Distinguishing Limited Liability from Moral Hazard in a Model of Entrepreneurship

Anna L. Paulson

Federal Reserve Bank of Chicago

Robert M. Townsend

University of Chicago and Federal Reserve Bank of Chicago

Alexander Karaivanov

Simon Fraser University

We present and estimate a model in which the choice between entrepreneurship and wage work may be influenced by financial market imperfections. The model allows for limited liability, moral hazard, and a combination of both constraints. The paper uses structural techniques to estimate the model and identify the source of financial market imperfections using data from rural and semiurban households in Thailand. Structural, nonparametric, and reduced-form estimates provide independent evidence that the dominant source of

A previous version of this paper has been circulated under the title "Distinguishing Limited Commitment from Moral Hazard in Models of Growth with Inequality." Comments from Daron Acemoglu, Patrick Bolton, Lars Hansen, Boyan Jovanovic, Andreas Lehnert, Bernard Salanié, Chris Udry, two anonymous referees, the editor of this *Journal*, and conference and seminar participants at the Federal Reserve Bank of Chicago, DELTA, Indiana University–Purdue University at Indianapolis, Massachusetts Institute of Technology, University of California at Los Angeles, University of Toulouse, Stanford, and Yale are gratefully acknowledged. We also thank Francisco Buera, Xavier Giné, and Yukio Koriyama for excellent research assistance as well as the National Institutes of Health and the National Science Foundation for funding. We are much indebted to Sombat Sakuntasathien for collaboration and for making the data collection possible. The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Bank of Chicago or the Federal Reserve System. The usual disclaimer applies.

[*Journal of Political Economy,* 2006, vol. 114, no. 1]

credit market imperfections is moral hazard. We reject the hypothesis that limited liability alone can explain the data.

I. Introduction

Financial market imperfections shape economic outcomes in many areas. In studying these outcomes, many papers posit a particular financial market imperfection and exclude the possibility of alternative sources of imperfections. The goal of this paper is to identify the source of financial constraints that limit entry into entrepreneurship. We use structural, nonparametric, and reduced-form techniques to distinguish the source of financial market imperfections using microeconomic data from Thailand.

Earlier work demonstrates that financial constraints have an important effect on who starts businesses and on how existing businesses are run in Thailand (see Paulson and Townsend 2004). A symptom of financial constraints is that wealth will be positively correlated with the probability of starting a business, with the characteristics of potential entrepreneurs held constant. A strong positive correlation between becoming an entrepreneur and beginning-of-period wealth can be seen in the nonparametric regression displayed in figure 1.[1] However, a positive correlation between wealth and entrepreneurship only demonstrates that financial constraints are likely to be important but does not illuminate the source of the constraint.[2]

The literature identifies two main sources of financial constraints that influence the decision to become an entrepreneur. In Evans and Jovanovic (1989), the financial constraint is due to limited liability. Agents can supplement their personal stake in entrepreneurial activities by borrowing. Wealth plays the role of collateral and limits default. In this environment low-wealth households may be prevented from borrowing enough to become entrepreneurs, and others that are able to start businesses may be constrained in investment. Limited liability is also featured in a variety of empirical studies of occupational choice. Evans and Jovanovic (1989) and Magnac and Robin (1996) provide structural estimates of this model for the United States and for France, respectively. In a limited-liability environment, constrained entrepreneurs borrow

[1] For each observation in fig. 1, a weighted regression is performed using 80 percent (bandwidth = 0.8) of the data around that point. The data are weighted using a tricube weighting procedure that puts more weight on the points closest to the observation in question. The weighted regression results are used to produce a predicted value for each observation. Because the graphs can be fairly sensitive to outliers, we have dropped the wealthiest 1 percent of the sample.

[2] In a dynamic setting with borrowing constraints, as in Buera (2005), the predicted probability of entrepreneurship can decrease at higher levels of wealth.

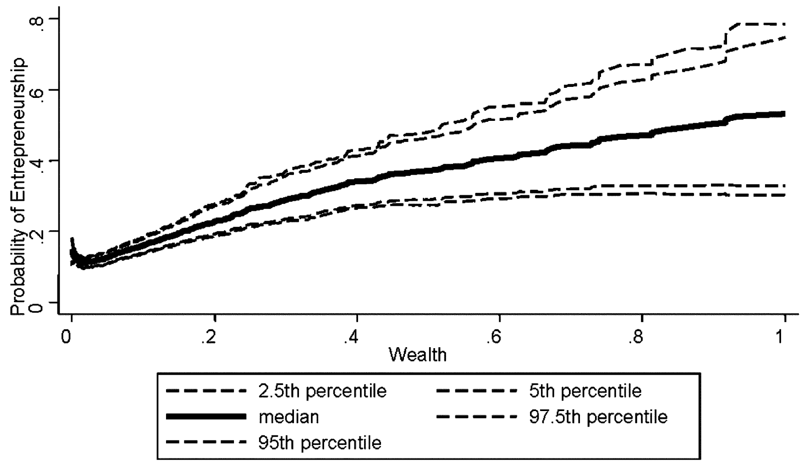

Fig. 1.—Lowess estimates of the probability of being an entrepreneur and wealth. 500 bootstrap estimates of the relationship between being an entrepreneur and wealth were created using a bandwidth of 0.8. The 2.5th percentile (dashed line), fifth percentile (dashed line), median (solid line), ninety-fifth percentile (dashed line), and 97.5th percentile (dashed line) estimates are shown in the figure.

more when wealth increases. With limited liability, borrowing does not automatically imply being constrained. Some entrepreneurs may be able to borrow enough to invest the optimal amount of capital, as though there were no constraints

Financial constraints that arise from moral hazard are the focus of the model of occupational choice featured in Aghion and Bolton (1997). Since entrepreneurial effort is unobserved and repayment is feasible only if a project is successful, poor borrowers have little incentive to be diligent, increasing the likelihood of project failure and default. In order to break even, lenders charge higher interest rates to low-wealth borrowers. Some low-wealth potential entrepreneurs will be unable, or unwilling at such high interest rates, to start businesses at any scale. Low-wealth entrepreneurs who do succeed in getting loans will be subject to a binding incentive compatibility constraint that ensures that they exert the appropriate level of effort. In contrast to the limited-liability case, when there is moral hazard and wealth increases, constrained entrepreneurs will increasingly self-finance and borrowing diminishes. In a moral hazard environment, all entrepreneurs who borrow will be constrained.[3]

The model that we estimate takes into account entrepreneurial talent

[3] This is true if the moral hazard environment does not produce the same solution as the first-best, which is generally the case.

and allows investment to be divisible and agents to be risk averse. Because the scale of the business can vary, the relationship between wealth and borrowing is not driven by indivisibilities. In addition, the model allows entrepreneurial talent to depend on wealth and formal education. Regardless of the assumptions regarding financial constraints, the model implies that entrepreneurship will be positively related to preexisting wealth. Of course the specific functional relationship between entrepreneurship and wealth will depend on the financial constraint. In addition, as discussed above, the relationship between being a borrower and being constrained and the response of constrained entrepreneurs to an increase in wealth depend on the financial market imperfection. In particular, if limited liability constrains financial markets, increases in wealth will allow constrained entrepreneurs to borrow more. However, not all borrowers need be constrained when there is limited liability. If moral hazard is the source of constraints, increases in wealth will be associated with less borrowing, and all borrowers will be constrained.

A central goal of this paper is to see whether limited liability can be distinguished from moral hazard in structural estimates using cross-sectional data from a sample of households from Thailand. We also consider the possibility that both are important.[4] The estimated models share a common technology, as well as common preferences and assumptions about the distribution of talent. They differ only in the assumed financial constraint. The appropriate Vuong (1989) test is used to compare the structural estimates and to determine which single financial constraint is most consistent with the data on entrepreneurial status, initial wealth, and education or if both are important. The Vuong test is also featured in Fafchamps (1993) and Wolak (1994). The structural model comparison tests are augmented with nonparametric and reduced-form estimates that capitalize on the richness of the data, which include information on household characteristics, borrowing, and collateral.

This paper is related to other work that tries to identify the underlying source of market imperfections. For example, Abbring et al. (2003) use dynamic data to distinguish moral hazard from adverse selection in the insurance context. Their work takes the insurance contract as given, on the basis of the regulatory environment. Our treatment of the limited-liability constraint is conceptually similar. We assume a standard debt contract and estimate the parameter that determines how much a potential entrepreneur can borrow as a function of wealth and entrepreneurial talent. The estimation is more innovative when the financial

[4] We have also considered the possibility that occupation choices are first-best and that there is *neither* limited liability nor moral hazard. Structural, reduced-form, and nonparametric findings reject this possibility.

environment is affected by moral hazard. The estimated financial contract is the endogenous solution to the mechanism design problem that satisfies the incentive compatibility constraint. To our knowledge, this is the first paper to provide structural estimates of a moral hazard model of occupational choice based on a mechanism design approach.

The Thai data come from a socioeconomic survey that was fielded in March–May of 1997 to 2,880 households, approximately 21 percent of which run their own businesses.[5] The sample focuses on households living in two distinct regions of the country: rural and semiurban households living in the central region, close to Bangkok, and more obviously rural households living in the semiarid and much poorer northeastern region.[6] The data include current and retrospective information on wealth (household, agricultural, business, and financial), occupational history (transitions to and from farm work, wage work, and entrepreneurship), and access to and use of a wide variety of formal and informal financial institutions (commercial banks, agricultural banks, village lending institutions, and money lenders as well as friends, family, and business associates). The data also provide detailed information on household demographics, education, and entrepreneurial activities.

The results indicate that progress can be made in identifying the nature of financial constraints. The dominant source of constraints is moral hazard. We reject the hypothesis that limited liability alone can explain the data. The evidence in favor of moral hazard is particularly strong for the wealthier central region. For the poorer northeastern region, we cannot rule out that limited liability may have a role to play, but only in combination with moral hazard.

These conclusions are based both on the formal financial regime comparison tests from the structural estimation, which use data on wealth, education, and entrepreneurial status, and on reduced-form and nonparametric estimates, which use data on wealth, entrepreneurial status, net savings, and other important household characteristics. The formal financial regime comparison tests are necessarily informative only about the relative success of a given financial regime for the particular set of assumptions regarding preferences, technology, and so forth that are imposed by the model. In contrast, the reduced-form and nonparametric estimates examine implications that are likely to distinguish moral hazard from limited liability for a large class of potential assumptions.

The rest of the paper is organized as follows. In Section II, the model and the financial constraints are presented. Section III describes the

[5] For estimation purposes, the data are restricted to households that have nonzero wealth and either currently own a business that was founded in the five years prior to the survey (14 percent) or have no business at the time of the survey (86 percent).

[6] See Binford, Lee, and Townsend (2001) for more details on the sampling methodology.

computational algorithm for the structural maximum likelihood estimation. Section IV describes the data. Section V reports on the structural maximum likelihood parameter estimates. In Section VI, we determine which financial regime best fits the data using structural, reduced-form, and nonparametric techniques. Section VII presents conclusions and suggests directions for future research.

II. Model and Implications

In this section, we describe the model of occupational choice and provide intuition for the solutions and the relationships among key variables. Since structural estimation lends itself to characterizing the model in a different, but equivalent, way, this section also describes the general linear programming problem that forms the basis of the structural estimation. The basic structure of the model—preferences, endowments, and technology—is the same regardless of the financial environment. The financial environment depends on which constraints are assumed to bind: limited liability, moral hazard, or both.

A. Economic Environment

Households are assumed to derive utility, U, from their own consumption, c, and disutility from effort, z:

$$U(c,\ z) = \frac{c^{1-\gamma_1}}{1-\gamma_1} - \kappa\frac{z^{\gamma_2}}{\gamma_2}. \tag{1}$$

We assume that utility displays constant relative risk aversion in consumption. The parameter $\gamma_1 \geq 0$ determines the degree of risk aversion. The parameters $\kappa > 0$ and $\gamma_2 \geq 1$ determine the loss in utility from expending effort. Consumption, c, and effort, z, must be nonnegative.

In discussing the implications of the model, we begin by assuming that agents are risk neutral, in other words, that $\gamma_1 = 0$. We reintroduce risk aversion in the presentation of the linear programming problem that forms the basis for the structural estimation.

There are three sources of household heterogeneity in the model: initial wealth, A, entrepreneurial talent, θ, and years of education, S. All these variables are determined ex ante and can be observed by all the agents in the model.[7] Wealth is normalized to lie in the interval $(0, 1]$. We assume that talent is lognormally distributed. Specifically,

$$\ln\theta = \delta_0 + \delta_1 \ln(A) + \delta_2 \ln(1+S) + \eta, \tag{2}$$

[7] The complications in estimation that arise from the fact that the econometrician cannot observe θ are addressed in Sec. III.

where η is normally distributed with mean zero and variance $\sigma_\eta = 1$. In order to avoid the spurious inference that wealth rather than talent is the source of constraints, an individual's expected talent can be correlated with wealth through δ_1. Talent may also be correlated with formal education via δ_2.

