Federal Reserve Bank of Chicago

Distinguishing Limited Liability from Moral Hazard in a Model of Entrepreneurship*

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Abstract

We present and estimate a model where the choice between entrepreneurship and wage work may be influenced by financial market imperfections. The model allows for limited liability, as in Evans and Jovanovic (1989), moral hazard, as in Aghion and Bolton (1996), 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 semi-urban households in Thailand. Structural, non-parametric and reduced form estimates provide independent evidence that the dominant source of credit market imperfections is moral hazard. We reject the hypothesis that limited liability alone can explain the data.

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1 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, non-parametric 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, holding constant the characteristics of potential entrepreneurs. A strong positive correlation between becoming an entrepreneur and beginning-of-period wealth can be seen in the non-parametric 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.

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, who 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 U.S. and for France, respectively. 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 (1996). Since entrepreneurial effort is unobserved and repayment is only feasible 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[2].

The model that we estimate takes into account entrepreneurial talent, allows investment

[1]For each observation in Figure 1, a weighted regression is performed using 80% (bandwidth = 0.8) of the data around that point. The data are weighted using a tri-cube 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% of the sample.

[2]This is true if the moral hazard enviroment does not produce the same solution as the first best which is generally the case.

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 pre-existing 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 depends on the financial market imperfection. In particular, if limited liability constraints 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 if 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.[3] 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 Wolak (1994) and Fafchamps (1993). The structural model comparison tests are augmented with non-parametric 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, Chiappori, Heckman and Pinquet (2002) use dynamic data to distinguish moral hazard from adverse selection in the insurance context. Their work takes the insurance contract as given, based on 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 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% of whom run their own businesses.[4] The sample focuses on households living in two distinct regions of the country: rural and semi-urban households living in the central region, close to Bangkok, and more obviously rural households living in the semi arid and much poorer northeastern region.[5] The data include current

[3]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 non-parametric findings reject this possibility.

[4]For esimation purposes, the data are restricted to households who have non-zero wealth and who either currently own a business that was founded in the five years prior to the survey (14%) or who have no business at the time of the survey (86%).

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

and retrospective information on wealth (household, agricultural, business and financial), occupational history (transitions to and from farm work, wage work and entrepreneurship), as well as access and use of a wide variety of formal and informal financial institutions (commercial banks, agricultural banks, village lending institutions, 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, as well as on reduced form and non-parametric estimates, which use data on wealth, entrepreneurial status, net savings, as well as other important household characteristics. The formal financial regime comparison tests are necessarily only informative about the relative success of a given financial regime for the particular set of assumptions regarding preferences, technology etc. that are imposed by the model. In contrast, the reduced form and non-parametric 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 the next section, the model and the financial constraints are presented. Section three describes the computational algorithm for the structural maximum likelihood estimation. Section four describes the data. Section five reports on the structural maximum likelihood parameter estimates. In section six, we determine which financial regime best fits the data using structural, reduced form and non-parametric techniques. The final section concludes and suggests directions for future research.

2 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.

2.1 Economic Environment

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

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

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 non-negative.

In discussing the implications of the model, we begin by assuming that agents are risk neutral, in other words that γ_1 is equal to zero. 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 of these variables are determined ex ante and can be observed by all of the agents in the model.[6] Wealth is assumed to lie in the interval $(0, 1]$. We assume talent is log normally distributed. Specifically:

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

where η is normally distributed with mean zero and variance σ_η. 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:[7]

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

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 $\frac{z}{1+z}$ and equal to zero with the residual probability.[8]

All households are price-takers and take the gross cost of borrowing, $r(A, \theta)$, which may vary with wealth and entrepreneurial talent, as given. 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 if 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.

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

$$\underset{z,k}{Max}\left\{\begin{array}{c} w\frac{z}{1+z} - \kappa\frac{z^{\gamma_2}}{\gamma_2} + \ rA, \text{ if } k = 0 \\ \theta\frac{k^\alpha z^{1-\alpha}}{1+k^\alpha z^{1-\alpha}} - \kappa\frac{z^{\gamma_2}}{\gamma_2} + r(A-k), \text{ if } k > 0, k \leq A \\ \theta\frac{k^\alpha z^{1-\alpha}}{1+k^\alpha z^{1-\alpha}} - \kappa\frac{z^{\gamma_2}}{\gamma_2} - r(A,\theta)(k-A)\frac{k^\alpha z^{1-\alpha}}{1+k^\alpha z^{1-\alpha}}, \text{ if } k > 0, k > A \end{array}\right\} \tag{4}$$

[6] The complications in estimation that arise from the fact that the econometrician cannot observe θ are addressed in Section 3.

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

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

As one can see above, agents have three possibilities: 1) wage work 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 only repaid when the project is successful. The planner's problem is subject to a constraint which guarantees that the expected rate of repayment on such loans covers the cost of outside funds, so that lenders break even:

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

2.2 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.[9] 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

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

represents the marginal impact of effort on loan repayment, through the effect of effort on the probability that an entrepreneurial project will be successful: $\frac{k^\alpha z^{1-\alpha}}{1+k^\alpha z^{1-\alpha}}$.

Note that when agents are risk neutral, moral hazard is only an issue 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).

2.3 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.[10] 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 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 where 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 agents 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.

[10] A wealth level of 0.1 corresponds to the 89th percentile of wealth in the data. Figure 2 shows the optimal assignment of effort and capital for an entrepreneurial household assuming that α is equal to 0.78, κ is 0.08, γ_2 is equal to one and λ is equal to 2.5. These parameter values are within the range of the values produced by the structural estimation.

Special Cases The risk neutral model described above includes special cases which have been studied in the literature. For example, 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 that 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. Holding wealth fixed, more talented entrepreneurs are more likely to be constrained. Entrepreneurial households who face a binding limited liability constraint will borrow and invest *more* when wealth increases.

We can also use our framework to generate the model of Aghion and Bolton (1996). Assume that capital can be either 0 or 1. 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 γ_2 is equal to two, 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.

2.4 The Linear Programming Problem

In this section, 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", while agents assigned a positive level of investment are called "entrepreneurs". Agents may now be risk averse, with risk neutrality embedded as a special case.

Non-convexities 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 program 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:

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

s.t.

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

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

$$\sum_{c,q} \pi(c,q,z,k|\theta,A,S)U(c,z) \geqq \sum_{c,q} \pi(c,q,z,k|\theta,A,S) \frac{\tilde{p}(q|z',k,\theta)}{\tilde{p}(q|z,k,\theta)} U(c,z') \tag{10}$$

$$\text{for all } k > 0, z, z' \neq z$$

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

The function $\widetilde{p}(q|z,k,\theta)$ 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 equation (3), but here it is conditioned on θ as well as 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, $\widetilde{p}(q|z,k,\theta)$, 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 which 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, i.e. 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,k are assumed to belong to the finite discrete sets C,Q,Z,K respectively. These sets, which are represented for computational purposes by grids of real numbers, are defined in more detail below.

3 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.

3.1 Solve the Linear Programming Problem

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

- Create grids for c, q, z, 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, 0 (entrepreneurial failure), θ (entrepreneurial success) and 1 (success in wage work).[11]
- 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 as they do not bind at the solution.

[11] 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 $\pi' s$) 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.

- Solve for the optimal contract, $\pi^*(c,q,z,k|\theta,A,S)$ using a call to the linear programming commercial library CPLEX[12] and obtain the probability of being 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.

