Financial market imperfections shape economic outcomes in many areas.

Many papers posit a particular financial market imperfection and exclude the possibility of alternative sources of imperfections.

**Goal Here**: Identify the source of financial constraints that limit entry into entrepreneurship.

Use structural, nonparametric, and reduced-form techniques to distinguish the source of financial market imperfections using microeconomic data from Thailand.

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.
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.

In a limited-liability environment, constrained entrepreneurs borrow 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.
Goal: 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.

Also consider the possibility that both are important.

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 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.

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.

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)

**The Conclusion**: 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.
Fig. 1.—Lowess estimates of the probability of being an entrepreneur and wealth. Five hundred 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.
Households are assumed to derive utility, $U$, from their own consumption, $c$, and disutility from effort, $z$:

$$U(c, z) = \frac{c^{1-\gamma_1}}{1-\gamma_1} - \kappa \frac{z^{\gamma_2}}{\gamma_2}$$  \hspace{1cm} (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 $\gamma_1 = 0$.

Reintroduce risk aversion in the presentation of the linear programming problem that forms the basis for the structural estimation.
Three sources of household heterogeneity in the model: initial wealth, $A$, entrepreneurial talent, $\theta$, and years of education, $S$.

All these variables are determined ex ante and can be observed by all the agents in the model.

Wealth is normalized to lie in the interval $(0, 1]$.

Talent is lognormally distributed. Specifically,

$$\ln \theta = \delta_0 + \delta_1 \ln(A) + \delta_2 \ln(1 + S) + \eta$$

(2)

where $\eta$ is normally distributed with mean zero and variance $\sigma^2_\eta = 1$. 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 $\delta_1$. Talent may also be correlated with formal education via $\delta_2$. 
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, $\theta$. The technology is stochastic and is written $P(q = \theta | z, k > 0)$, the probability of achieving output $q$ given effort $z$ and capital $k$.

\[
P(q = \theta | z, k > 0) = \frac{k^\alpha z^{1-\alpha}}{1 + k^\alpha z^{1-\alpha}}
\]

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.

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.

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.

For simplicity, assume intermediations are risk neutral and care only about expected profits.
In sum, when agents are risk neutral, the planner makes an effort recommendation, $z$, and a capital recommendation, $k$ to solve

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

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

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

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 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:

\[ r(A, \theta) \frac{k^\alpha z^{1-\alpha}}{1 + k^\alpha z^{1-\alpha}} = r \quad \text{for} \quad k > A, \forall \theta, \forall A \]  

(5)

NOTE: This contracting problem is in partial equilibrium, in that the wage \( w \) and interest rate \( r \) are fixed from the outside and taken as given here.
Financial Environment

- When financial markets are “first-best” and are subject to neither limited liability nor moral hazard, no further constraints are imposed.

- **Limited liability**— 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 $\lambda A$, and the maximum amount that a household can borrow is investment minus wealth, or given by $(\lambda - 1)A$, that $k - A = \lambda A - A = (\lambda - 1)A$.

- When limited liability is a concern, the planner’s maximization problem will be subject to

  $$ k \leq \lambda A \quad (6) $$

- 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.

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

which is an entrepreneurial household’s first-order condition for effort, \(z\), for a given interest rate schedule and capital, \(k\).

Differentiate equation (4) with respect to \(z\).
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 assumed not an issue for wage workers and also entrepreneurs who self-finance. The planner can assign effort to them, the latter 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.** — the possibility that credit markets are characterized by both moral hazard and limited liability.

Modeled by assuming that the entrepreneurial choice problem is subject to both equation (6) and equation (7) in addition to equation (5).
Characterization of Solutions

- Risk-neutral case.—Figure 2

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 $\lambda = 2.50$. 
The Linear Programming Problem

- Restate the occupational choice problem faced by an agent with wealth $A$, schooling $S$, and entrepreneurial talent $\theta$ 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 $(\theta, A, S)$ 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.
The first constraint, equation (8) below, 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) below, 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) below, 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.
The linear programming approach allows us to use a set of well-known maximization routines in the structural estimation.

Solve the following linear programming problem:

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

(LP)

subject to

$$\sum_{c} \pi(c,q,z,k | \theta, A, S) = \tilde{p}(q | z, k, \theta) \sum_{c,q} \pi(c,q,z,k | \theta, A, S)$$  

for all $q, z, k$  

(8)

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

(9)
\[
\sum_{c,q} \pi(c, q, z, k \mid \theta, A, S) U(c, z) \geq
\]

\[
\sum_{c,q} \pi(c, q, z, k \mid \theta, A, S) \frac{\tilde{\rho}(q \mid z', k, \theta)}{\tilde{\rho}(q \mid z, k, \theta)} U(c, z')
\]

for all \( k > 0, z, z' \neq z \) \hspace{1cm} (10)

and

\[
\sum_{c,q,z,k} \pi(c, q, z, k \mid \theta, A, S) = 1 \hspace{1cm} (11)
\]

- The function \( \tilde{\rho}(q|z, k, \theta) \) defines the probability of output \( q \), given effort, capital, and entrepreneurial talent.
- The derivation of equation (10) is in Prescott and Townsend (1984, *Econometrica*), p. 28
3. Solve for the optimal contract, \( \pi^*(c, q, z, k|\theta, A, S) \), using a call to the linear programming commercial library CPLEX 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 \( 1 - \pi^E(\theta, A, S) \).
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. 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, 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 $\lambda > 0$.

In the final specification, both limited liability and moral hazard, we assume that effort is unobservable and that investment must be less than $\lambda A$.

The contract elements $c$, $q$, $z$, and $k$ are assumed to belong to the finite discrete sets $C$, $Q$, $Z$, and $K$, respectively. These sets, which are represented for computational purposes by grids of real numbers, are defined in more detail below.
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, $\theta$, education, $S$, and initial wealth, $A$.
- **Stage 2:** Construct the likelihood function from the solutions of the stage 1 problems for the occupational choices, given 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.
Construct the Likelihood Function-I

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 $\tilde{\pi}^F(A, S)$ 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 $H(A_i|\psi)$, 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 seconds per likelihood evaluation, depending on the regime. The log likelihood function is given by

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

Across the financial regimes, in

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<th>Limited Liability</th>
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D. Risk Aversion, Estimated Talent

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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.

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.

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 so related to wealth, which is consistent with the findings for the Northeast.
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, $K$, 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), $\theta$ (entrepreneurial success), and one (success in wage work).

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.
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

\[
\ln \theta = \delta_0 + \delta_1 \ln A + \delta_2 \ln (S + 1) + \eta,
\]

where \(\eta\) 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:\(^{15}\)

\[
\tilde{\pi}^E(A, S) = \int_{-\infty}^{\infty} \pi^E(\theta, A, S) d\phi(\eta).
\]

Since the linear programming stage 1 is costly in terms of computation time,\(^ {16}\) we cannot afford to compute \(\tilde{\pi}^E(A, S)\) 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, \(A\).\(^ {17}\) The function \(\tilde{\pi}^E(A, S)\) is computed only at these 20 grid points.
The general idea of the algorithm is to obtain the probability of being an entrepreneur for given model parameters and input data, \( \theta, S, \) and \( A \) in stage 1, and then integrate over entrepreneurial ability \( \theta \), 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.

Details the procedures followed in each of the above stages.