Entrepreneurs produce output q from their own effort z and from capital k. Output q can take on two values, namely, $q = \theta$, which corresponds to success and occurs with positive probability, and $q = 0$, which is equivalent to bankruptcy and occurs with the remaining probability. Note that output is increasing in entrepreneurial talent, θ. The technology is stochastic and is written $P(q = \theta | z, k > 0)$, the probability of achieving output q given effort z and capital k. Specifically,[8]

$$P(q = \theta | z, k > 0) = \frac{k^\alpha z^{1-\alpha}}{1 + k^\alpha z^{1-\alpha}}. \tag{3}$$

Output can be costlessly observed by everyone.

When $k = 0$, the firm is not capitalized. This means that the household works in the wage sector. Earnings, w, in the wage sector are also stochastic and depend on effort. They are equal to one with probability $z/(1 + z)$ and equal to zero with the residual probability.[9]

All households are price takers and take as given the gross cost of borrowing, $r(A, \theta)$, which may vary with wealth and entrepreneurial talent. Entrepreneurs who do not borrow (who have $k < A$) and wage workers earn the given, riskless gross interest rate, r, on their net savings.

Occupational assignments are determined by a social planner who maximizes agents' utility subject to constraints that describe the financial intermediary and any financial market imperfections. This approach is equivalent to a situation in which a large number of financial institutions compete to attract clients so that in the end it is as though the agents in the economy maximize their utility subject to the financial institution earning zero profits, and subject, of course, to constraints having to do with financial market imperfections.

[8] The probability of entrepreneurial success is scaled by $1 + k^\alpha z^{1-\alpha}$ to guarantee that it will lie between zero and one.

[9] Again, this formulation guarantees that the probability of success in the wage sector will lie between zero and one.

In sum, when agents are risk neutral, the planner makes an effort recommendation, z, and a capital recommendation, k to solve

$$\max_{z,k}\left\{w\frac{z}{1+z}-\kappa\frac{z^{\gamma_2}}{\gamma_2}+rA\right\}\quad\text{if } k=0,$$

$$\max_{z,k}\left\{\theta\frac{k^{\alpha}z^{1-\alpha}}{1+k^{\alpha}z^{1-\alpha}}-\kappa\frac{z^{\gamma_2}}{\gamma_2}+r(A-k)\right\}\quad\text{if } k>0,\ k\leq A,$$

$$\max_{z,k}\left\{\theta\frac{k^{\alpha}z^{1-\alpha}}{1+k^{\alpha}z^{1-\alpha}}-\kappa\frac{z^{\gamma_2}}{\gamma_2}+r(A,\ \theta)(A-k)\frac{k^{\alpha}z^{1-\alpha}}{1+k^{\alpha}z^{1-\alpha}}\right\}\quad\text{if } k>A. \tag{4}$$

As one can see above, agents have three possibilities: (1) working for wages, which corresponds to $k=0$; (2) becoming an entrepreneur but not borrowing, which happens when capital is positive and less than or equal to wealth, $k>0$ and $k\leq A$; or (3) becoming an entrepreneur and borrowing, which happens when capital is positive and exceeds wealth, $k>0,\ k>A$.

The first term in the maximand is the expected utility of a risk-neutral wage worker: expected wages minus the cost of effort, plus a riskless return on wealth. The second term is the expected utility of a risk-neutral entrepreneur who does not need to borrow to carry out the recommended k: expected output minus the cost of effort, plus a riskless return on any wealth not invested in the project. The final term is the expected utility of an entrepreneur who must borrow to carry out the assigned k: expected output minus the cost of effort, minus the expected cost of repaying the loan. Note that the loan is repaid only when the project is successful. The planner's problem is subject to a constraint that guarantees that the expected rate of repayment on such loans covers the cost of outside funds, so that lenders break even:

$$r(A,\ \theta)\frac{k^{\alpha}z^{1-\alpha}}{1+k^{\alpha}z^{1-\alpha}}=r\quad\text{for } k>A,\ \forall\theta,\ \forall A. \tag{5}$$

B. *Financial Environment*

We introduce variations in the financial environment through additional constraints on the planner's problem. When financial markets are "first-best" and are subject to neither limited liability nor moral hazard, no further constraints are imposed.

Limited liability.—To model limited liability, we assume, as in Evans and Jovanovic (1989), that households can borrow up to some fixed multiple of their total wealth, but no more. The maximum amount that can be invested in a firm is equal to λA, and the maximum amount that a household can borrow is given by $(\lambda - 1)A$. When limited liability is a concern, the planner's maximization problem will be subject to

$$k \leq \lambda A \tag{6}$$

in addition to equation (5).

Moral hazard.—When there is moral hazard, entrepreneurial effort is unobservable and the financial contract cannot specify an agent's effort. In terms of the planner's problem, this translates into a requirement that the capital assignment and the interest rate schedule are compatible with the effort choice that a borrowing entrepreneur would have made on his or her own. In other words, the capital assignment and the interest rate schedule must not violate the first-order condition with respect to effort of the entrepreneur's own maximization problem. In this case, in addition to equation (5), the planner's maximization problem will be subject to

$$[\theta - r(A,\ \theta)(k - A)]\left[\frac{(1-\alpha)k^{\alpha}z^{-\alpha}}{(1+k^{\alpha}z^{1-\alpha})^2}\right] - \kappa z^{\gamma_2 - 1} = 0, \tag{7}$$

which is an entrepreneurial household's first-order condition for effort, z, for a given interest rate schedule and capital, k.[10] Equation (7) requires that the planner's effort recommendation equate the marginal benefit of effort with the marginal cost of effort plus a term that represents the marginal impact of effort on loan repayment, through the effect of effort on the probability that an entrepreneurial project will be successful: $k^{\alpha}z^{1-\alpha}/(1 + k^{\alpha}z^{1-\alpha})$.

Note that when agents are risk neutral, moral hazard is an issue only for entrepreneurs who borrow. The lack of observability of effort is not an issue for wage workers and entrepreneurs who self-finance. The planner can assign effort to them without having to satisfy the incentive compatibility constraint, equation (7), because there is no moral hazard problem when the optimal capital investment does not require borrowing.

Moral hazard and limited liability.—We also consider the possibility that credit markets are characterized by both moral hazard and limited liability. This is modeled by assuming that the entrepreneurial choice problem is subject to both equation (6) and equation (7) in addition to equation (5).

[10] See Karaivanov (2005) for a proof that this approach is valid here.

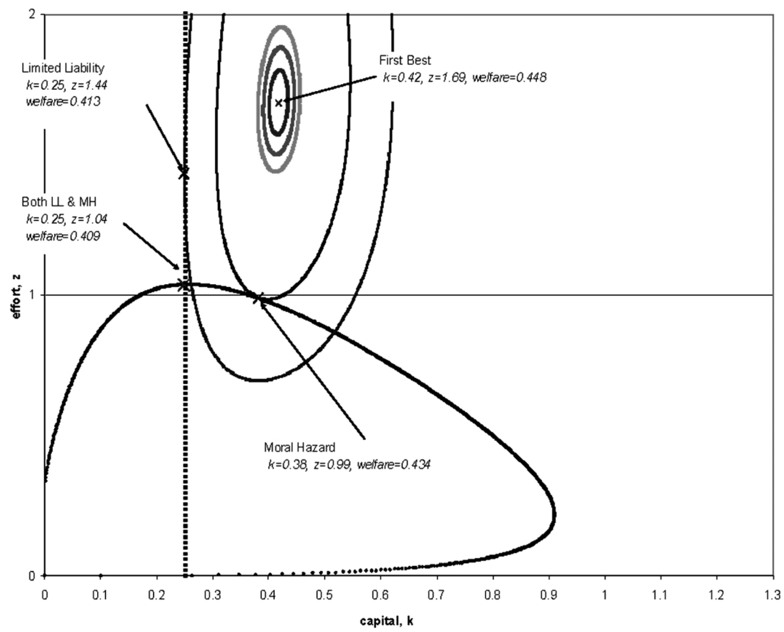

Fig. 2.—Assignments of capital (k) and effort (z) for the entrepreneurs in the risk-neutral model: moral hazard, limited liability, and both moral hazard and limited liability assumptions: $\theta = 2.56$, $A = 0.10$, $\alpha = 0.78$, $\kappa = 0.08$, $\gamma_2 = 1.00$, $r = 1.10$, and $\lambda = 2.50$.

C. *Characterization of Solutions*

Risk-neutral case.—Figure 2 describes the optimal assignment of effort and capital for a risk-neutral entrepreneurial household for each of the three potential financial regimes and compares them to the first-best solution in which there are no financial constraints. We assume that the household has wealth, A, equal to 0.1 and talent, θ, equal to 2.56.[11] The first-best capital, effort, and welfare levels are, as one might imagine, highest. The ellipses that radiate out from the first-best solution are the agent's indifference curves in effort and capital. Utility is decreasing as one moves away from the first-best solution.

The vertical dotted line to the left of the first-best solution represents the set of potential allocations of capital and effort when there is a *binding* limited-liability constraint and investment can be at most λA, or

[11] A wealth level of 0.1 corresponds to the eighty-ninth percentile of wealth in the data. Figure 2 shows the optimal assignment of effort and capital for an entrepreneurial household assuming that $\alpha = 0.78$, $\kappa = 0.08$, $\gamma_2 = 1$, and $\lambda = 2.50$. These parameter values are within the range of the values produced by the structural estimation.

0.25 in this example. As seen in the graph, imposing the limited-liability constraint results in lower capital and effort and, naturally, lower welfare.

The set of possible allocations of capital and labor in the moral hazard case are described by the ear-shaped curve that begins in the lower left-hand corner of the graph. When there is moral hazard, utility is maximized at the point at which the allocation possibilities are tangent to the entrepreneur's indifference curve. In this example, this occurs where investment is equal to 0.38 (of which 0.1 comes from the agent's own wealth and the remaining 0.28 must be borrowed) and effort is equal to 0.99. When there is moral hazard and binding limited liability, both constraints must be satisfied, and the solution is found where the moral hazard allocation curve intersects the vertical line that describes the limited-liability constraint, where investment is equal to 0.25 and effort is equal to 1.04. Note that for these parameter values, welfare is lowest when both limited liability and moral hazard are an issue and that moral hazard alone delivers higher welfare than limited liability alone.

Regardless of the financial constraint, when wealth increases, capital and effort both increase toward the first-best solution, although the path will of course depend on the financial environment. If there are no constraints and the solution is first-best, the solution is unchanged when wealth increases.

Special cases.—The risk-neutral model described above includes special cases that have been studied in the literature. For example, the model of Evans and Jovanovic (1989) can be derived by first eliminating a role for entrepreneurial effort by setting z to one and setting the disutility of effort, κ, to zero. Next, assume that output is a deterministic function of capital, k, so that $q = \theta k^{\alpha}$ and loans must be fully repaid in the amount rk, no matter what. The maximum loan size is determined by the limited-liability constraint, equation (6), which requires $k \leq \lambda A$. Apart from the normalized probabilities, these assumptions deliver the limited-liability model of Evans and Jovanovic. The likelihood of becoming an entrepreneur is increasing in wealth and entrepreneurial talent. With wealth held fixed, more talented entrepreneurs are more likely to be constrained. Entrepreneurial households that face a binding limited-liability constraint will borrow and invest *more* when wealth increases. A version of the model in which there is no credit, as in Lloyd-Ellis and Bernhardt (2000), can be derived by assuming that $\lambda = 1$, so that no borrowing is possible. Giné and Townsend (2004) extend that model and use it to assess the aggregate growth effects and the distributional consequences of financial liberalization in Thailand from 1976 to 1996.

We can also use our framework to generate the model of Aghion and Bolton (1997). Assume that capital can be either zero or one. In other words, firms must be capitalized at $k = 1$. Eliminate any role for entrepreneurial talent by setting θ equal to one, and assume that the income of wage workers is unaffected by effort or, equivalently, assume that $z = 1$ for wage workers. Finally, assume that $\gamma_2 = 2$ so that the disutility of effort is quadratic. Apart from the normalized probabilities, these assumptions deliver the model of Aghion and Bolton. As they stress, effort, z, which must be incentive compatible, will be a monotonically increasing function of wealth. As wealth increases, the probability of entrepreneurial success increases, which means that wealthier households will face lower interest rates. Low-wealth households face such high interest rates that they may choose not to borrow and become wage workers rather than entrepreneurs. Entrepreneurial households with wealth less than one must borrow an amount equal to $1 - A$ to finance their firm, which, again, must be capitalized at one. These households are subject to a binding incentive compatibility constraint. In contrast to the limited-liability model of Evans and Jovanovic (1989), when wealth increases for these constrained households, they will borrow *less* and continue to invest the same amount in their firms.