3.2 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:[13]

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

Since the linear programming stage 1 is costly in terms of computation time[14], we cannot afford to compute $\bar{\pi}^E(A,S)$ at all possible combinations of A and S (more than 2000) 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.[15] 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 entrepreneur, predicted by the model, for an agent with wealth A_i in the data, which we denote by $H(A_i|\psi)$[16], where

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

[13] The numerical integration method used is Gauss-Legendre quadrature with 5 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 of it has desirable asymptotic properties.

[14] 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.

[15] The log-spaced grid takes into account that the actual wealth data is 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 of 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 as more information is used in the non-parametric regression to compute the education values corresponding to the wealth grid points.

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

$\psi \equiv (\gamma_1, \gamma_2, \kappa, \alpha, \delta_0, \delta_{1,} \delta_2, \lambda)$ 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:

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

In the above equation n is the number of observations, E_i is a binary variable, which takes the value of 1 if agent i is entrepreneur in the data and 0 otherwise, and A_i is the wealth level of agent i (again from the data).

3.3 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.[17]

The riskless gross interest rate is assumed to be 1.1. In comparison, the net annual interest rate on collateralized loans to individuals from the Bank for Agriculture and Agricultural Cooperatives (BAAC) is roughly 13% in the data and interest rates on loans from commercial banks, the vast majority of which are collateralized, average 22%. In addition, there are many informal loans, often between relatives, where the reported interest rate is zero.[18] The relevant interest rate for the model is a riskless one, where default is 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 which maximizes L.[19] The best parameter configuration from the grid search is then taken 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]

4 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

[17]In some specifications only a subset of these parameters is estimated. Section 5 reports on the parameter estimates for each specification.

[18]For further details see Giné (2005).

[19]The grid search is computationally time intensive and can take up to 2-3 days depending on the number of estimated parameters.

[20]This latter procedure solves the non-linear 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 2.5-7 hrs 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 3-4 days for each estimated parameter configuration.

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 twelve geographic areas (tambons) was selected.[22] 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 fifteen households was interviewed.

The businesses we study are quite varied and include shops and restaurants, trading activities, raising shrimp or livestock and the provision of construction or transportation services.[23] While there are many different types of businesses, shrimp and/or fish raising, shops and trade account for 70% of the businesses in the whole sample and make up a similar percentage of the businesses in each region. Median initial investment in the households business 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 Northeast and the central region. In the Northeast, the median initial investment in trade is 21,000 baht compared to 23,000 baht in the central region.[24] 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% of the businesses paid anyone for work during the year prior to the survey.[25] More than 60% of the businesses were established in the past five years. In the empirical work we restrict our attention to these businesses.[26] Savings (either in the form of cash or through asset sales) is the most important source of initial business investment. Approximately 60% of initial investment in household businesses comes from savings. Loans from commercial banks account for about 9% of initial business investment and the Bank for Agriculture and Agricultural Cooperatives (BAAC) accounts for another 7%. 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 non-business households. The current median income of business households is about twice that of non-business

[22] A tambon typically includes 10 - 12 villages.

[23] 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 taken 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.

[24] Median investment in shrimp and/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. This is because shrimp farming, which requires substantial initial investment, is concentrated in the central region, while fish farms are more important in the Northeast.

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

[26] 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% 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 5 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 start businesses more than five years ago.

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 as well as prior to starting a business, compared to their non-business 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 non-business households that are used in the structural maximum likelihood estimates and the business household information that is used in the reduced form and non-parametric analysis. The wealth variable measures the value of real, non-financial 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.[27]

In addition to using data on past wealth, entrepreneurial status, and years of education, the reduced form and non-parametric analyses make use of additional data on the demographic characteristics of the head of the business household (age, age-squared) and on characteristics of the household (the number of adult males, adult females and children in the household). All of 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 non-parametric 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, being subject to a binding limited liability or incentive compatibility constraint. For example, of the businesses who reported that they were constrained, 37% said that they had not expanded their business because they lacked sufficient funds to do so. Another 30% said that they did not have enough land to expand. An additional 13% reported that they lacked time or labor for expansion.

[27] 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% 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 data 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 ten years and the current value of that plot is 100,000 baht, then six years ago the value of that plot will also be 100,000 baht (in 1997 baht). In addition land purchase and sale information is used to measure the value of land that a household owned in the past.

5 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 as well as assignments of capital, effort, and consumption for each agent.

Most of the structural estimates are produced assuming that the talent parameters, δ_0, $\delta_{1,}$ 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% increase in wealth raises entrepreneurial talent by 0.6%. The parameter δ_2 is set equal to 0.125, which means that a 10% increase in years of schooling increases entrepreneurial talent by 1.25%. 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 based on the observed income of entrepreneurs relative to non-entrepreneurs. Ignoring the scaling required to ensure that probabilities lie between 0 and 1, the model implies that the output 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. Mapping from the data back into the model, this implies that the median entrepreneur has a θ of 2.56. Using 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%. 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

[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.

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

incomplete since direct data on the distribution, let alone the level, of entrepreneurial talent is not available.[30] Therefore, we allow estimated talent parameters to vary freely with the financial regimes and compare these estimates with estimates where 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 relationships between capital, effort, consumption and wealth for entrepreneurs in the benchmark case are described in Figure 3.

5.1 Parameter Estimates

Across the financial regimes, in the benchmark case (Panel 1 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% increase in business investment would lead to a 4.2% to 5.1% 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% chance of success in the moral hazard case, 41% in the limited liability case and 33% when both moral hazard and limited liability are a concern. These figures are relatively low partly due to the normalization that ensures the probability of success will always lie between 0 and 1 (see equation (3)). When we ignore the normalization, the probability of success is 47% in the moral hazard case, 71% in the case of limited liability and 49% when both limited liability and moral hazard are important. By comparison, survey data from Thailand suggest that 67% 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 2 of Table 2). Comparing the benchmark income method (Panel 1) with the estimates where talent parameters are estimated (Panel 4), 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 3), the estimates produce values of α that are close to one for the moral hazard and limited liability case. With these assumptions, the predicted probability of entrepreneurial success is 46% for moral hazard, 42% for limited liability and 36% 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

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

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 3). In the case of moral hazard alone, γ_1 is equal to 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 4).

There are two parameters that determine the disutility of effort, κ and γ_2 (see equation (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 from 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 Figure 3). Entrepreneurs are assigned higher levels of effort in the limited liability financial regime compared to the regime where moral hazard is also a concern. There is some tendency for the structural estimation to produce parameters which 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 to 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 3 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 2 (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 where λ is estimated.[31]

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.[32] On the other hand, there are also

[31] These estimates are available from the authors.

[32] Land is the most common source of collateral and indivisibilities in land may account for some of the very low loan to 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 they use as collateral, the loan to collateral ratio will be 0.1.

many unsecured loans in the data. That is, there are many loans where λ would appear to be infinite.

As discussed above, in the first three sets of estimates, the parameters which describe the relationship between entrepreneurial talent and wealth and schooling are held fixed at $\delta_1 = 0.06$, $\delta_2 = 0.125$. 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 4 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. 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%. 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% in the case of moral hazard alone and by 8% 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 of the financial regimes in the benchmark "income" case and about 3.9 in the "% entrepreneur" case.

5.2 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 2, the simulations were performed at all actual wealth and schooling levels from the data, i.e. no splines were used, unlike in 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 as well as 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.

