q) = \epsilon$ and $W^{2,u}(e, q) = \epsilon$, Inequality (A24) implies Inequality (A25), and the result is proved.

Suppose $\theta(e+q) > \epsilon$. This implies that

$$W^{2,c}(e, q+\lambda) - W^{2,c}(e, q) \geq \theta(e+q+\lambda) - \theta(e+q) \geq g - \theta\lambda, \tag{A26}$$

where the final inequality follows from Inequality (6). This shows that Inequality (A25) holds.

For the failure of the converse, consider the labor-hiring equilibrium described in the proof of Result 2. If $q \in (\bar{q} - 2\lambda - \frac{s}{1-\theta}, \bar{q} - \lambda - \frac{s}{1-\theta})$ and $\theta(f+q) + 2\theta\lambda - g > \epsilon$, then the worker makes a firm-specific investment in the constrained firm, but not in the unconstrained firm.

A5 Proof of Result 4

For any given f and first-period worker quality q, Result 3 shows that if firm-specific investment occurs in the unconstrained firm, then it also occurs in the constrained firm. That shows that $E\left[\pi^{1,c}\right] \geq E\left[\pi^{1,u}\right]$. I denote the expected second-period worker match quality by q^c and q^u, for the constrained and unconstrained entrepreneurs, respectively. If first-period firm-specific investment occurs either in both the constrained and unconstrained firms or in neither, at the end of the first period, the employee in both firm types has the same quality $\hat{q}$. As described in the proof of Lemma 1, the unconstrained entrepreneur has more second-period options from which to pick. The additional options involve making retention payments (σ_a) or signing payments (σ_b), so the unconstrained entrepreneur will only select them if $q^u \geq q^c$ (and, hence, $\pi^{2,u} \geq \pi^{2,c}$). Otherwise, the two entrepreneurs choose the same action and $q^u = q^c$ and $\pi^{2,u} = \pi^{2,c}$.

The second case is the one in which first-period investment occurs only in the constrained firm. In this case, Inequality (A25) holds, and the proof of Result 3 shows that it must be that $\theta(f+q+\lambda) > \epsilon$. This shows that action σ_c is dominated for the unconstrained entrepreneur. I first suppose that $\pi_E(f, q+\lambda, \sigma_b) < \pi_E(f, q+\lambda, \sigma_a)$. That implies that the unconstrained entrepreneur retains the first-period worker, so $W^{2,u}(f, q+\lambda) = W^{2,c}(f, q+\lambda)$. I also have $W^{2,u}(f, q) \leq W^{2,c}(f, q)$ in general, because the additional options available to unconstrained entrepreneurs grant the employee his minimum payoff of ϵ. This shows that Inequality (A25) implies Inequality (A24), so the employee in the unconstrained firm would also make a firm-specific investment, which contradicts my initial assumption. I now suppose that $\pi_E(f, q+\lambda, \sigma_b) \geq \pi_E(f, q+\lambda, \sigma_a)$. That implies that $(1-\theta)(f+\bar{q}) - s \geq (1-\theta)(f+q+\lambda)$. I conclude that $q^u = \bar{q} \geq q + \lambda = q^c$, so $\pi^{2,u} \geq \pi^{2,c}$ in this second case as well.

I now prove the second part of the result about second-period conditional output. If $x < \frac{\epsilon}{\theta}$, then the employee in the constrained firm will leave after the first period, since his payoff in the firm will not increase in the second period and he does better to receive his opportunity cost. In this case, since the constrained firm cannot hire a new employee, $E\left[\pi^{2,c} | \pi^{1,c} = x\right] = 0 \leq E\left[\pi^{2,u} | \pi^{1,u} = x\right]$. If $x \geq \frac{\epsilon}{\theta}$, then $E\left[\pi^{2,c} | \pi^{1,c} = x\right] \leq x$, since the constrained firm can do no better than to retain the existing employee, and this employee will never make a second-period firm-specific investment. Given a first-period output of $x \geq \frac{\epsilon}{\theta}$, the unconstrained entrepreneur may either retain the employee or hire a new one, so his expected second-period output is weakly higher than x. This shows that $E\left[\pi^{2,c} | \pi^{1,c} = x\right] \leq x \leq E\left[\pi^{2,u} | \pi^{1,u} = x\right]$.