D. The Linear Programming Problem

In this subsection, we restate the occupational choice problem faced by an agent with wealth A, schooling S, and entrepreneurial talent θ as a principal-agent problem between the agent and a competitive financial intermediary. The optimal contract between the two parties consists of prescribed investment, k, recommended effort, z, and consumption, c. Consumption can be contingent on the output realization, q. Agents assigned zero investment are referred to as "workers," and agents assigned a positive level of investment are called "entrepreneurs." Agents may now be risk averse, with risk neutrality embedded as a special case.

Nonconvexities arising from the incentive constraints, from the indivisibility of the choice between wage work and entrepreneurship, and from potential indivisibilities in k mean that, in general, standard numerical solution techniques that rely on first-order conditions will fail. By writing the principal-agent problem as a linear programming problem with respect to lotteries over consumption, output, effort, and investment, we can restore convexity and compute solutions.

Let the probability that a particular allocation (c, q, z, k) occurs in the optimal contract for agent (θ, A, S) be denoted by $\pi(c, q, z, k|\theta, A, S)$. The choice object, $\pi(c, q, z, k|\theta, A, S)$, enters linearly into the objective function as well as in every constraint. See Prescott and Townsend (1984) and Phelan and Townsend (1991) for a detailed description of this methodology. The linear programming approach allows us to use a set of well-known maximization routines in the structural estimation.

In particular, we solve the following linear programming problem:

$$\max_{\pi(c,q,z,k|\theta,A,S)\geq 0} \sum_{c,q,z,k} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S)U(c,\ z) \tag{LP}$$

subject to

$$\sum_{c} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S) = \tilde{p}(q|z,\ k,\ \theta) \sum_{c,q} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S) \quad \text{for all } q,\ z,\ k, \tag{8}$$

$$\sum_{c,q,z,k} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S)(c-q) = r\sum_{c,q,z,k} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S)(A-k), \tag{9}$$

$$\sum_{c,q} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S)U(c,\ z) \geqq \sum_{c,q} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S)\frac{\tilde{p}(q|z',\ k,\ \theta)}{\tilde{p}(q|z,\ k,\ \theta)}U(c,\ z') \quad \text{for all } k>0,\ z,\ z' \neq z, \tag{10}$$

and

$$\sum_{c,q,z,k} \pi(c,\ q,\ z,\ k|\theta,\ A,\ S) = 1. \tag{11}$$

The function $\tilde{p}(q|z, k, \theta)$ defines the probability of output q, given effort, capital, and entrepreneurial talent. It is analogous to the original $P(q=\theta|z,\ k>0)$ (see eq. [3]), but here it is conditioned on θ as well as on z and k, and it is also relevant for wage workers, who have $k = 0$.

The first constraint, equation (8), is a Bayesian consistency constraint, ensuring that the conditional probabilities, $\tilde{p}(q|z,\ k,\ \theta)$, are consistent with the production function. The second constraint, equation (9), is a break-even condition, which ensures that the financial intermediary earns zero profits. Intuitively, financial intermediary payments, $c-q$, must equal interest earnings, $r(A-k)$. The third constraint, equation (10), is the incentive compatibility constraint, which ensures that the recommended effort, z, will be undertaken rather than any alternative effort, z'. Because agents may be risk averse and value insurance that is provided by the financial intermediary, the incentive compatibility constraint may bind for all firms, not just firms that require outside capital. The final constraint, equation (11), ensures that the probabilities sum to one.

We consider three alternative specifications of the above linear programming problem, which correspond to different assumptions about the informational and financial constraints faced by agents in the model. In the first specification, moral hazard, we assume that effort is unobservable and that the incentive compatibility constraint, equation (10), must be satisfied. In this specification, the feasible investment levels are independent of A; that is, each agent can invest any feasible amount no matter what her wealth is.

In the second specification, limited liability, we assume that effort is observable and that the incentive compatibility constraint does not have to be satisfied. In the case of limited liability, the investment levels that an agent with wealth A can undertake are constrained to lie in the interval $[0, \lambda A]$, with $\lambda > 0$ as in Evans and Jovanovic (1989). In the final specification, both limited liability and moral hazard, we assume that effort is unobservable and that investment must be less than λA.

The contract elements c, q, z, and k are assumed to belong to the finite discrete sets $\boldsymbol{C}$, $\boldsymbol{Q}$, $\boldsymbol{Z}$, and $\boldsymbol{K}$, respectively. These sets, which are represented for computational purposes by grids of real numbers, are defined in more detail below.

III. Computational Algorithm for Structural Estimation

The algorithm for computing and estimating the occupational choice problem uses a structural maximum likelihood approach and consists of the following main stages.

Stage 1: Solve for the optimal contract between the financial intermediary and an agent with given ability, θ, education, S, and initial wealth, A. As discussed above, three alternative specifications of the constraints on the optimal contract are considered: moral hazard, limited liability, and both moral hazard and limited liability.

Stage 2: Construct the likelihood function from the solutions of the stage 1 problems for the occupational choices, wealth, and education observed in the data.

Stage 3: Maximize the likelihood function to obtain estimates for the structural parameters of the model and standard errors.

The general idea of the algorithm is to obtain the probability of being an entrepreneur for given model parameters and input data, θ, S, and A in stage 1, and then integrate over entrepreneurial ability θ, which is not observed by the econometrician, to obtain the expected probability that an agent with wealth A and education S would be in business for all wealth and education levels in the data. The expected probabilities generated from the model are then used to construct and maximize the appropriate likelihood function. The rest of this section details the procedures followed in each of the above stages.

A. *Solve the Linear Programming Problem*

The numerical procedure for solving the linear programming problem (LP) takes the following steps:

1. Create grids for c, q, z, and k: We use 10 linearly spaced grid points for c on [0, 10] and 10 linearly spaced grid points for z on [0.0001, 5]. For capital we use 16 log-spaced grid points for k on [0, 5], when limited liability is not a concern. This range for capital was chosen to ensure that it did not place restrictions on capital choices in a "first-best" environment. When limited liability constrains financial contracts, the investment grid, $\boldsymbol{K}$, consists of 16 points on $[0, \lambda A]$ for each given A at which the linear program is computed. As explained in the model description, output, q, can take three possible values: zero (entrepreneurial failure), θ (entrepreneurial success), and one (success in wage work).[12]
2. Use Matlab to construct the matrices of coefficients corresponding to the constraints and the objective of the linear program (LP). We use the single-crossing property to eliminate some of the incentive constraints since they do not bind at the solution.
3. Solve for the optimal contract, $\pi^*(c, q, z, k|\theta, A, S)$, using a call to the linear programming commercial library CPLEX[13] and obtain the probability of being an entrepreneur:

$$\pi^E(\theta, A, S) \equiv \sum_{c,q,z,k} \pi^*(c, q, z, k|\theta, A, S, k > 0).$$

The probability of being a worker is simply $1 - \pi^E(\theta, A, S)$.

Stage 1 is the building block of each of the following stages. Since it is moderately time-consuming, it is crucial to minimize the number of linear programs computed in the estimation procedure.

[12] The dimension of the grids was influenced by computational time considerations. Notice that even with these grid dimensions, we still have to solve a constrained optimization problem with 2,400 variables (the π's) and, potentially, 802 constraints for each (θ, A, S) we consider. When limited liability is the only constraint, the 320 incentive compatibility constraints are eliminated. We can handle a much larger number of variables, but then computational time increases exponentially in the estimation stage of the algorithm.

[13] Using CPLEX instead of Matlab's internal linear programming routine (linprog) improves computational time by a factor of 10–15.

B. Construct the Likelihood Function

In stage 2, we construct the log likelihood function that is used to estimate the structural models. For estimation purposes, observed wealth in Thai baht is rescaled on (0, 1], where 1 corresponds to the wealth of the wealthiest household in the data. Recall that entrepreneurial ability is given by

$$\ln\theta = \delta_0 + \delta_1 \ln A + \delta_2 \ln(S+1) + \eta, \tag{12}$$

where η is distributed $N(0, 1)$. For a given wealth level, A, and education level, S, we compute the *expected* probability that an agent (A, S) will be an entrepreneur by numerically integrating over the ability distribution. In other words, we numerically approximate the following expression:[14]

$$\bar{\pi}^E(A, S) = \int_{-\infty}^{\infty} \pi^E(\theta, A, S)\, d\phi(\eta). \tag{13}$$

Since the linear programming stage 1 is costly in terms of computation time,[15] we cannot afford to compute $\bar{\pi}^E(A, S)$ at all possible combinations of A and S (more than 2,000) because it would take at least 1.5 hours for *each* likelihood function evaluation. We overcome this problem by constructing a 20-point log-spaced grid for wealth, A.[16] The function $\bar{\pi}^E(A, S)$ is computed only at these 20 grid points.

In order to be able to compute the probability for all data points, which is necessary to evaluate the likelihood, we use a cubic spline interpolation of $\bar{\pi}^E(A, S)$ over the wealth points in the data, which generates the expected probability of being an entrepreneur, predicted by the model, for an agent with wealth A_i in the data. We denote this by $H(A_i|\psi)$,[17] where $\psi \equiv (\gamma_1, \gamma_2, \kappa, \alpha, \delta_0, \delta_1, \delta_2, \lambda)$ is the vector of model parameters. This procedure reduces the computational time to 30–50

[14] The numerical integration method used is Gauss-Legendre quadrature with five nodes for η on $[-3, 3]$ (see Judd 1998). This method was chosen because it minimizes the number of linear program computations (we solve only five linear programs for a given A, S pair) and because it has desirable asymptotic properties.

[15] Three seconds for each A, S pair. All calculations were performed on a 3 GHz Pentium 4 machine with 1 GB RAM running Windows XP with hyperthreading.

[16] The log-spaced grid takes into account that the actual wealth data are heavily skewed toward the low end of the wealth distribution. In order to compute $\bar{\pi}^E(A, S)$, we also need values for education, S, that correspond to the grid points for wealth, A. We obtain these by running a nonparametric lowess regression of education on wealth using all the data. The resulting nonlinear function that relates education to wealth is then evaluated at the 20 wealth grid points to obtain the corresponding 20 values for S. This method is preferable to simply picking an education value corresponding to the data point closest to a particular wealth grid point since more information is used in the nonparametric regression to compute the education values corresponding to the wealth grid points.

[17] Notice that H is implicitly a function of agents' education levels.

seconds per likelihood evaluation, depending on the regime. The log likelihood function is given by

$$L(\psi) = \frac{1}{n}\sum_{i=1}^{n} E_i \ln H(A_i|\psi) + (1 - E_i)\ln [1 - H(A_i|\psi)]. \qquad (14)$$

In equation (14), n is the number of observations, E_i is a binary variable that takes the value of one if agent i is an entrepreneur in the data and zero otherwise, and A_i is the wealth level of agent i (again from the data).

C. *Solve for Optimal Parameter Values*

In stage 3, we solve for the parameter values that maximize the likelihood of model occupational assignments that correspond to the occupational assignments in the data. In other words, we maximize the likelihood function, equation (14), over the choice of parameter values—the vector $\psi \equiv (\gamma_1, \gamma_2, \kappa, \alpha, \delta_0, \delta_1, \delta_2, \lambda)$, given the data.[18]

The riskless interest rate is assumed to be 10 percent, that is, $r = 1.1$ in the model. In comparison, the net annual interest rate on collateralized loans to individuals from the Bank for Agriculture and Agricultural Cooperatives (BAAC) is roughly 13 percent in the data, and interest rates on loans from commercial banks, the vast majority of which are collateralized, average 22 percent. In addition, there are many informal loans, often between relatives, in which the reported interest rate is zero (see Giné [2005] for further details). The relevant interest rate for the model is a riskless one, with default not an option. Clearly default is a possibility for the loans and interest rates observed in the data, so we assume that the riskless gross interest rate is lower than those observed in the data.

The actual maximization of the log likelihood function $L(\psi)$ is performed in the following way. First, in order to ensure that a global maximum is reached, we do an extensive deterministic grid search over the parameters and pick the parameter configuration that maximizes L.[19] The best parameter configuration from the grid search is then taken

[18] In some specifications only a subset of these parameters is estimated. Section V reports on the parameter estimates for each specification.