Turning first to 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° line. Capital assignments above the 45° 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, as 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, who have lower talent and lower wealth, has investment that first declines with wealth and then increases with wealth. The range where investment decreases when wealth increases is also a range where borrowing is decreasing, which has the effect of relaxing the incentive compatibility constraint. The range where investment increases with wealth is a range where 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 as 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° 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 where 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[33]. In addition, although this cannot be seen in the figure, the low wealth, high effort group tends to have greater entrepreneurial talent on average compared to 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% 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 compared to 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 mimics the situation when there is only moral hazard.

[33]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.

6 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, non-parametric 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 non-parametric 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 non-parametric 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.

6.1 Structural Evidence

In this sub-section, we provide formal tests of which of the candidate financial regimes best fit the whole sample and the various sub-samples 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.[34]

We use the Vuong test for strictly non-nested 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 where financial markets are characterized by only moral hazard. This is because 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 and "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 non-nested, overlapping or nested. However, the asymptotic distribution of the test statistic depends on the relationship between the models.[35] Using the distribution that is appropriate for

[34] One could use the same procedure where 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.

[35] 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-squared distribution. In the case of non-nested models the test statistic is normally distributed.

non-nested models is the conservative choice, in the sense that is makes it more difficult to statistically distinguish the financial regimes.

6.1.1 Whole Sample Findings

Tables 3A - C report 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 where the talent parameters are estimated). The likelihoods are reported for the whole sample (3A), the Northeast (3B) and the central region (3C). The results of the comparison tests for the three possible financial regimes, moral hazard, limited liability and both, are provided in Tables 4A B and C, for the whole sample, Northeast and central region, respectively.

For the whole sample, the case where moral hazard alone describes financial markets significantly outperforms the limited liability case and the case where financial markets are characterized by both moral hazard and limited liability. 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 which use the relative income of entrepreneurs and non-entrepreneurs to fix the mean of the talent distribution.[36]

When the estimation also produces estimates of the talent parameters (the fourth row), the distinction between the moral hazard and the both case 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.

6.1.2 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% of all funds lent. Other formal lenders account for only 11% of lending. In the Central region lending is much more dispersed. The BAAC accounts for 24% of lending. Commercial banks and relatives account for another 21% and 17% of lending, respectively.

Despite these regional differences, the comparisons of the financial regimes for the Northeast and the Central region in Tables 4B and C reinforce the findings for the whole sample.

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

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.

6.1.3 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 a 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% or the bottom 5% 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 where both moral hazard and limited liability are a concern.

Identification of Business Households We return now to the issue of whether the assignment of entrepreneurial and non-entrepreneurial 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 where 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.

6.1.4 Summary of Structural Evidence

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

Figures 4A and B compare 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. These figures also include non-parametric 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 non-parametric relationship between

[37]Specifically, we computed versions of the model with 5 grid points for efffort, versions with 10 grid points for investment, as well as versions with higher upper bounds on the grids for effort and investment (10 instead of 5).

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 Figures 4A and 4B is the non-parametric estimate of the relationship between the survey reports of entrepreneurial status and wealth. For each structural estimate and the data, non-parametric estimates of the relationship between entrepreneurship and wealth were produced using the same techniques as Figure 1 (see footnote 1 for details).

Figure 4A shows what happens to the likelihood of starting a business over the entire domain of wealth and Figure 4B restricts the wealth domain to the 5th through the 95th percentile. 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.

Looking first at Figure 4A, it appears that the predicted probability of being an entrepreneur generated by the moral hazard regime is closest to the Thai data. Further from Figure 4B, 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 over-estimate 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 99th percentile of the wealth distribution (see Figure 4A). In comparison, the moral hazard estimate implies that entrepreneurship increases more modestly with wealth for almost all of 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 small variation in effort. In contrast, under moral hazard, capital is on average not moving much with wealth while effort increases, starting from a lower value. Evidently the moral hazard constraint is more damaging at low levels of wealth than is limited liability.

6.2 Non-parametric and Reduced Form Evidence

In addition to comparing the financial regimes based on the structural evidence about who will start a business as a function of wealth and talent, we can also use non-parametric 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 dominant financial market constraint is due to 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% 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.

6.2.1 Non-parametric Evidence

Figure 5A summarizes the non-parametric relationship between the probability of being a borrower and wealth for constrained business households. Figure 5B reports on the predicted the relationship between net savings and wealth for constrained business households. Both figures were produced using the same non-parametric techniques that were used to create Figure 1. The domain of wealth is restricted to the 5th to the 95th percentile. The dashed lines in the figures represent the 25th percentile and the 75th percentile bootstrap estimates of the relationship between borrowing and wealth and between net savings and wealth.

Turning first to Figure 5A, we see that the probability of being a borrower decreases with as wealth goes from 0 to about 0.02. Approximately 60% 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% of the survey households. When wealth is greater than 0.08, the probability of borrowing again decreases with wealth as would be expected if moral hazard was responsible for restrictions on financial contracts. This range accounts for about 9% 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, or, equivalently, net savings, is examined in Figure 5B. Here we see a similar pattern. As wealth goes from 0 to 0.005, net savings increases, as 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% 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% 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 Figures 5A and B.[38]

6.2.2 Reduced Form Evidence

Whole Sample Findings We now turn to reduced form parametric estimates to examine the relationship between the borrowing and wealth and between net savings and wealth for constrained business households. Table 5A 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

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

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 who 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 5B 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 5A). Table 5B shows that a 1,000,000 baht increase in wealth is predicted to increase net savings by 48,000 baht in the Central region, as we would expect if moral hazard were a concern.

According to the estimates reported in Tables 5A, 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 5A 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 5B). We cannot rule out the possibility that an increase in wealth would be associated with a decrease in net savings (increase in borrowing) as 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.

6.2.3 Summary of Non-parametric and Reduced Form Evidence

Taken together the non-parametric and reduced form evidence indicate that limited liability alone cannot explain the observed relationship between borrowing and wealth and net savings and wealth. Figures 5A and B suggest 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.

7 Conclusions and Discussion

Identifying the source of financial constraints that limit entry into entrepreneurship was a key objective of the paper. Non-parametric, 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 is 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, non-parametric and reduced form evidence, which is independent of assumptions regarding utility functions, production, talent and errors, also points to moral hazard being 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 who 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.