References

Aghion, P., and J. Tirole. 1997. Formal and Real Authority in Organizations. *The Journal of Political Economy* 105:1–29.

Almedia, H., and M. Campello. 2005. Financial Constraints, Asset Tangibility, and Corporate Investment. Working Paper, New York University.

Angrist, J. 2001. Estimation of Limited-Dependent Variable Models with Dummy Endogenous Regressors: Simple Strategies for Empirical Practice. *Journal of Business and Economics Statistics* 19:2–28.

Berger, A., R. Rosen, and G. Udell. 2001. The Effect of Market Size Structure on Competition: The Case of Small Business Lending. Working Paper, Federal Reserve Board.

Binmore, K., A. Rubinstein, and A. Wolinsky. 1986. The Nash Bargaining Solution in Economic Modeling. *The RAND Journal of Economics* 17:176–88.

Black, B., and R. J. Gilson. 1998. Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets. *Journal of Financial Economics* 47:243–77.

Black, S., and L. Lynch. 2001. How to Compete: The Impact of Workplace Practices and Information Technology on Productivity. *The Review of Economics and Statistics* 83:434–45.

Black, S., and P. Strahan. 2002. Entrepreneurship and Bank Credit Availability. *Journal of Finance* 57:2807–33.

Bronars, S., and D. Deere. 1991. The Threat of Unionization, the Use of Debt, and the Preservation of Shareholder Wealth. *Quarterly Journal of Economics* 106:231–54.

Burgess, R., and R. Pande. 2003. Do Rural Banks Matter? Evidence from the Indian Social Banking Experiment. Working Paper, London School of Economics.

Carlin, W., and C. Mayer. 2003. Finance, Investment, and Growth. *Journal of Financial Economics* 69:191–226.

Cetorelli, N., and M. Gambera. 2001. Banking Market Structure, Financial Dependence, and Growth: International Evidence from Industry Data. *Journal of Finance* 56:617–48.

Cetorelli, N., and P. Strahan. 2004. Finance as a Barrier to Entry: Bank Competition and Industry Structure in Local U.S. Markets. Working Paper, Federal Reserve Bank of Chicago.

DeMarzo, P. M., and M. J. Fishman. 2002. Optimal Long-Term Financial Contracting with Privately Observed Cash Flows. Working Paper, Stanford University.

Demirguc-Kunt, A., and V. Maksimovic. 1998. Law, Finance, and Firm Growth. *Journal of Finance* 53:2107–37.

Dessein, W., and T. Santos. 2003. The Demand for Coordination. Working Paper, Columbia University Graduate School of Business.

Dupuy, A., and A. de Grip. 2003. Do Large Firms Have More Opportunities to Substitute Labor than Small Firms? Working Paper, Maastricht University.

Eisfeldt, A., and A. Rampini. 2005a. Leasing, Ability to Repossess, and Debt Capacity. Working Paper, Northwestern University.

Eisfeldt, A., and A. Rampini. 2005b. New or Used? Investment with Credit Constraints. Working Paper, Northwestern University.

Freeman, R., and M. Kleiner. 2000. Who Benefits Most from Employee Involvement: Firms or Workers? *American Economic Review* 90:219–23.

Garicano, L. 2000. Hierarchies and the Organization of Knowledge in Production. *Journal of Political Economy* 108:874–904.

Gromb, D. 1999. Renegotiation in Debt Contracts. Working Paper, Massachusetts Institute of Technology.