[19] The grid search is computationally time-intensive and can take up to two to three days depending on the number of estimated parameters.

as the initial parameter guess for a second-stage likelihood optimization procedure.[20]

Finally, we compute the standard errors for the estimated parameters using standard bootstrapping methods drawing with replacement from the original sample.[21]

IV. Data and Background Information

This section briefly describes some of the salient features of the data and reviews the evidence that financial constraints seem to play an important role in determining who becomes an entrepreneur and how existing businesses are run. The reader who is interested in more details is referred to Paulson and Townsend (2004).

The data we analyze cover four provinces in Thailand. Two of the provinces are in the central region and are relatively close to Bangkok. The other two provinces are much further from Bangkok and are located in the relatively poor northeastern region. The contrast between the survey areas is deliberate and has obvious advantages. Within each province a stratified random sample of 12 geographic areas (*tambons*, typically 10–12 villages) was selected. The stratification ensured that the sample was ecologically diverse. In each tambon, four villages were selected at random. In each village, a random sample of 15 households were interviewed.

The businesses we study are quite varied and include shops and restaurants, trading activities, shrimp or livestock raising, and the provision of construction or transportation services.[22] While there are many different types of businesses, shrimp or fish raising, shops, and trade account for 70 percent of the businesses in the whole sample and make up a similar percentage of the businesses in each region. Median initial

[20] This latter procedure solves the nonlinear optimization problem of maximizing L by using the Matlab routine fminsearch, which is a generalization of the polytope method using the Nelder-Mead simplex algorithm. We chose this method because of its high reliability, relative insensitivity to initial values, and good performance with low-curvature objective functions. Typically the optimization takes 300–400 iterations, which amounts to two and a half to seven hours of computer time depending on the regime.

[21] Even with a fairly small number of bootstrap draws (10), this is the most time-intensive part of the algorithm and can take up to three to four days for each estimated parameter configuration.

[22] We are aware that some farms are run like businesses and that the dividing line between businesses and farms is not always clear. However, farming, particularly of rice and other crops, can be thought of as a "default" career choice. An active decision to do something else has been made by the households that we define to be business households. We experimented with alternative categorizations and found that the one we use has content in the sense that the performance of the structural estimation deteriorates when entrepreneurial status is randomly assigned compared to when entrepreneurial status is determined by the data.

investment in the household businesses varies substantially with business type.

Despite this variation, the median initial investment appears to be relatively similar across regions for the same type of business, particularly for the most common business types. For example, the median investment in a shop is 16,000 baht in both the northeastern and the central regions. In the Northeast, the median initial investment in trade is 21,000 baht compared to 23,000 baht in the central region.[23] For future reference, note that average annual household income in Thailand at the time of the survey is 105,125 baht, or roughly $4,200.

Most business households run a single business and rely heavily on family workers. Only 10 percent of the businesses paid anyone for work during the year prior to the survey.[24] More than 60 percent of the businesses were established in the past five years. In the empirical work we restrict our attention to these businesses.[25] Savings (either in the form of cash or through asset sales) is the most important source of initial business investment. Approximately 60 percent of initial investment in household businesses comes from savings. Loans from commercial banks account for about 9 percent of initial business investment, and the BAAC accounts for another 7 percent. In the Northeast, the BAAC plays a larger role than commercial banks, and in the central region the opposite is true.

Entrepreneurial households are a bit younger and more educated than nonbusiness households. The current median income of business households is about twice that of nonbusiness households. This difference is used to calibrate the talent parameter, δ_0, in the baseline structural estimates. Business households are wealthier both at the time of the survey and prior to starting a business, compared to their nonbusiness counterparts. In addition, business households are more likely to be customers of commercial banks and the BAAC and to participate in village financial institutions.

Table 1 summarizes the data for business and nonbusiness households

[23] Median investment in shrimp or fish does differ depending on the region: in the Northeast it is 9,000 baht compared to 51,000 baht in the central region. The reason is that shrimp farming, which requires substantial initial investment, is concentrated in the central region, whereas fish farms are more important in the Northeast.

[24] This means that the set of entrepreneurial firms is unlikely to be very affected by the case in which wealthy, but untalented, households hire poor, but talented, managers to run their firms.

[25] Although these results are not presented in the paper, we have also looked at businesses that were established in the past 10 years. This group includes 83 percent of the businesses in the sample. None of the results are sensitive to which group of businesses we examine. The decision to focus on businesses that were started in the past five years was the result of weighing the benefit of having more accurate measures of beginning-of-period wealth against the cost of eliminating the 224 households that started businesses more than five years ago.

TABLE 1
Summary Statistics

	Whole Sample	Northeast	Central Region
	A. Variables Used in Structural and Reduced Form/Nonparametric Estimation (All Households)		
Number of households	2,313	1,209	1,104
Business households	14%	9%	19%
Years of schooling:			
All households	4.03	3.97	4.09
	(2.56)	(2.45)	(2.67)
Business households	4.70	5.00	4.50
	(2.90)	(3.00)	(2.80)
Wealth six years prior to survey:			
All households	1,007,166	355,996	1,712,046
	(3,929,520)	(648,590)	(5,545,901)
Business households	2,532,464	428,490	3,614,755
	(7,603,877)	(558,630)	(9,168,505)
Constrained business households*	1,199,500	313,093	1,655,471
	(5,770,877)	(546,497)	(7,051,744)
Unconstrained business households	1,562,854	137,406	2,296,109
	(5,550,756)	(343,281)	(6,713,852)
	B. Variables Used in Reduced Form/Nonparametric Estimation (Business Households Only)		
Number of households	361	122	239
Initial business investment	148,734	81,311	179,349
	(339,562)	(176,918)	(388,312)
Net savings	4,562	−13,680	13,946
	(714,701)	(410,166)	(829,564)
% who are net borrowers	55%	61%	51%
% who report they are constrained*	56%	68%	50%
Age of head	49.5	48.4	50.1
	(13.9)	(13.6)	(14.1)
Adult women in the household	1.6	1.6	1.7
	(.9)	(.8)	(.9)
Adult men in the household	1.6	1.5	1.7
	(.9)	(.9)	(.9)
Children (< 18 years) in the household	1.5	1.5	1.6
	(1.2)	(1.1)	(1.3)
	C. Business Households That Were Member/Customer of Organization/Institution Six Years Ago		
Formal financial institution	23%	16%	27%
Village institution/organization	11%	10%	12%
Agricultural lender	33%	33%	33%
BAAC group	22%	29%	18%
Money lender	4%	5%	4%

Note.—Standard errors are in parentheses. Wealth is in Thai baht. The exchange rate at the time of the survey is 25 baht to $1.00.

* Households that reported that their businesses would be more profitable if it were expanded are labeled "constrained"; households that report that their business would *not* be more profitable if it were expanded are labeled "unconstrained."

that are used in the structural maximum likelihood estimates and the business household information that is used in the reduced-form and nonparametric analysis. The wealth variable measures the value of real, nonfinancial wealth that the household owned six years prior to the survey. It is equal to the total value of the household, agricultural, and land assets that the household owned then. This corresponds to beginning-of-period wealth, that is, wealth prior to choosing an occupation. The value of any business assets that the household may have owned six years ago is excluded.[26]

In addition to using data on past wealth, entrepreneurial status, and years of education, the reduced-form and nonparametric analyses make use of additional data on the demographic characteristics of the head of the business household (age and age squared) and on characteristics of the household (the number of adult men, adult women, and children in the household). All these variables are measured at the time of the survey. We also use data on net financial savings at the time of the survey, which is equal to the financial savings of the household plus the value of loans that are owed to them minus current debt. In some estimates, we control for the impact of credit market availability by including measures of whether or not the household was a member or a customer of various financial institutions in the past.

Household business reports of whether or not they are "constrained" are a key variable in the reduced-form and nonparametric analysis. Household businesses are considered constrained if they answer yes to the question "Would your business be more profitable if it were expanded?" Fifty-six percent of business households answer yes to this question. Further information from the survey suggests that household responses to this question may reasonably approximate the theoretical notion of being constrained or being subject to a binding limited-liability or incentive compatibility constraint. For example, of the businesses that reported that they were constrained, 37 percent said that they had not expanded their business because they lacked sufficient funds to do

[26] The past value of real assets is found by depreciating the purchase price of the asset (in 1997 baht) from the time of purchase to what it would have been worth six years prior to the survey. We assume that the depreciation rate for all household and agricultural assets is 10 percent per year. If the household purchased a tractor 10 years before the survey for 100,000 baht, we would first convert the purchase price to 1997 baht (using the Thai consumer price index) and then multiply this figure by $(0.90)^4$ to account for four years of depreciation between the purchase date and six years prior to the survey. This procedure would give us the value of the tractor six years prior to the survey. Past values of land are treated differently. Households were asked to report the current value of each plot that they own. In calculating past land values, we assume that there have been no real changes in land prices. So if the household has had one plot for 10 years and the current value of that plot is 100,000 baht, then six years ago the value of that plot would also be 100,000 baht (in 1997 baht). In addition, information on land purchases and sales is used to measure the value of land that a household owned in the past.

so. Another 30 percent said that they did not have enough land to expand. An additional 13 percent reported that they lacked time or labor for expansion.[27]

V. Structural Maximum Likelihood Estimates

In this section the structure of the model is taken literally to determine how well it fits the observed pattern of who becomes an entrepreneur as a function of wealth, the imputed distribution of entrepreneurial talent in the Thai data, and various assumptions about the financial regime. We consider three financial regimes: moral hazard, limited liability, and both moral hazard and limited liability.

Each structural maximum likelihood estimate produces a measure of the likelihood that a given set of assumptions about the financial environment could have generated the patterns of wealth, education, and entrepreneurial status observed in the Thai data. In addition, the estimation delivers the maximized values of the model parameters, the probability that each agent will become an entrepreneur, and assignments of capital, effort, and consumption for each agent.

Most of the structural estimates are produced assuming that the talent parameters δ_0, δ_1, and δ_2 are fixed. This is done to ensure that a given agent has the same expected talent regardless of the financial environment. The talent parameter δ_1 is set equal to 0.06, which means that a 10 percent increase in wealth raises entrepreneurial talent by 0.6 percent. The parameter δ_2 is set equal to 0.125, which means that a 10 percent increase in years of schooling increases entrepreneurial talent by 1.25 percent. Throughout the estimation, we also assume that the standard deviation of shocks to entrepreneurial talent, σ_η, is one. The values of δ_1, δ_2, and σ_η were chosen to be consistent with structural estimates of a version of the model of Evans and Jovanovic (1989) using the Thai data.[28] Because these estimates also use income data, they bring additional information to bear on the relationship between entrepreneurial talent, wealth, and education. Current computational methods prevent us from using income data in the structural estimates discussed below.

We consider two methods of fixing the talent parameter, δ_0. In the first method, which is referred to as "income" in the tables, δ_0 is assigned on the basis of the observed income of entrepreneurs relative to nonentrepreneurs. When the scaling required to ensure that probabilities lie between zero and one is ignored, the model implies that the output

[27] See Townsend et al. (1997) for further details on the survey design and implementation.

[28] These estimates were produced using the methods described in Evans and Jovanovic (1989). Their methodology cannot be used to estimate the model discussed in this paper.

of a successful entrepreneur is equal to θ and the output of a successful wage worker is equal to one. The data reveal that the median entrepreneur has income that is 2.56 times higher than that of the median wage worker. When we map from the data back into the model, this implies that the median entrepreneur has a θ of 2.56. From equation (2), which maps wealth and schooling into log talent, as well as the assumptions about δ_1 and δ_2 discussed above, this implies that δ_0 must be equal to 0.922.

In the second method, which we refer to as the "% entrepreneur" case, δ_0 is chosen so that the predicted percentage of entrepreneurs from the structural estimation of the model matches the percentage of entrepreneurs observed in the data, namely 14 percent. In this case, δ_0 is set equal to 1.295.[29]

We also estimate δ_0, δ_1, and δ_2 for each of the financial regimes. These estimates are labeled "estimated delta" in the tables. Both the model and common sense suggest that entrepreneurial talent plays an important role in occupational choice and, potentially, in determining the availability and cost of credit. However, success in this area is necessarily incomplete since direct data on the distribution, let alone the level, of entrepreneurial talent are not available.[30] Therefore, we allow estimated talent parameters to vary freely with the financial regimes and compare these estimates with estimates in which the talent parameters are fixed a priori, as described above.