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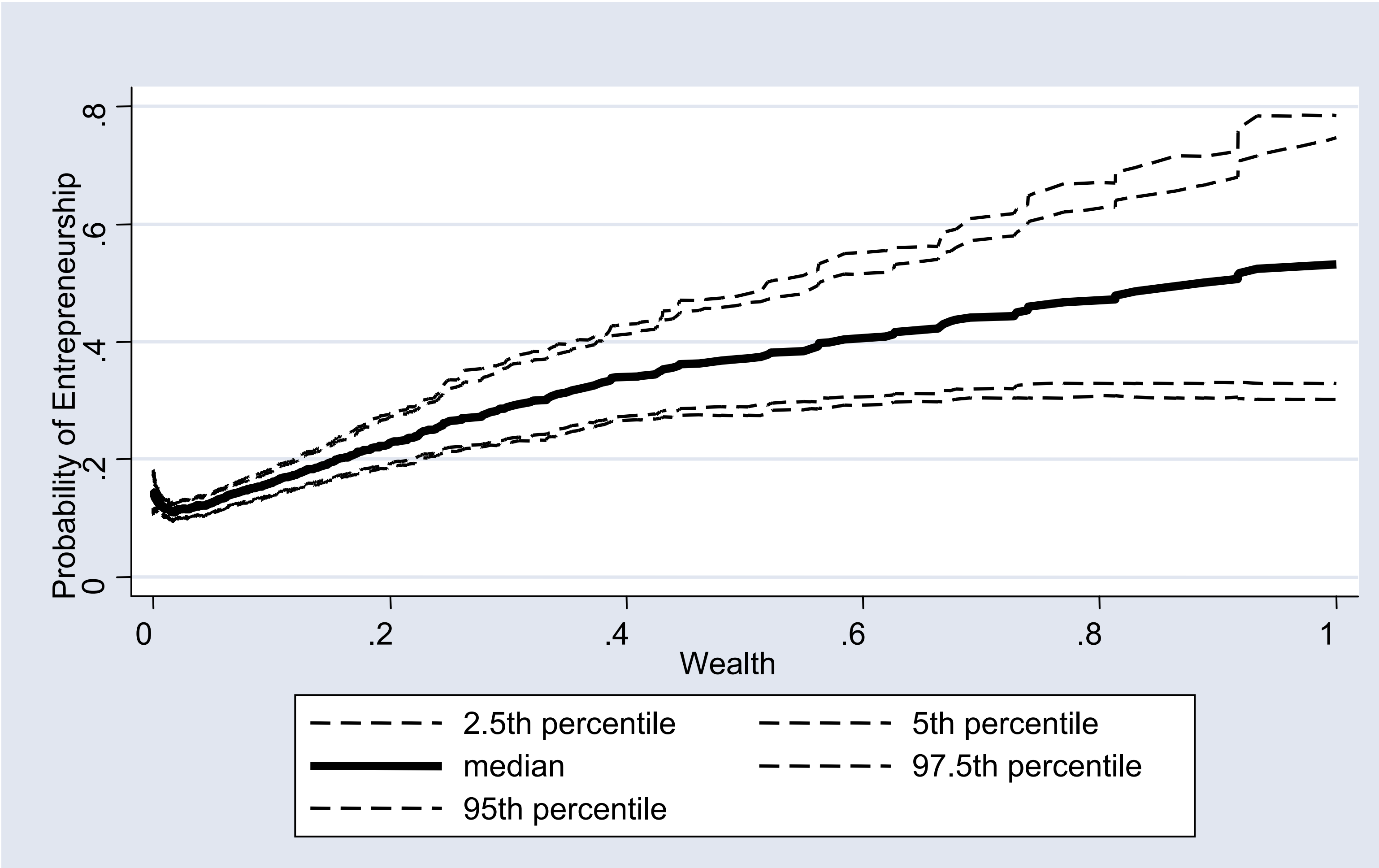

Figure 1: Lowess Estimates of the Probability of Being an Entrepreneur and Wealth

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), 5th percentile (dashed line) median (solid line), 95th percentile (dashed line) and 97.5th percentile (dashed line) estimates are shown in the figure.

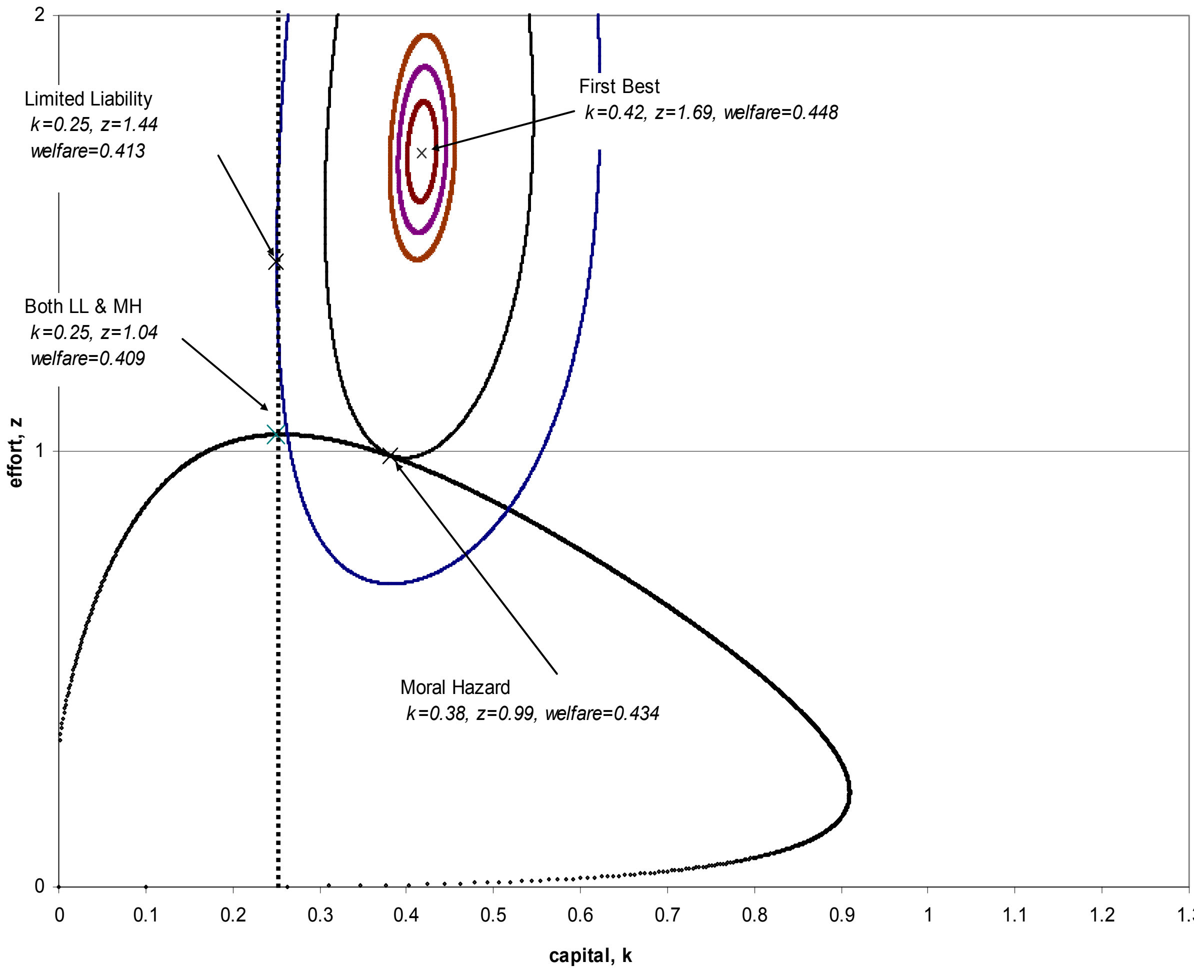

Figure 2: Assignments of Capital (k) and Effort (z) for the Entrepreneurs in the Risk Neutral Model Moral Hazard, Limited Liability and Both Moral Hazard and Limited Liability