Hamilton, B. 2000. Does Entrepreneurship Pay? An Empirical Analysis of the Returns to Self-Employment. *Journal of Political Economy* 108:604–31.

Hanka, G. 1998. Debt and the Terms of Employment. *Journal of Financial Economics* 48:245–82.

Hannan, T. 1997. Market Share Inequality, the Number of Competitors, and the HHI: An Examination of Bank Pricing. *Review of Industrial Organization* 12:23–35.

Harris, M., and A. Raviv. 1995. The Role of Games in Security Design. *Review of Financial Studies* 8:327–67.

Harris, M., and A. Raviv. 2002. Organization Design. *Management Science* 48:852–65.

Hart, O., and J. Moore. 1994. A Theory of Debt Based on the Inalienability of Human Capital. *Quarterly Journal of Economics* 109:841–79.

Headd, B. 2000. The Characteristics of Small-Business Employees. *Monthly Labor Review* 123:13–18.

Hellmann, T., and M. Puri. 2002. Venture Capital and the Professionalization of Start-Up Firms: Empirical Evidence. *Journal of Finance* 57:169–97

Inderst, R., and H. Muller. 2004. The Effect of Capital Market Characteristics on the Value of Start-Up Firms. *Journal of Financial Economics* 72:319–56.

Joel Popkin and Company. 2001. Small Business Share of Employment Growth. Report submitted to the U.S. Small Business Administration.

Kalleberg, A., D. Knoke, and P. Marsden. 1996–1997. National Organizations Survey (NOS) [Computer file]. ICPSR version. Minneapolis, MN: University of Minnesota Center for Survey Research [producer], 1997. Ann Arbor, MI: Inter-University Consortium for Political and Social Research [distributor], 2001.

Kahn, J., and J. Lim. 1998. Skilled Labor-Augmenting Technical Progress in U.S. Manufacturing. *Quarterly Journal of Economics* 113:1281–308.

Kang, J., and A. Shivdasani. 1997. Corporate Restructuring During Performance Declines in Japan. *Journal of Financial Economics* 46:29–65.

Kelejian, H. 1971. Two-Stage Least Squares and Econometric Systems Linear in Parameters but Nonlinear in the Endogenous Variables. *Journal of the American Statistical Association* 66:373–74.

Kimura, F. 2001. Subcontracting and the Performance of Small and Medium Firms in Japan. Working Paper, World Bank Institute.

Klein, M., J. Peek, and E. Rosengren. 2002. Troubled Banks, Impaired Foreign Investment: The Role of Relative Access to Credit. *American Economic Review* 92:664–82.

Lane, J., A. Isaac, and D. Stevens. 1996. Firm Heterogeneity and Worker Turnover. Working Paper, American University.

Michelacci, C., and V. Quadrini. 2005. Financial Markets and Wages. Working Paper, University of Southern California.

Moskowitz, T., and A. Vissing-Jorgensen. 2002. The Returns to Entrepreneurial Investment: A Private Equity Premium Puzzle? *American Economic Review* 92:745–78.

Ofek, E. 1993. Capital Structure and Firm Response to Poor Performance: An Empirical Analysis. *Journal of Financial Economics* 34:3–30.

Oi, W. 1983. Heterogeneous Firms and the Organization of Production. *Economic Inquiry* 21:147–71.

Peek, J., and E. Rosengren. 2000. Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States. *American Economic Review* 90:30–45.

Petersen, M., and R. Rajan. 2002. Does Distance Still Matter? The Information Revolution in Small Business Lending. *Journal of Finance* 57:2533–70.

Ueda, M. 2004. Banks versus Venture Capital: Project Evaluation, Screening, and Expropriation. *Journal of Finance* 59:601–21.

Vayanos, D. 2003. The Decentralization of Information Processing in the Presence of Interactions. *Review of Economic Studies* 70:667–95.

Wilkinson, A. 1999. Employment Relations in SMEs. *Employee Relations* 21:206–17.

Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.