Table 2 reports on the structural estimates for the whole sample for the three financial market possibilities: moral hazard, limited liability, and both. Each column of information in the table corresponds to a financial market regime. There are four sets of estimates for each financial market regime. The first set assumes that average entrepreneurial talent is set according to the "income" method described above and that agents may be risk averse. We treat these estimates as the "benchmark" case and use the others to make sure that our conclusions are robust. The second set makes the same assumptions about entrepreneurial talent but assumes that agents are risk neutral. The third set of estimates returns to the assumption that agents may be risk averse and uses the % entrepreneur method to set the average talent parameter. In the final set of estimates, talent parameters are estimated as discussed above and agents are assumed to be risk averse. The predicted rela-

[29] We assumed that financial markets were characterized by moral hazard and used the whole sample to calibrate δ_0 so as to deliver the percentage of entrepreneurs observed in the data.

[30] Other researchers have used information from the distribution of test scores to pin down the talent distribution (see, e.g., Cunha, Heckman, and Navarro 2004). Equivalent information for the individuals in the Thai data is not available.

TABLE 2
Parameter Values from Structural Estimation: Whole Sample

	Moral Hazard	Limited Liability	Both
	A. Risk Aversion, Talent (Income)		
γ_1	.0985	.0982	.1025
	(.0125)	(.0003)	(.0046)
γ_2	2.1007	1.1713	2.4753
	(.3216)	(.0037)	(.1797)
κ	.1257	.1079	.1190
	(.0227)	(.0003)	(.0062)
α	.7775	.6937	.7208
	(.0325)	(.0165)	(.0108)
λ	. . .	22.9885	20.8082
		(.0727)	(1.4882)
	B. Risk Neutrality, Talent (Income)		
γ_2	1.5801	1.3475	1.5511
	(.0243)	(.0167)	(.0171)
κ	.0530	.0675	.0789
	(.0009)	(.0009)	(.0008)
α	.7700	.6800	.6902
	(.0099)	(.0273)	(.0043)
λ	. . .	24.5000	28.3848
		(.3307)	(.3095)
	C. Risk Aversion, Talent (% Entrepreneur)		
γ_1	1.0737	.0668	.7781
	(.0123)	(.0004)	(.0035)
γ_2	1.0000	1.0000	1.0000
	(.0192)	(.0141)	(.0105)
κ	.0904	.0722	.1219
	(.0001)	(.0001)	(.0016)
α	.9780	.9702	.5062
	(.0032)	(.0003)	(.0066)
λ	. . .	10.7281	1.9014
		(.0305)	(.0042)
	D. Risk Aversion, Estimated Talent		
γ_1	.5753	.0957	.1002
	(.0175)	(.0002)	(.0005)
γ_2	1.0494	1.2314	1.0939
	(.0171)	(.0120)	(.0061)
κ	1.2312	.9889	1.0022
	(.0649)	(.0049)	(.0065)
α	.7931	.2283	.7985
	(.0148)	(.0030)	(.0188)
δ_0	1.0175	.8853	.1002
	(.0464)	(.0108)	(.0007)
δ_1	.0604	.0285	.0503
	(.0218)	(.0002)	(.0004)
δ_2	.0516	−.2226	.3005
	(.0053)	(.0046)	(.0018)
λ	. . .	21.0118	5.0088
		(.2223)	(.0970)

Note.—Bootstrap standard errors are in parentheses.

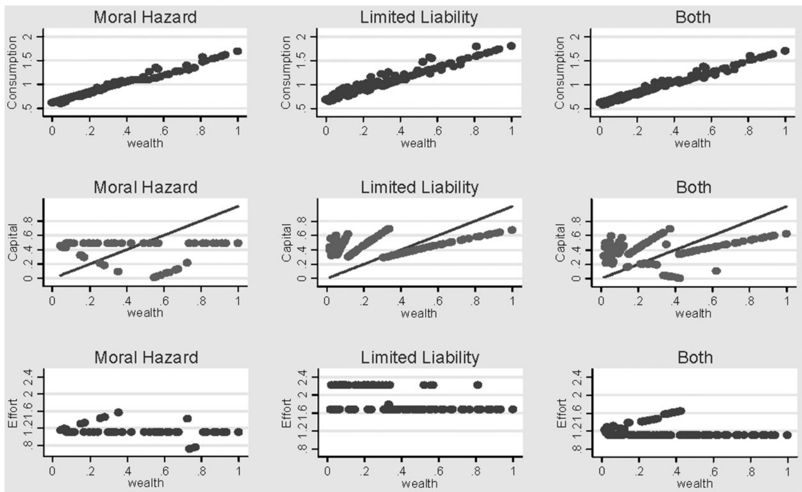

FIG. 3.—Expected assigned consumption, capital, and effort relative to wealth for entrepreneurs from benchmark structural estimates of moral hazard, limited liability, and both moral hazard and limited-liability financial regimes. The 45-degree line is included in capital figures

tionships between capital, effort, consumption, and wealth for entrepreneurs in the benchmark case are described in figure 3.

A. *Parameter Estimates*

Across the financial regimes, in the benchmark case (panel A of table 2), the production parameter, α, is estimated to range from 0.69 to 0.78. This means that, all else equal, a 10 percent increase in business investment would lead to a 4.2–5.1 percent increase in the probability of entrepreneurial success. The parameter estimates for α can be used together with predicted values for effort and investment to calculate the implied probability that the average business will be successful. In the baseline case, an entrepreneur who invests the average amount of capital and exerts the average amount of effort has a 32 percent chance of success in the moral hazard case, 41 percent in the limited-liability case, and 33 percent when both moral hazard and limited liability are a concern. These figures are relatively low partly because of the normalization that ensures that the probability of success will always lie between zero and one (see eq. [3]). When we ignore the normalization, the probability of success is 47 percent in the moral hazard case, 71 percent in the case of limited liability, and 49 percent when both limited liability and moral hazard are important. By comparison, survey data from Thailand suggest that 67 percent of businesses started in 1998 were still in operation in 2001.

Estimates of α are very similar when the income method is used to determine talent and risk neutrality is assumed (panel B of table 2). When the benchmark income method (panel A) is compared with the estimates in which talent parameters are estimated (panel D), α stays roughly the same for the moral hazard and both cases and falls from 0.69 to 0.23 in the case of limited liability. When the % entrepreneur method is used to pin down talent (panel C), the estimates produce values of α that are close to one for the moral hazard and limited-liability cases. With these assumptions, the predicted probability of entrepreneurial success is 46 percent for moral hazard, 42 percent for limited liability, and 36 percent when financial markets are characterized by both moral hazard and limited liability.

The degree of risk aversion is estimated to be fairly consistent both across financial regimes and across assumptions about the talent parameters. The estimates for γ_1 are generally close to 0.1, which implies that households are not particularly risk averse. There are three exceptions to this general finding. Estimated risk aversion is considerably higher when the % entrepreneur method is used to calibrate talent and there is moral hazard (see panel C). In the case of moral hazard alone, $\gamma_1 = 1.07$, and when there is moral hazard together with limited liability, γ_1 is estimated to be 0.78. Moral hazard alone generates a γ_1 of 0.58 when talent parameters are estimated (panel D).

There are two parameters that determine the disutility of effort, κ and γ_2 (see eq. [1]). Estimates of κ, a scale parameter measuring the distastefulness of effort, are very consistent across the three financial regimes, ranging from 0.11 to 0.13 in the benchmark case, 0.05 to 0.08 when we assume risk neutrality, and 0.09 to 0.12 when the % entrepreneur method is used to calibrate talent. However, when talent parameters are estimated, κ is much higher, ranging from 0.99 to 1.23.

There is some variation in the parameter γ_2 across financial regimes. This parameter, which is similar to a risk aversion parameter, measures the extent to which agents dislike variability in effort. For example, in the benchmark case, this parameter is lowest in the limited-liability case at 1.2, goes up to 2.1 in the case of moral hazard, and reaches 2.5 when both moral hazard and limited liability are a concern. This reveals some interesting interaction between the financial regime and the parameters. In the limited-liability case, the estimates want to assign relatively low disutility of effort compared to the moral hazard and "both" cases when effort assignments must satisfy an incentive compatibility constraint. This is also consistent with information on how effort assignments are made across the financial regimes (see fig. 3). Entrepreneurs are assigned higher levels of effort in the limited-liability financial regime than in the regime in which moral hazard is also a concern. There is some tendency for the structural estimation to produce parameters that make higher effort less costly to agents when there is limited liability and no moral hazard.

Estimates of the parameter λ, which determines how much agents can borrow in the limited-liability and both cases, seem too high. In the benchmark estimates, λ is estimated to be between 21 and 23. This means that agents can borrow between 20 and 22 times their wealth.

The limited liability parameter, λ, is very sensitive to assumptions about average talent, δ_0. When average talent is calibrated to fit the observed percentage of entrepreneurs in the data (see panel C of table 2), estimates of λ decline markedly, ranging from 1.9 when both moral hazard and limited liability are a concern to 10.7 when the financial environment is characterized by limited liability alone.

To further explore this issue, we have estimated the limited-liability model fixing the value of λ at two (i.e., households can borrow an amount equal to their own wealth). In these estimates, the other parameter values are similar to the values that are obtained when λ is also estimated, although the overall fit of the model, as measured by the log likelihood, declines compared to the case in which λ is estimated. (These estimates are available from the authors.)

An examination of the data reveals that, in practice, loan to collateral values are typically quite low, and very often the value of the loan is significantly less than the value of the collateral used to secure it, consistent with a λ of less than one.[31] On the other hand, there are also many unsecured loans in the data. That is, there are many loans in which λ would appear to be infinite.

As discussed above, in the first three sets of estimates, the parameters that describe the relationship between entrepreneurial talent and wealth and schooling are held fixed at $\delta_1 = 0.06$ and $\delta_2 = 0.125$. These two parameters remain the same, and δ_0 is set equal to 0.922 for the benchmark income case and is higher, at $\delta_0 = 1.295$, in the % entrepreneur case. In the final set of results (panel D of table 2), these parameters are estimated for each of the financial regimes. Estimates of δ_0 range from a low of 0.1 in the case of both limited liability and moral hazard to a high of 1.0175 when moral hazard alone is assumed to govern financial constraints. Estimates of δ_1, which measures the relationship between wealth and entrepreneurial talent, are all positive and range from 0.03 in the limited-liability case to 0.06 in the moral hazard case.

[31] Land is the most common source of collateral, and indivisibilities in land may account for some of the very low loan/collateral ratios that we see. For example, if a household wishes to borrow 10,000 baht and has a plot of land worth 100,000 baht that it uses as collateral, the loan/collateral ratio will be 0.1.

This range includes the assigned value for δ_1, 0.06, that is assumed in the other sets of estimates.

Estimates of the parameter δ_2, which captures the relationship between entrepreneurial talent and formal schooling, display the most variation across the financial regimes. In the case of limited liability and no moral hazard, estimates of δ_2 suggest that entrepreneurial talent decreases with formal schooling, with each additional year of schooling decreasing entrepreneurial talent by 4 percent. When moral hazard is a concern, either on its own or together with limited liability, additional schooling is associated with higher entrepreneurial talent, with an additional year of schooling increasing entrepreneurial talent by 0.9 percent in the case of moral hazard alone and by 8 percent in the case of moral hazard and limited liability.

Despite the variation in talent parameters across the financial regimes, especially in δ_2, average entrepreneurial talent is estimated to be relatively similar across the regimes: 2.8 in the case of moral hazard, 2.1 in the case of limited liability, and 2.0 when both moral hazard and limited liability are an issue. By comparison, average entrepreneurial talent is estimated to be about 3.0 for all the financial regimes in the benchmark income case and about 3.9 in the % entrepreneur case.

B. *Benchmark Assignments of Capital, Effort, and Consumption*

Figure 3 uses simulated data from each of the three model regimes evaluated at their respective structural maximum likelihood parameter estimates to describe how expected assigned entrepreneurial capital, effort, and consumption vary with wealth for the whole-sample, benchmark case with risk aversion. To illustrate more clearly the distinctions between the regimes and the intuition behind the solutions to the corresponding linear programs from Section II, the simulations were performed at all actual wealth and schooling levels from the data; that is, no splines were used, in contrast to the actual estimation. Each graph shows the expected assignment of consumption, capital, and effort as a function of wealth for agents that the structural estimates assign to have $k > 0$, in other words, entrepreneurs. The discreteness of the grids we use for computational reasons and the heterogeneity in average entrepreneurial talent, which fluctuates with schooling through δ_2 and thus plays an important role in determining capital, effort, and consumption, account for the variability and "clustering" displayed in the figures.