assumptions: θ=2.56, A = 0.10, α=0.78, κ=0.08, γ2=1.00, r=1.10, λ = 2.50

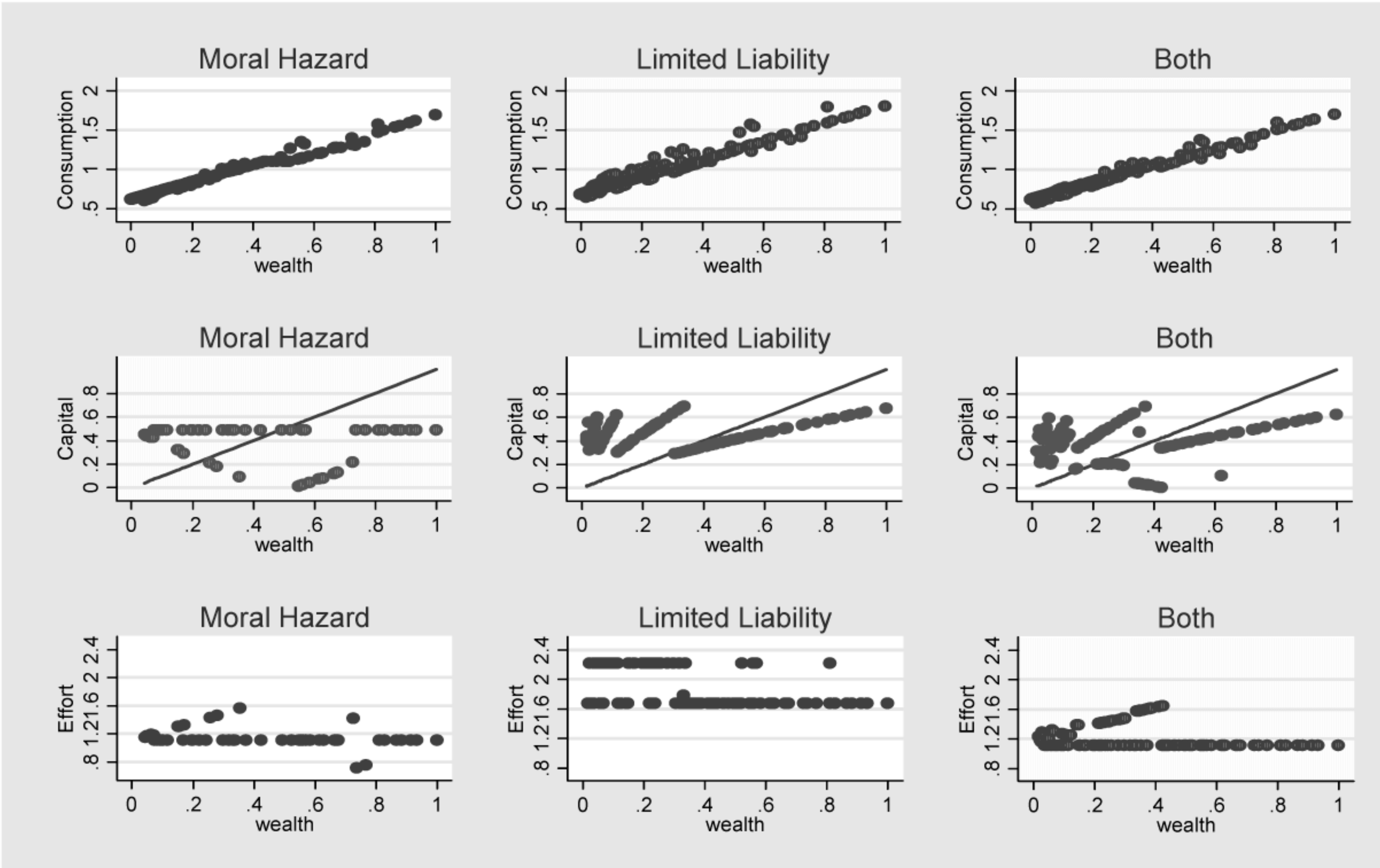

Figure 3: Expected Assigned Consumption, Capital and Effort Relative to Wealth for Entrepreneurs

From Benchmark Structural Estimates of Moral Hazard, Limited Liability and both Moral Hazard and Limited Liability Financial Regimes

Note: 45º Line is included in Capital Figures

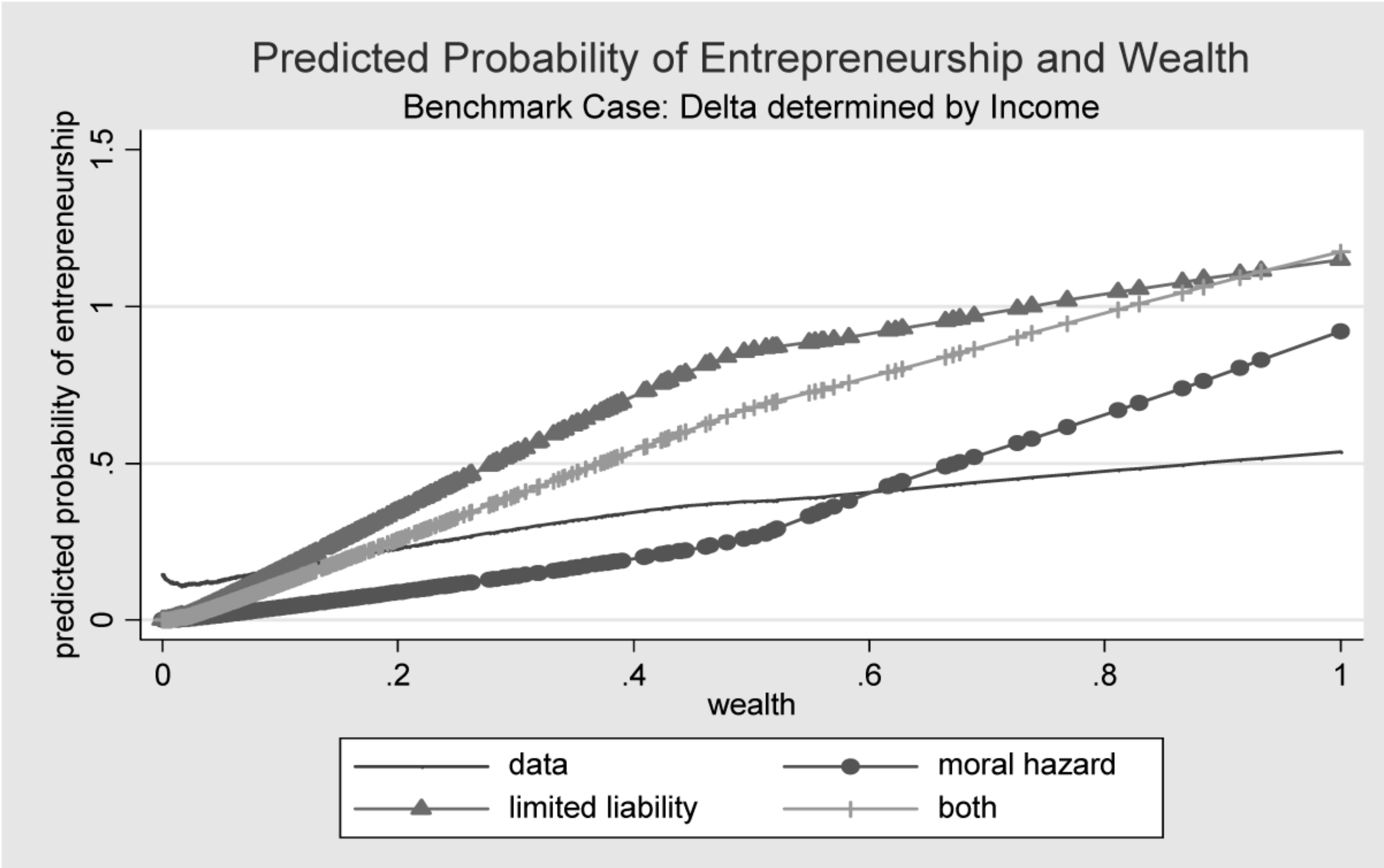

Figure 4A: Predicted Probability of Entrepreneurship and Wealth,

Entire Wealth Domain

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

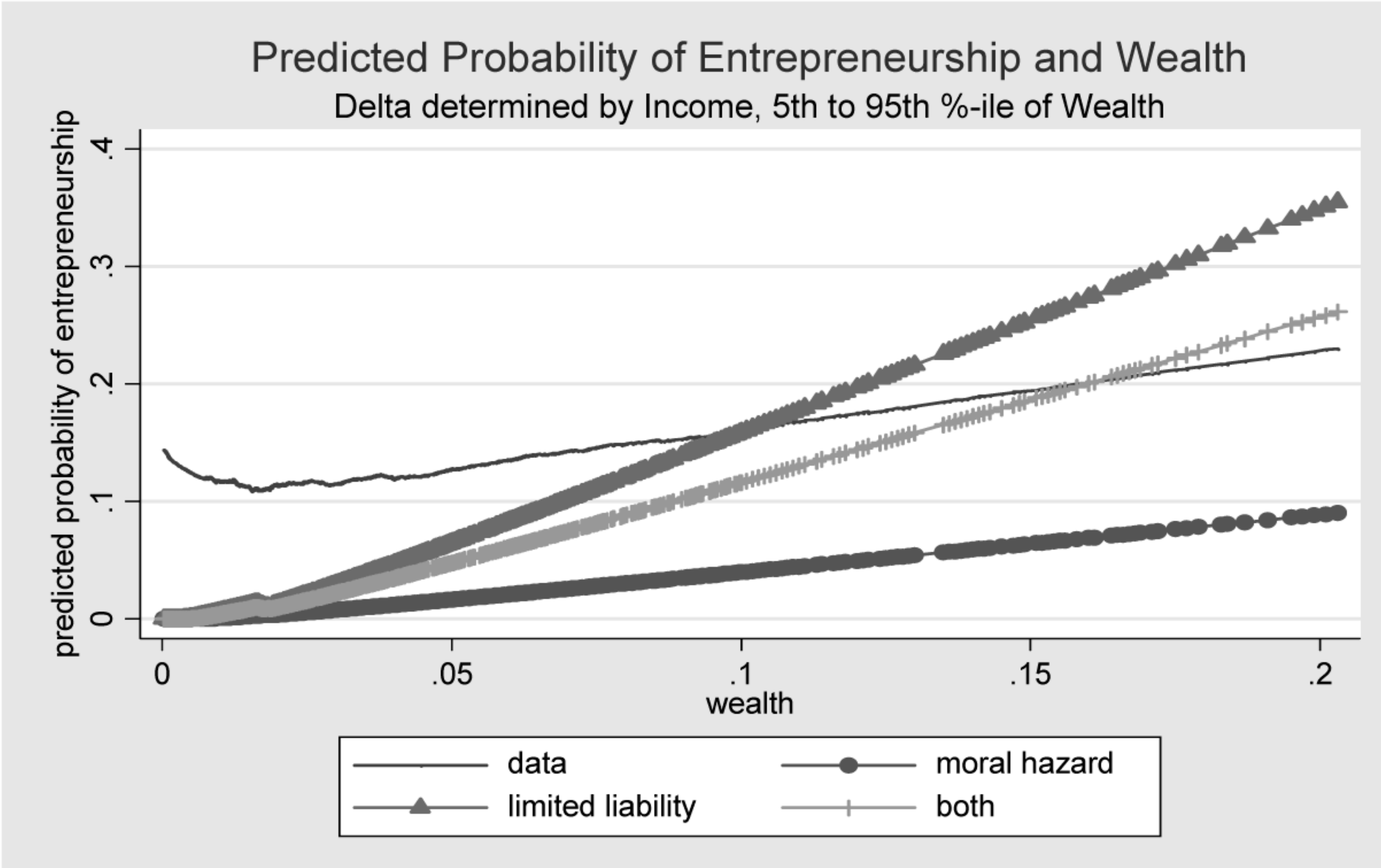

Figure 4B: Predicted Probability of Entrepreneurship and Wealth, 5th to 95th Percentile of Wealth

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

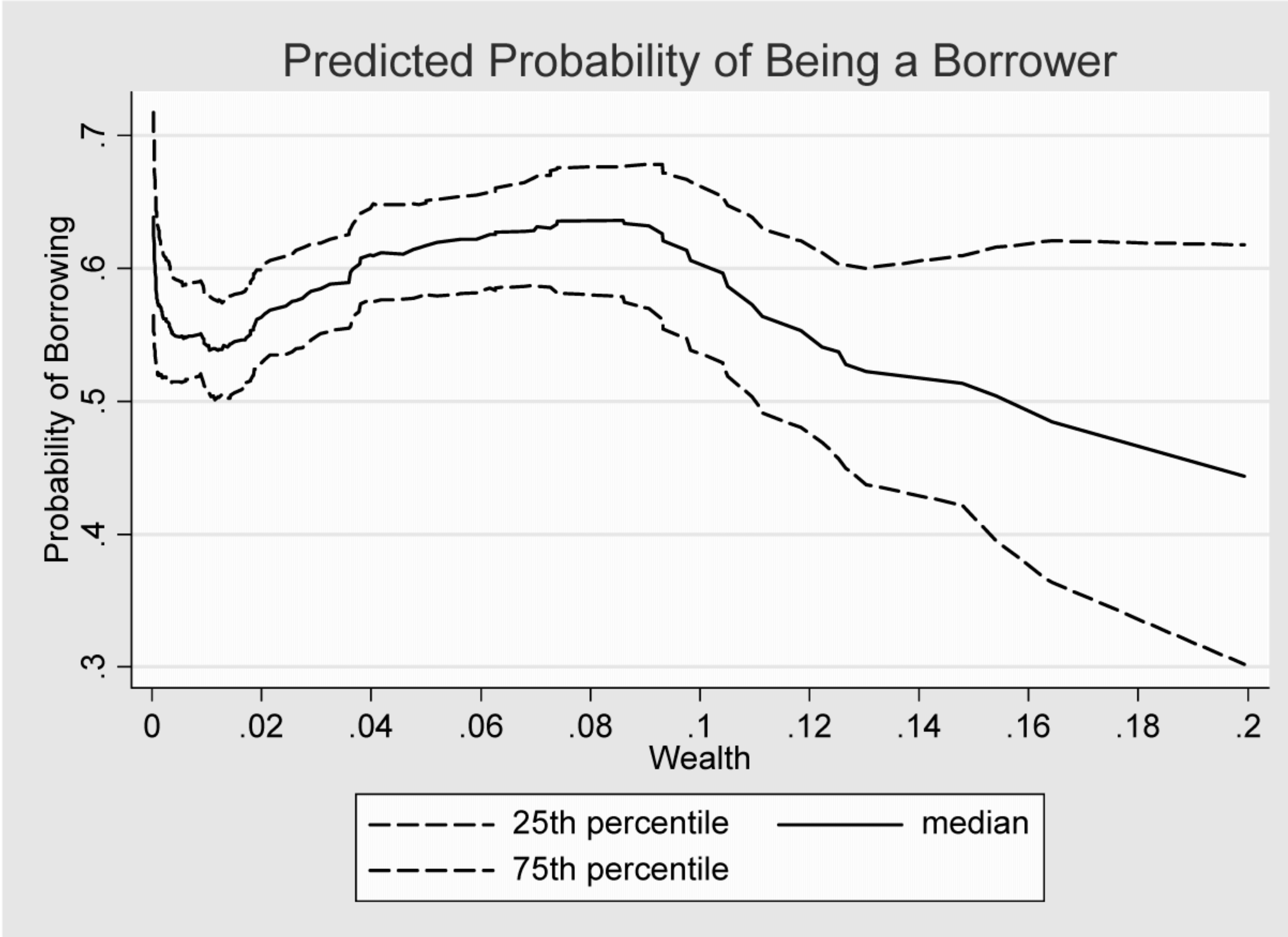

Figure 5A: Lowess Estimate of the Probability of Being a Borrower for Constrained Business Households
500 bootstrap estimates of the relationship between being a borrower and wealth were created using a bandwidth of 0.8. The 25th percentile (dashed line), median (solid line) and 75th percentile estimates (dashed line) are shown in the figure. Note that the figure shows the relationship for the 5th to the 95th percentile of wealth.