In the case of consumption, the figure shows that consumption increases more or less linearly with wealth, regardless of what is assumed about financial market imperfections. This is what we would expect for unconstrained entrepreneurs, regardless of what is assumed about financial market imperfections. In the limited-liability case, most entrepreneurs turn out to be unconstrained. However, in the moral hazard case, all risk-averse entrepreneurs are subject to a binding incentive compatibility constraint. For these households the roughly linear relationship between consumption and wealth is a result of the large fraction of capital assignments that are the same regardless of wealth. With recommended investment often invariant to wealth, additional wealth is invested at the gross interest rate, r, and augments consumption by the gross interest rate multiplied by any additional net savings.

Looking at the relationship between capital and wealth reveals differences in what is expected across the models. The straight line in the capital figures is the 45-degree line. Capital assignments above the 45-degree line correspond to borrowing, and capital assignments below the line involve no borrowing. When financial markets are characterized by moral hazard alone, there appear to be two groups of entrepreneurs. The largest group has investment that is largely unchanged with wealth. For this group, borrowing decreases unambiguously with wealth, which we would expect as constrained entrepreneurs relax the incentive compatibility constraint by relying less on outside funding when wealth goes up. This group has higher average talent and wealth. The second group, with lower talent and lower wealth, has investment that first declines with wealth and then increases with wealth. The range in which investment decreases when wealth increases is also a range in which borrowing is decreasing, which has the effect of relaxing the incentive compatibility constraint. The range in which investment increases with wealth is a range in which the entrepreneurs are net savers and do not rely on outside funding for their businesses.

Entrepreneurial investment and, hence, borrowing increase sharply with wealth along several distinct lines when limited liability is a concern. This effect is driven by λ. Constrained entrepreneurs increase investment and borrowing since increasing wealth relaxes the limited-liability constraint. Note that the rate of increase in investment is higher for low-wealth entrepreneurs that borrow (their capital assignments are above the 45-degree line) than it is for higher-wealth households that are net savers. When both moral hazard and limited liability are a concern, the relationship between investment and wealth is a combination of what was observed for the cases in which there was only moral hazard or only limited liability, with the exception that there is no group of entrepreneurs for whom investment appears to be the same regardless of wealth.

Effort tends to be higher when there is limited liability and no moral hazard, as one might expect. In this case, the structural estimates predict essentially two levels of effort, high and low, that do not vary with wealth. There is some tendency for the low-wealth entrepreneurs to have higher effort and wealthier entrepreneurs to have lower effort.[32] In addition, although this cannot be seen in the figure, the low-wealth, high-effort group tends to have greater entrepreneurial talent, on average, than the high-wealth, low-effort group.

When moral hazard constrains financial contracts, there is also a large group of entrepreneurs who have the same, relatively low, effort regardless of wealth. This group accounts for 78 percent of the businesses produced by the moral hazard estimation. However, there is another, much smaller, group of entrepreneurs with low to medium wealth who exert more effort as wealth increases. This group has lower average entrepreneurial talent than the group whose effort does not vary with wealth. When both moral hazard and limited liability are a concern, the data produced by the structural estimation more closely mimic the situation in which there is only moral hazard.

VI. Comparison of the Financial Regimes

In this section the financial regimes are compared using two complementary techniques. First, we distinguish between the financial regimes using formal tests based on the structural estimates discussed above. Next, nonparametric and reduced-form techniques are used to provide additional, independent evidence about the source of financial market imperfections in the Thai data.

While the structural estimates impose a number of restrictions on the data, they rely on a very limited subset of the available data: past wealth, the entrepreneurial status of the household, and the years of schooling of the household head. In contrast, the nonparametric estimates impose almost no structure on relationships between the key variables of interest and explore relationships between variables that are not used in the structural estimation. The reduced-form estimates draw on the richness of the available survey data, while imposing a particular functional form on the relationship between the dependent and independent variables. Both the nonparametric and the reduced-form findings offer completely independent evidence of the nature of financial constraints and enhance the overall interpretation of what we see in the data.

A. *Structural Evidence*

In this subsection, we provide formal tests of which of the candidate financial regimes best fit the whole sample and the various subsamples

[32] Notice that there are relatively more points on the upper effort level "line" in the "effort" panel of the limited-liability part of fig. 3 for low wealth levels and relatively more points on the low-level "line" for higher wealth levels.

of the data that were described earlier. The financial regimes are compared using the Vuong likelihood ratio test (see Vuong 1989). One attractive feature of the Vuong test is that it does not require either model to be correctly specified. This feature is appealing given the necessity of studying models that are much simpler than reality. The null hypothesis is that the two models are equally near the actual data-generating process. The Vuong test delivers an asymptotic test statistic that measures the weight of the evidence in favor of one model or the other.[33]

We use the Vuong test for strictly nonnested models. For the purposes of this test, model A nests model B if, for any possible allocation that can arise in model B, there exist parameter values such that this is the allocation in model A. In the current context, the case with both limited liability and moral hazard nests the case in which financial markets are characterized by only moral hazard. The reason is that for a sufficiently large λ, the "both" case will reproduce the exact same assignment of households to occupations as the moral hazard alone case. On the other hand, the "both" case does not nest the limited-liability case, because there is no parameter that can make effort observable, "turn off" the moral hazard constraint, and deliver the same assignment of entrepreneurial status as in the limited liability alone case. In any case, the likelihood ratio test statistic that Vuong proposes is appropriate regardless of whether the three financial regimes are completely nonnested, overlapping, or nested. However, the asymptotic distribution of the test statistic depends on the relationship between the models.[34] Using the distribution that is appropriate for nonnested models is the conservative choice, in the sense that is makes it more difficult to statistically distinguish the financial regimes.

1. Whole Sample Findings

Table 3 reports the log likelihoods for each of the three possible financial regimes (moral hazard, limited liability, and both) and the four sets of assumptions we make in estimation (income with risk aversion and with risk neutrality, % entrepreneur with risk aversion, and the case in which the talent parameters are estimated). The likelihoods are reported for the whole sample (panel A), the Northeast (panel B), and the central region (panel C). The results of the comparison tests for

[33] One could use the same procedure in which the null hypothesis was that one model was closer to the actual data-generating process. The test statistic would remain the same; however, the critical values for rejecting the null would of course change.

[34] The comparisons of financial regimes that we report are based on the more conservative critical values for the case of strictly nested models, where the test statistic has a χ^2 distribution. In the case of nonnested models, the test statistic is normally distributed.

TABLE 3
Log Likelihoods from Structural Estimation

	Moral Hazard	Limited Liability	Both
		A. Whole Sample	
Risk aversion, talent (income)	−.4038	−.4706	−.4683
Risk neutrality, talent (income)	−.4104	−.4608	−.4372
Risk Aversion, talent (% entrepreneur)	−.4590	−.7514	−.6064
Risk aversion, estimated talent	−.3996	−.4134	−.4035
		B. Northeast	
Risk aversion, talent (income)	−.3044	−.3474	−.3258
Risk neutrality, talent (income)	−.3046	−.3474	−.3474
Risk aversion, talent (% entrepreneur)	−.3408	−.4588	−.4250
Risk aversion, estimated talent	−.3040	−.3045	−.3029
		C. Central	
Risk aversion, talent (income)	−.5014	−.5966	−.5668
Risk neutral, talent (income)	−.5190	−.5966	−.5553
Risk aversion, talent (% entrepreneur)	−.6104	−.8658	−.7902
Risk aversion, estimated talent	−.4991	−.5355	−.5185

the three possible financial regimes—moral hazard, limited liability, and both—are provided in panels A–C of table 4 for the whole sample, Northeast, and central region, respectively.

For the whole sample, the case in which moral hazard alone describes financial markets significantly outperforms the limited-liability case and the case in which financial markets are characterized by both moral hazard and limited liability.[35] This finding is robust to alternative assumptions about risk aversion and to alternative methods of calibrating average entrepreneurial talent. Because the moral hazard case performs best even when talent is calibrated to match the observed percentage of entrepreneurs in the data, we gain confidence that the results are not in some way driven by the relatively low number of entrepreneurs produced by the estimates that use the relative income of entrepreneurs and nonentrepreneurs to fix the mean of the talent distribution.[36]

[35] Using different methods and data, Ligon (1998) finds that a model with moral hazard better explains the degree of consumption smoothing in Indian villages relative to either a model with full risk sharing or a model in which only self-insurance is possible.

[36] The benchmark income results imply that 3 percent of the sample will become entrepreneurs when there is moral hazard, 6 percent if there is limited liability, and 5 percent when there is limited liability and moral hazard. In the data, 14 percent of households have a business. By design, the % entrepreneur estimates imply that 14 percent of households will have a business when there is moral hazard. When there is limited liability or limited liability and moral hazard, 26 percent of households are predicted to have a business in the % entrepreneur case.

TABLE 4
Comparison of Financial Regimes, Vuong Test Results

	MH vs. LL	MH vs. Both	LL vs. Both	Best Overall Fit
	A. Whole Sample			
Risk aversion, talent (income)	MH*** (.0000)	MH*** (.0001)	Both (.8866)	MH
Risk neutrality, talent (income)	MH*** (.0010)	MH** (.0252)	Both*** (.0033)	MH
Risk aversion, talent (% entrepreneur)	MH*** (.0000)	MH*** (.0000)	Both*** (.0000)	MH
Risk aversion, estimated talent	MH*** (.0046)	MH (.3402)	Both*** (.0046)	MH or both
	B. Northeast			
Risk aversion, talent (income)	MH*** (.0071)	MH* (.0519)	Both*** (.0081)	MH
Risk neutrality, talent (income)	MH*** (.0073)	MH*** (.0073)	Tie (.1018)	MH
Risk aversion, talent (% entrepreneur)	MH*** (.0000)	MH*** (.0012)	Both*** (.0000)	MH
Risk aversion, estimated talent	MH (.4213)	Both (.3718)	Both (.1846)	MH, LL or both
	C. Central			
Risk aversion, talent (income)	MH*** (.0003)	MH*** (.0008)	Both (.1897)	MH
Risk neutrality, talent (income)	MH*** (.0007)	MH** (.0263)	Both** (.0133)	MH
Risk aversion, talent (high)	MH*** (.0000)	MH*** (.0000)	Both*** (.0027)	MH
Risk aversion, estimated talent	MH*** (.0004)	MH** (.0426)	Both (.1342)	MH

Note.—MH = moral hazard, LL = limited liability, both = moral hazard and limited liability. The abbreviation for the model that best fits the data in the pairwise comparison is reported. The p-values for the Vuong tests are in parentheses.
* Significant at at least the 10 percent level.
** Significant at at least the 5 percent level.
*** Significant at at least the 1 percent level.

When the estimation also produces estimates of the talent parameters (the fourth row), the distinction between the moral hazard and the both cases decreases somewhat. While these estimates strongly reject the possibility that financial markets are characterized by limited liability alone, they do allow for the possibility that limited liability in concert with moral hazard might be as good a candidate for explaining the data as moral hazard alone.

2. Regional Findings

We next consider the possibility that the financial regime varies by region. There are a number of reasons to consider this possibility, the first being the large differences in wealth between the more developed central region and the less developed northeastern region. In addition to this difference, the dominant financial institution is different in the two regions, and one prominent lender, the BAAC, appears to operate differently in the two regions.

In the Northeast the percentage of total funds lent is very concentrated compared to the central region. The BAAC accounts for 39 percent of all funds lent. Other formal lenders account for only 11 percent of lending. In the central region, lending is much more dispersed. The BAAC accounts for 24 percent of lending. Commercial banks and relatives account for another 21 percent and 17 percent of lending, respectively.

Despite these regional differences, the comparisons of the financial regimes for the northeastern and the central regions in panels B and C of table 4 reinforce the findings for the whole sample. Hidden information, specifically hidden action, drives the key financial constraint in Thailand. For the central region, the findings are even stronger than for the whole sample. Regardless of assumptions about risk aversion and talent, these estimates favor moral hazard alone as an explanation for the patterns of entrepreneurship in the central region. In the Northeast, the same pattern emerges, with one exception. When the estimation allows talent parameters to vary with the financial regime, the three financial regimes cannot be statistically distinguished from one another.

3. Robustness Checks

Grid sizes and bounds.—In producing the structural estimates, we have experimented with different grid sizes for investment and effort, as well as with different upper bounds on the potential range for investment and effort.[37] The superior fit of the moral hazard financial regime is not affected by alternative assumptions about the number of grids or the range of potential investment and effort levels.

Sensitivity of results to outliers.—In order to ensure that the findings are not driven by outliers in the data, we have estimated the model, under the benchmark assumptions, for each of the financial regimes, dropping observations that fall into the top 5 percent or the bottom 5 percent of the wealth distribution. When the influence of potential outliers is eliminated, the moral hazard regime continues to significantly outperform the limited-liability regime as well as the regime in which both moral hazard and limited liability are a concern.