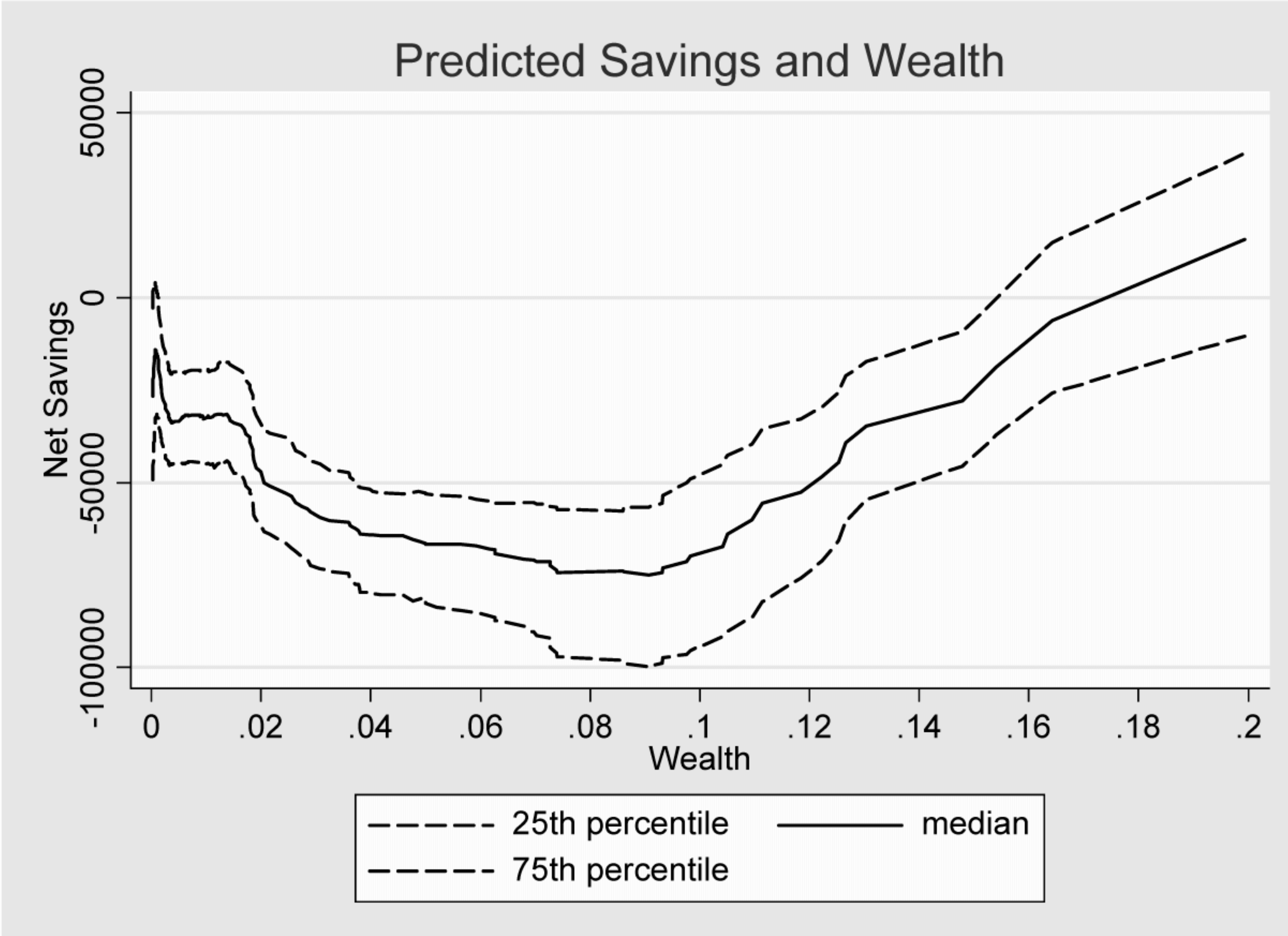

Figure 5B: Lowess Estimate of Net Savings and Wealth for Constrained Business Households

500 bootstrap estimates of the relationship between net savings and wealth were created using a bandwidth of 0.8. The 25th percentile (dashed line), median (solid line) and 75th percentile estimates (dashed line) are shown in the figure. Note that the figure shows the relationship for the 5th to the 95th percentile of wealth.

Table 1: Summary Statistics

	Whole Sample	Northeast	Central
Variables used in Structural and Reduced Form/Non-parametric 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)
Variables used in Reduced Form/Non-parametric 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)
# of Adult Females in the Household	1.6	1.6	1.7
	(0.9)	(0.8)	(0.9)
# of Adult Males in the Household	1.6	1.5	1.7
	(0.9)	(0.9)	(0.9)
# of Children (< 18 years) in the Household	1.5	1.5	1.6
	(1.2)	(1.1)	(1.3)
% of Business Households who were Member/Customer of Organization/Institution Six Years Ago			
Formal Financial Inst.	23%	16%	27%
Village Inst./Org	11%	10%	12%
Agricultural Lender	33%	33%	33%
BAAC Group	22%	29%	18%
Money Lender	4%	5%	4%

Notes: Standard errors in parentheses. Wealth is in Thai Baht. The exchange rate at the time of the survey is 25 Baht to $1.

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

Table 2: Parameter Values from Structural Estimation, Whole Sample
Bootstrap Standard Errors in Parentheses

	Moral Hazard	Limited Liability	Both
1. Risk Aversion, Talent (Income)			
γ_1	0.0985	0.0982	0.1025
	(0.0125)	(0.0003)	(0.0046)
γ_2	2.1007	1.1713	2.4753
	(0.3216)	(0.0037)	(0.1797)
κ	0.1257	0.1079	0.1190
	(0.0227)	(0.0003)	(0.0062)
α	0.7775	0.6937	0.7208
	(0.0325)	(0.0165)	(0.0108)
λ	--	22.9885	20.8082
		(0.0727)	(1.4882)
2. Risk Neutral, Talent (Income)			
γ_2	1.5801	1.3475	1.5511
	(0.0243)	(0.0167)	(0.0171)
κ	0.0530	0.0675	0.0789
	(0.0009)	(0.0009)	(0.0008)
α	0.7700	0.6800	0.6902
	(0.0099)	(0.0273)	(0.0043)
λ	--	24.5000	28.3848
		(0.3307)	(0.3095)
3. Risk Aversion, Talent (% Entrepreneur)			
γ_1	1.0737	0.0668	0.7781
	(0.0123)	(0.0004)	(0.0035)
γ_2	1.0000	1.0000	1.0000
	(0.0192)	(0.0141)	(0.0105)
κ	0.0904	0.0722	0.1219
	(0.0001)	(0.0001)	(0.0016)
α	0.9780	0.9702	0.5062
	(0.0032)	(0.0003)	(0.0066)
λ		10.7281	1.9014
		(0.0305)	(0.0042)
4. Risk Aversion, Estimated Talent			
γ_1	0.5753	0.0957	0.1002
	(0.0175)	(0.0002)	(0.0005)
γ_2	1.0494	1.2314	1.0939
	(0.0171)	(0.0120)	(0.0061)
κ	1.2312	0.9889	1.0022
	(0.0649)	(0.0049)	(0.0065)
α	0.7931	0.2283	0.7985
	(0.0148)	(0.0030)	(0.0188)
δ_0	1.0175	0.8853	0.1002
	(0.0464)	(0.0108)	(0.0007)
δ_1	0.0604	0.0285	0.0503
	(0.0218)	(0.0002)	(0.0004)
δ_2	0.0516	-0.2226	0.3005
	(0.0053)	(0.0046)	(0.0018)
λ	--	21.0118	5.0088
		(0.2223)	(0.0970)

Table 3: Log Likelihoods from Structural Estimation

A. Whole Sample

	Moral Hazard	Limited Liability	Both
Risk Aversion, Talent (Income)	-0.4038	-0.4706	-0.4683
Risk Neutral, Talent (Income)	-0.4104	-0.4608	-0.4372
Risk Aversion, Talent (% Entrepreneur)	-0.4590	-0.7514	-0.6064
Risk Aversion, Estimated Talent	-0.3996	-0.4134	-0.4035

B. Northeast

	Moral Hazard	Limited Liability	Both
Risk Aversion, Talent (Income)	-0.3044	-0.3474	-0.3258
Risk Neutral, Talent (Income)	-0.3046	-0.3474	-0.3474
Risk Aversion, Talent (% Entrepreneur)	-0.3408	-0.4588	-0.4250
Risk Aversion, Estimated Talent	-0.3040	-0.3045	-0.3029

C. Central

	Moral Hazard	Limited Liability	Both
Risk Aversion, Talent (Income)	-0.5014	-0.5966	-0.5668
Risk Neutral, Talent (Income)	-0.5190	-0.5966	-0.5553
Risk Aversion, Talent (% Entrepreneur)	-0.6104	-0.8658	-0.7902
Risk Aversion, Estimated Talent	-0.4991	-0.5355	-0.5185

Table 4: Comparison of Financial Regimes, Vuong Test Results

A. Whole Sample

	MH v. LL	**MH v. Both**	**LL v. Both**	**Best Overall Fit**
Risk Aversion, Talent (Income)	MH***	MH***	Both	MH
	(0.0000)	(0.0001)	(0.8866)	
Risk Neutral, Talent (Income)	MH***	MH**	Both***	MH
	(0.0010)	(0.0252)	(0.0033)	
Risk Aversion, Talent (% Entrepreneur)	MH***	MH***	Both***	MH
	(0.0000)	(0.0000)	(0.0000)	
Risk Aversion, Estimated Talent	MH***	MH	Both***	MH or Both
	(0.0046)	(0.3402)	(0.0046)	

B. Northeast

	MH v. LL	**MH v. Both**	**LL v. Both**	**Best Overall Fit**
Risk Aversion, Talent (Income)	MH***	MH*	Both***	MH
	(0.0071)	(0.0519)	(0.0081)	
Risk Neutral, Talent (Income)	MH***	MH***	Tie	MH
	(0.0073)	(0.0073)	(0.1018)	
Risk Aversion, Talent (% Entrepreneur)	MH***	MH***	Both***	MH
	(0.0000)	(0.0012)	(0.0000)	
Risk Aversion, Estimated Talent	MH	Both	Both	MH, LL or Both
	(0.4213)	(0.3718)	(0.1846)	

C. Central

	MH v. LL	**MH v. Both**	**LL v. Both**	**Best Overall Fit**
Risk Aversion, Talent (Income)	MH***	MH***	Both	MH
	(0.0003)	(0.0008)	(0.1897)	
Risk Neutral, Talent (Income)	MH***	MH**	Both**	MH
	(0.0007)	(0.0263)	(0.0133)	
Risk Aversion, Talent (High)	MH***	MH***	Both***	MH
	(0.0000)	(0.0000)	(0.0027)	
Risk Aversion, Estimated Talent	MH***	MH**	Both	MH
	(0.0004)	(0.0426)	(0.1342)	

Note: MH = Moral Hazard, LL = Limited Liability, Both = Moral Hazard and Limited Liability. The abbreviation for model which best fits the data in the pairwise comparison is reported. The p-value for the Vuong tests are in parentheses. *** indicates significance at at least the one percent level, ** at at least the 5% level and * at at least the 10% level.

Table 5A: 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)*	0.0849	1.55	-0.0491	-0.48	0.1321	1.97
Wealth Six Years ago†	-0.0013	-0.24	0.1880	1.75	0.0007	0.12
Age of Head	-0.0115	-0.82	-0.0149	-0.58	-0.0116	-0.67
Age of Head Squared	0.0001	0.65	0.0001	0.47	0.0001	0.49
Years of Schooling – Head	0.0049	0.47	-0.0027	-0.16	0.0010	0.07
# of Adult Females in household	0.0494	1.37	0.1320	1.81	0.0268	0.62
# of Adult Males in household	-0.0701	-2.05	-0.1838	-2.64	-0.0334	-0.82
# of Children (< 18 years) in household	0.0344	1.47	0.1338	2.63	0.0059	0.21
Observed Frequency	0.5457		0.6066		0.5146	
Predicted Frequency at mean of X	0.5483		0.6367		0.5153	
Log Likelihood	-237.02		-70.50		-158.47	
Pseudo R-squared	4.70%		13.79%		4.28%	
Number of Observations	361		122		239	

Net savings is defined to be financial assets plus loans owned to household minus debt. Dummy variables are marked by an asterisk. †Wealth six years ago is made up of the value of household assets, agricultural assets and land. Number in table is estimated coefficient multiplied by 1,000,000. The sample excludes the top 1% of households by wealth. The estimates also include controls for past membership/patronage of various financial institutions and organizations.

Table 5B: Regression Estimates of Net Savings, Business Households

	Whole Sample		Northeast		Central Region	
	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic
Wealth Six Years ago – Constrained Business†	0.048	4.32	-0.004	0.05	0.048	3.63
Wealth Six Years ago – Unconstrained Business†	0.012	1.42	0.383	3.31	0.012	1.19
Age of Head	9592.724	0.52	5639.596	0.29	15814.300	0.60
Age of Head Squared	-93.922	-0.56	-71.272	-0.41	-161.393	-0.68
Years of Schooling – Head	-23179.890	-1.67	-12283.410	-0.96	-28433.790	-1.35
# of Adult Females in household	-105875.200	-2.18	-133223.000	-2.59	-104812.200	-1.56
# of Adult Males in household	108636.700	2.37	60962.520	1.22	140117.500	2.22
# of Children (< 18 years) in household	37710.180	1.21	-60660.900	-1.68	64761.760	1.54
Constant	-234535.400	-0.48	121595.300	0.25	-461081.300	-0.65
Adjusted R-squared	7.86%		9.94%		8.71%	
Number of Observations	361		122		239	

Net savings is defined to be financial assets plus loans owned to household minus debt. Dummy variables are marked by an asterisk. †Wealth six years ago is made up of the value of household assets, agricultural assets and land. Number in table is estimated coefficient multiplied by 1,000,000. The sample excludes the top 1% of households by wealth.

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