[37] Specifically, we computed versions of the model with five grid points for effort, versions with 10 grid points for investment, and versions with higher upper bounds on the grids for effort and investment (10 instead of five).

Identification of business households.—We return now to the issue of whether the assignment of entrepreneurial and nonentrepreneurial status to the sample households has content. This is evaluated using simulations of the Evans and Jovanovic (1989) limited-liability model, because this model is relatively speedy to estimate numerically. We construct 100 samples of the Thai data in which entrepreneurial status is randomly assigned, ignoring the actual occupation of the household. The overall fraction of randomly assigned entrepreneurs is fixed at the proportion of business households actually observed in the original data. The overall fit of the limited-liability model deteriorates substantially when it is estimated using the simulated data.

4. Summary of Structural Evidence

Taking together all the evidence from the formal comparison of the three financial regimes, we conclude that moral hazard is the key financial market imperfection that affects who becomes an entrepreneur in Thailand. We reject the possibility that limited liability alone could explain the data.

Figure 4 compares the predicted likelihood of starting a business as a function of wealth at the maximized parameter values produced by each financial regime for the benchmark whole-sample results. The figure also includes nonparametric estimates of the probability of starting a business as a function of wealth from the survey data. In the case of the structural estimates, the graphs represent the nonparametric relationship between entrepreneurship and wealth implied by the assignments of capital and effort produced by the structural estimates. For each wealth and talent value, the structural estimates generate the probability that a household with that wealth and talent will become an entrepreneur. The curve labeled "data" in both panels of figure 4 is the nonparametric estimate of the relationship between the survey reports of entrepreneurial status and wealth. For each structural estimate and the data, nonparametric estimates of the relationship between entrepreneurship and wealth were produced using the same techniques as in figure 1 (see n. 1 for details).

Figure 4*a* shows what happens to the likelihood of starting a business over the entire domain of wealth, and figure 4*b* restricts the wealth domain to the fifth through the ninety-fifth percentiles. It is important to keep in mind that the probability of starting a business as a function of wealth produced by the structural estimates also includes the impact of integrating out over the talent distribution. Similarly, the estimates produced from the survey data make no attempt to control for entrepreneurial talent or schooling.

From figure 4*a*, it appears that the predicted probability of being an

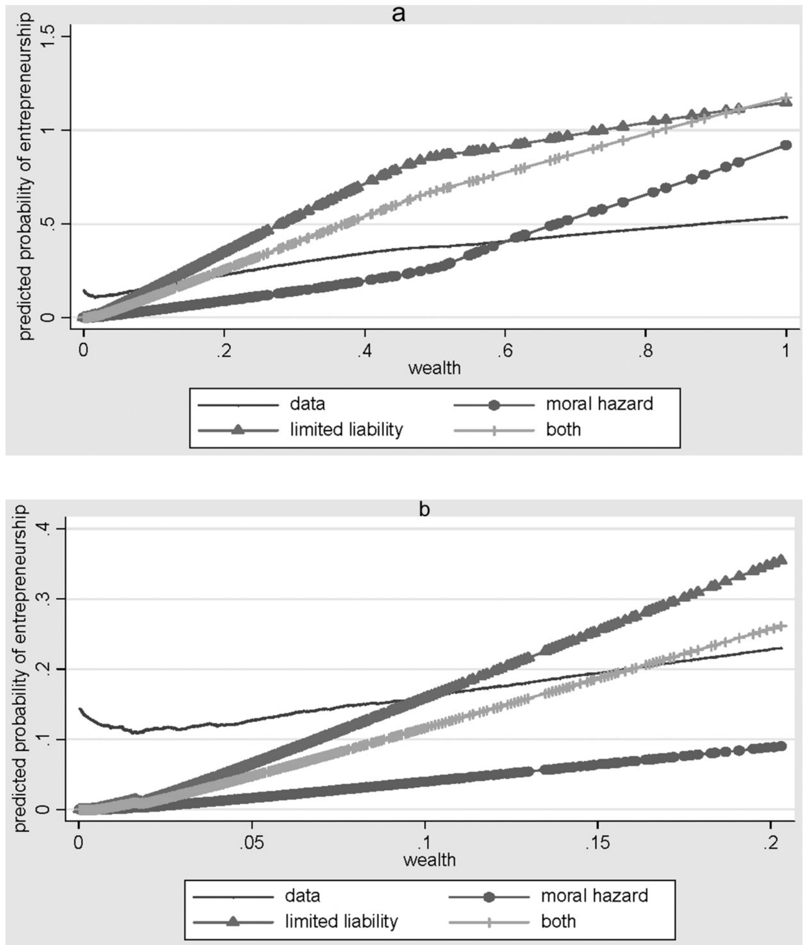

Fig. 4.—Predicted probability of entrepreneurship and wealth. *a*, Entire wealth domain. *b*, Fifth to ninety-fifth percentiles of wealth. Lowess estimates of the relationship between entrepreneurial status and wealth from survey data and entrepreneurial status assigned in benchmark structural estimates (moral hazard, limited liability, and both moral hazard and limited liability). Bandwidth = 0.8.

entrepreneur generated by the moral hazard regime is closest to the Thai data. Further, from figure 4*b*, one can see that while the moral hazard estimate underpredicts the percentage of entrepreneurs relative to most of the data, this estimate does a good job of matching the slope observed in the data. In other words, the moral hazard regime closely mimics the relatively constant observed rate of increase of entrepreneurship with wealth in the data.

In contrast, the limited-liability and the "both" estimates overestimate the rate of increase in entrepreneurship with wealth for the majority of households. Specifically, both of these regimes suggest that the rate of increase in entrepreneurship with wealth is highest among low-wealth households, and this slows down only when wealth reaches approximately 0.55, or nearly the ninety-ninth percentile of the wealth distribution (see fig. 4*a*). In comparison, the moral hazard estimate implies that entrepreneurship increases more modestly with wealth for almost all the wealth distribution and then increases sharply with wealth at the highest wealth levels. Some intuition is provided by an examination of figure 2, the risk-neutral case, and figure 3. Under limited liability, increases in wealth for constrained entrepreneurs sharply increase the level of capital with only a small variation in effort. In contrast, under moral hazard, capital is, on average, not moving much with wealth whereas effort increases, starting from a lower value. Evidently the moral hazard constraint is more damaging at low levels of wealth than limited liability is.

B. Nonparametric and Reduced-Form Evidence

In addition to comparing the financial regimes on the basis of the structural evidence about who will start a business as a function of wealth and talent, we can also use nonparametric and reduced-form techniques and additional variables to try to distinguish financial regimes. While none of the findings presented here is definitive on its own, taken together they reinforce the findings from the structural model comparisons: the financial market constraint is dominant because of moral hazard.

Limited liability and moral hazard have different implications for how borrowing will change with wealth, particularly for constrained business owners. Recall that constrained business households are those that report that their business would be more profitable if it were expanded and that 56 percent of the business households are "constrained" according to this definition. In the limited-liability case, constrained business owners have borrowed up to the maximum multiple of wealth allowed, so increases in wealth will necessarily lead to increased borrowing for these businesses. In the moral hazard case, the opposite is true: borrowing will decrease with wealth for constrained business owners. Business owners can relax the incentive compatibility constraint by borrowing less. We investigate these implications by examining the relationship between the likelihood of being a borrower and wealth and the level of net savings and wealth for constrained business households.

1. Nonparametric Evidence

Figure 5*a* summarizes the nonparametric relationship between the probability of being a borrower and wealth for constrained business households. Figure 5*b* reports on the predicted relationship between net savings and wealth for constrained business households. Both figures were produced using the same nonparametric techniques that were used to create figure 1. The domain of wealth is restricted to the fifth to the ninety-fifth percentiles. The dashed lines in the figures represent the twenty-fifth percentile and the seventy-fifth percentile bootstrap estimates of the relationship between borrowing and wealth and between net savings and wealth.

Turning first to figure 5*a*, we see that the probability of being a borrower decreases as wealth goes from zero to about 0.02. Approximately 60 percent of the survey households have wealth in this range. This relationship is consistent with moral hazard. As wealth goes from 0.02 to about 0.05, the likelihood of borrowing increases with wealth, as we would expect if limited liability constrained financial markets. This range corresponds to about 17 percent of the survey households. When wealth is greater than 0.08, the probability of borrowing again decreases with wealth, which would be expected if moral hazard were responsible for restrictions on financial contracts. This range accounts for about 9 percent of households. Thus for the majority of households in the Thai data, the relationship between borrowing and wealth is consistent with moral hazard, although we cannot rule out the possibility that limited liability also plays a role in shaping financial markets.

The relationship between the *level* of borrowing and, equivalently, net savings is examined in figure 5*b*. Here we see a similar pattern. As wealth goes from zero to 0.005, net savings increases, which we would expect if moral hazard were important. This range accounts for approximately one-third of households. As wealth goes from 0.005 to 0.09, net savings decrease or, equivalently, borrowing increases. This range is consistent with limited liability and corresponds to about 55 percent of households in the sample. When wealth is greater than 0.09, net savings again increases with wealth, and this range accounts for the remaining 12 percent of households. These estimates suggest that both moral hazard and limited liability may be important for explaining the data, with about half of the observations being consistent with each financial constraint. However, limited liability alone cannot account for the relationship between the likelihood of borrowing and borrowing levels and wealth described in figure 5.[38]

[38] Small sample sizes preclude us from creating regional versions of these estimates.

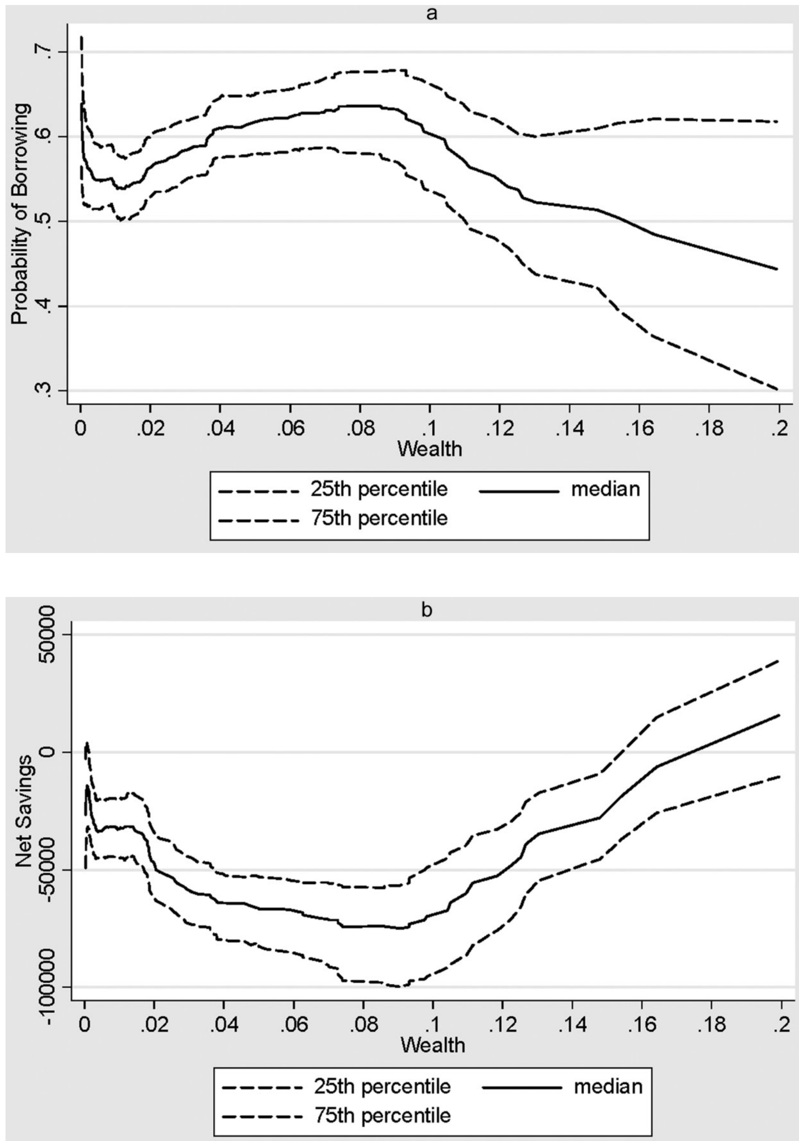

FIG. 5.—*a*, Lowess estimate of the probability of being a borrower for constrained business households. *b*, Lowess estimate of net savings and wealth for constrained business households. 500 bootstrap estimates of the relationship between being a borrower and wealth were created using a bandwidth of 0.8. The twenty-fifth percentile (dashed line), median (solid line), and seventy-fifth percentile estimates (dashed line) are shown in the figure. Note that the figure shows the relationship for the fifth to the ninety-fifth percentiles of wealth.

TABLE 5
PROBIT ESTIMATES OF BEING A NET BORROWER (Net Savings < 0), BUSINESS HOUSEHOLDS

	WHOLE SAMPLE		NORTHEAST		CENTRAL REGION	
	*dF/dx**	*Z*-Statistic	*dF/dx**	*Z*-Statistic	*dF/dx**	*Z*-Statistic
Constrained (= 1 if constrained, 0 otherwise)*	.0849	1.55	−.0491	−.48	.1321	1.97
Wealth six years ago†	−.0013	−.24	.1880	1.75	.0007	.12
Age of head	−.0115	−.82	−.0149	−.58	−.0116	−.67
Age of head squared	.0001	.65	.0001	.47	.0001	.49
Years of schooling—head	.0049	.47	−.0027	−.16	.0010	.07
Adult women in household	.0494	1.37	.1320	1.81	.0268	.62
Adult men in household	−.0701	−2.05	−.1838	−2.64	−.0334	−.82
Children (< 18 years) in household	.0344	1.47	.1338	2.63	.0059	.21
Observed frequency	.5457		.6066		.5146	
Predicted frequency at mean of X	.5483		.6367		.5153	
Log likelihood	−237.02		−70.50		−158.47	
Pseudo R^2	4.70%		13.79%		4.28%	
Observations	361		122		239	

NOTE.—Net savings is defined to be financial assets plus loans owed to household minus debt. Numbers in table are the estimated coefficient multiplied by 1 million. The sample excludes the top 1 percent of households by wealth. The estimates also include controls for past membership/patronage of various financial institutions and organizations.
* Dummy variables.
† Wealth six years ago is made up of the value of household assets, agricultural assets, and land.

2. Reduced-Form Evidence

Whole-sample findings.—We now turn to reduced-form parametric estimates to examine the relationship between borrowing and wealth and between net savings and wealth for constrained business households. Table 5 reports on probit estimates of whether entrepreneurial households borrow as a function of demographic controls, past use of various financial institutions, past wealth, and whether or not the household reports that its business is constrained. For the whole sample, these results suggest that constrained business households are 8.5 percentage points more likely to borrow than their unconstrained counterparts.

This finding is more consistent with moral hazard than with limited liability. When financial markets are characterized by moral hazard and incentive constraints bind, everyone who borrows will be constrained. In the limited-liability case, the relationship between borrowing and being constrained is much weaker. Some households that borrow will be able to invest the optimal amount of capital and will not be constrained, and others will not be able to borrow enough to invest the optimal amount and will be constrained.

Table 6 reports on the relationship between the extent of borrowing, or, equivalently, net savings, and wealth for constrained and unconstrained business households. This table includes regression estimates of net savings for business households as a function of various demographic controls and wealth for business households. The effect of wealth is allowed to differ depending on whether the business is constrained or not. For the whole sample, net savings is positively correlated (or, equivalently, borrowing is negatively correlated) with wealth for constrained businesses. A 1,000,000-baht increase in wealth for a constrained business would increase net savings (decrease borrowing) by 48,000 baht.

The same increase in wealth for an unconstrained business is predicted to increase net savings by 12,000 baht, and the coefficient on wealth for unconstrained businesses is not statistically different from zero. This is the relationship we would expect to see between net savings and wealth among constrained businesses if financial markets are characterized by moral hazard and households are risk neutral. By decreasing borrowing when wealth goes up, constrained businesses can relax the incentive compatibility constraint associated with moral hazard. If financial markets were characterized by limited liability, we would expect net savings to go down (borrowing to increase) with wealth for constrained businesses.

Regional findings.—The results for the central region favor moral hazard and are very similar to the results for the whole sample. The likelihood of being a borrower is predicted to be 13 percentage points higher among constrained business households in the central region (see table 5). Table 6 shows that a 1,000,000-baht increase in wealth is predicted to increase net savings by 48,000 baht in the central region, which we would expect if moral hazard were a concern.

According to the estimates reported in table 5, being constrained has no statistically significant effect on the likelihood of borrowing for businesses in the Northeast. When financial markets are characterized by limited liability, the probability of borrowing should not be related to wealth, which is consistent with the findings in table 5 for the Northeast. A much stronger case would exist if the point estimate for the effect of being constrained on the probability of borrowing were close to zero and precisely estimated. As it is, the precision of the estimate is consistent with the impact of being constrained having either a negative or a positive impact on the likelihood of borrowing in the Northeast.

We also find that the level of net savings is imprecisely related to wealth among constrained businesses in the Northeast (see table 6). We cannot rule out the possibility that an increase in wealth would be

TABLE 6
Regression Estimates of Net Savings, Business Households

	Whole Sample		Northeast		Central Region	
	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Wealth six years ago:						
Constrained business*	.048	4.32	−.004	.05	.048	3.63
Unconstrained business*	.012	1.42	.383	3.31	.012	1.19
Age of head	9,592.724	.52	5,639.596	.29	15,814.300	.60
Age of head squared	−93.922	−.56	−71.272	−.41	−161.393	−.68
Years of schooling (head)	−23,179.890	−1.67	−12,283.410	−.96	−28,433.790	−1.35
Adult women in household	−105,875.200	−2.18	−133,223.000	−2.59	−104,812.200	−1.56
Adult men in household	108,636.700	2.37	60,962.520	1.22	140,117.500	2.22
Children (< 18 years) in household	377,10.180	1.21	−60,660.900	−1.68	64,761.760	1.54
Constant	−234,535.400	−.48	121,595.300	.25	−461,081.300	−.65
Adjusted R^2	7.86%		9.94%		8.71%	
Observations	361		122		239	

Note.—Net savings is defined to be financial assets plus loans owned to household minus debt. Numbers in the table are estimated coefficients multiplied by 1 million. The sample excludes the top 1 percent of households by wealth.

† Wealth six years ago is made up of the value of household assets, agricultural assets, and land.

associated with a decrease in net savings (increase in borrowing), which we would expect if limited liability constrains financial markets. On the other hand, the results do not allow us to rule out the opposite either.

3. Summary of Nonparametric and Reduced-Form Evidence

Taken together, the nonparametric and reduced-form evidence indicates that limited liability alone cannot explain the observed relationship between borrowing and wealth and net savings and wealth. Figure 5 suggests that both moral hazard and limited liability have a role to play in explaining patterns of entrepreneurship in Thailand. The strength of the evidence in favor of moral hazard for the central region and the lack of evidence to distinguish moral hazard from limited liability in the Northeast provide independent confirmation of the patterns observed in the formal model comparison tests for the two regions.

VII. Conclusions and Discussion

Identifying the source of financial constraints that limit entry into entrepreneurship was a key objective of the paper. Nonparametric, reduced-form, and structural evidence all indicate that moral hazard is the key financial constraint that restricts entrepreneurship in Thailand. To the extent that limited liability plays a role in constraining entrepreneurs and potential entrepreneurs, it does so in conjunction with moral hazard.

The paper emphasizes different potential assumptions regarding the constraints on financial contracting. The model has common assumptions about utility, production, the distribution of talent, and error terms, regardless of financial constraints. Therefore, these aspects of the model do not account for the success of the moral hazard model in the structural estimates. In addition, nonparametric and reduced-form evidence, which is independent of assumptions regarding utility functions, production, talent, and errors, also points to moral hazard as the dominant financial market imperfection.

The issues raised in the paper contribute to the discussion of the desirability of policy interventions that are intended to alleviate financial constraints. In particular, the paper highlights the fact that the presence of financial constraints does not establish grounds for a policy intervention. Given the financial market imperfections, the existing set of contracts may be the optimal ones. Nonetheless, the findings suggest useful directions for policy discussions.

Currently the BAAC emphasizes joint liability lending groups for poor farmers. Our findings suggest that these groups, which may use superior information that villagers have about one another to mitigate moral hazard problems, could be usefully extended to more households. Indeed, we find some evidence that wealthier households that participate in BAAC borrowing groups may be less constrained in the central region (see Paulson and Townsend 2004), as though the BAAC were using these groups as a screening mechanism and channeling larger loans to individuals who are deemed acceptable group members by their peers. In contrast, a program to establish secure property rights in land (so that it could serve as collateral and overcome limited-liability constraints) might be a lower priority for much of Thailand. The main point is that a successful policy intervention must address the underlying financial market imperfection rather than its symptoms.

Our work suggests a number of fruitful avenues for future research. Clearly more work on the role of entrepreneurial talent is a priority. Success in this area is likely to require additional data to help pin down both the distribution of talent and its role in production. In addition, it would be valuable, from both a theoretical and an empirical perspective, to extend the cross-sectional framework and findings reported on here to a dynamic setting. Finally, it would be interesting to explore the extent to which the findings for Thailand generalize to other developing and developed countries.

References

Abbring, Jaap H., Pierre-André Chiappori, James J. Heckman, and Jean Pinquet. 2003. "Adverse Selection and Moral Hazard in Insurance: Can Dynamic Data Help to Distinguish?" *J. European Econ. Assoc.* 1 (April/May): 512–21.

Aghion, Phillippe, and Patrick Bolton. 1997. "A Theory of Trickle-Down Growth and Development." *Rev. Econ. Studies* 64 (April): 151–72.

Binford, Michael, Tae Jeong Lee, and Robert M. Townsend. 2001. "Sampling Design for an Integrated Socioeconomic and Ecologic Survey Using Satellite Remote Sensing and Ordination." Manuscript, Univ. Chicago.

Buera, Francisco. 2005. "A Dynamic Model of Entrepreneurial Choice with Borrowing Constraints." Manuscript, Northwestern Univ.

Cunha, Flavio, James J. Heckman, and Salvador Navarro. 2004. "Separating Uncertainty from Heterogeneity in Life Cycle Earnings." IZA Discussion Paper no. 1437, Inst. Study Labor, Bonn.

Evans, David S., and Boyan Jovanovic. 1989. "An Estimated Model of Entrepreneurial Choice under Liquidity Constraints." *J.P.E.* 97 (August): 808–27.

Fafchamps, Marcel. 1993. "Sequential Labor Decisions under Uncertainty: An Estimable Household Model of West-African Farmers." *Econometrica* 61 (September): 1173–97.

Giné, Xavier. 2005. "Access to Capital in Rural Thailand: An Estimated Model of Formal versus Informal Credit." Policy Research Working Paper no. 3502, World Bank, Washington, DC.

Giné, Xavier, and Robert M. Townsend. 2004. "Evaluation of Financial Liberalization: A General Equilibrium Model with Constrained Occupation Choice." *J. Development Econ.* 74 (August): 269–307.

Judd, Kenneth L. 1998. *Numerical Methods in Economics*. Cambridge, MA: MIT Press.

Karaivanov, Alexander. 2005. "Incomplete Financial Markets and Occupational Choice: Evidence from Thai Villages." Manuscript, Simon Fraser Univ.

Ligon, Ethan. 1998. "Risk Sharing and Information in Village Economies." *Rev. Econ. Studies* 65 (October): 847–64.

Lloyd-Ellis, Huw, and Dan Bernhardt. 2000. "Enterprise, Inequality and Economic Development." *Rev. Econ. Studies* 67 (January): 147–68.

Magnac, Thierry, and Jean-Marc Robin. 1996. "Occupational Choice and Liquidity Constraints." *Ricerche Economiche* 50 (June): 105–33.

Paulson, Anna L., and Robert M. Townsend. 2004. "Entrepreneurship and Financial Constraints in Thailand." *J. Corporate Finance* 10 (March): 229–62.

Phelan, Christopher, and Robert M. Townsend. 1991. "Computing Multi-period, Information-Constrained Optima." *Rev. Econ. Studies* 58 (October): 853–81.

Prescott, Edward C., and Robert M. Townsend. 1984. "Pareto Optima and Competitive Equilibria with Adverse Selection and Moral Hazard." *Econometrica* 52 (January): 21–45.

Townsend, Robert M. [principal investigator], with Anna L. Paulson, Sombat Sakuntasathien, Tae Jeong Lee, and Michael Binford. 1997. "Questionnaire Design and Data Collection for NICHD Grant 'Risk, Insurance and the Family' and NSF Grants." Manuscript, Univ. Chicago.

Vuong, Quang H. 1989. "Likelihood Ratio Tests for Model Selection and Non-nested Hypotheses." *Econometrica* 57 (March): 307–33.

Wolak, Frank A. 1994. "An Econometric Analysis of the Asymmetric Information, Regulator-Utility Interaction.." *Annales d'Economie et de Statistique*, no. 34 (April–June): 13–69.