

The Shape of Returns to Assets for Mexican Micro-enterprises

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1 Introduction

Understanding the potential returns to capital in small enterprises has both practical implications for microfinance and theoretical relevance to the understanding of poverty dynamics. Are huge returns to small investments widespread, just waiting for expanded access to microfinance, or are they rare and concentrated in specific contexts? Are returns to scale diminishing as in standard models, supporting a long-run prediction of conditional convergence in incomes? Or, conversely, are there regions of increasing returns to scale that many micro-enterprises do not have the resources to reach, leaving them stuck in a poverty trap?

The major obstacle to measuring marginal returns to capital is the difficulty in controlling for unobserved productivity. Naive estimates of the relationship between profits and assets in a cross-section are likely subject to serious selection bias because we expect assets to be correlated with productivity. The initial assets of an individual entering the workforce will be correlated with the quality of nutrition and education they received as children, as well as with other forms of human capital passed on by their parents. Then, those with higher productivity and therefore higher income will be able to build up assets more quickly, thereby strengthening the correlation of productivity with assets.

I control for the relationship between assets and productivity by taking full advantage of panel data on Mexican households. I construct a Roy model of choice between wage

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work and self-employment in which entrepreneurial¹income depends on assets. I prove non-parametric identification of the schedule of returns to assets for different productivity types. That is, I not only estimate the marginal returns to assets for non-agricultural micro-enterprises, but also trace out a full schedule of returns available to them. This enables predictions about the returns from large increases in assets as well as small.

I also show what can be non-parametrically identified about the joint distribution of entrepreneurial productivity and initial assets. Because entrepreneurial income is only observed for some of the population, only set-identification is possible for this distribution. The model of entrepreneurial choice bounds the set, treating every observation of a wage income as an upper bound for that person’s potential entrepreneurial income.

The extensive literature on micro-enterprises (a.k.a. the informal sector) in developing countries informs the model presented here. For instance, [Maloney \(1999\)](#) argues that data on sectoral transitions show that self-employment is a choice, not just a fallback for those queuing for wage work, contrary to traditional explanations.

Recent U.S. studies have documented the importance of initially non-employer firms even in a developed economy setting. [Davis et al. \(2009\)](#) find that “Over a three-year horizon, three percent of the roughly seven million non-employers in our selected industries [hire paid workers]... They account for 28 percent of firms and 20 percent of revenues among young employers (three years or less since first hire) in our selected industries.” [Bhide \(2000\)](#) reminds that “Sam Walton built a distribution center in 1969, more than two decades after opening his first store,” and argues that “Most [ultimately highly successful and innovative] entrepreneurs start their businesses by copying or slightly modifying someone else’s idea.”

The recent resurgence of interest in estimating production functions, of which [Gandhi et al. \(2009\)](#) is perhaps the most recent example, is indirectly related.² More relevant are several recent papers that seek to measure the marginal returns to capital in micro-enterprises using experimental or quasi-experimental methods. They find marginal returns of over 100% annually in a variety of contexts.³ Yet, this work tends to study a narrow range of businesses, which raises doubts about the external validity of these findings and offers little information about the distribution of potential returns to capital, generally.

¹I will use the terms ‘self-employment’ and ‘entrepreneurship’ interchangeably throughout, defined as self-directed activity. Acknowledging that there are huge differences in ability and ambition across entrepreneurs, there is good reason to study even the smallest non-employer entrepreneurs. For the vast majority of them that are well-described as ‘subsistence’ entrepreneurs, they are important for understanding the persistence of poverty. Then there are a small fraction with potential to become ‘transformational’ entrepreneurs and introduce significant innovations.

²The goal in that literature is to estimate production (usually revenue) as a function of capital, labor, and other inputs, and the challenge is that these inputs are chosen optimally with reference to a productivity realization unobserved by the econometrician. In contrast, I estimate the functional dependence of profit on assets available to the firm (i.e. household assets), assuming that productivity is fixed across time for each individual and that changes in assets over time are driven by transitory income or preference shocks rather than anticipated productivity shocks.

³For instance, [McKenzie and Woodruff \(2008\)](#) randomly assign \$140 (US\$) grants (consisting of either cash or requested in-kind capital) to retail firms in León, Mexico that start with less than \$500 of capital (excluding buildings). They estimate annualized returns of 240-400% (\$336-\$560).

One exception is [McKenzie and Woodruff \(2006\)](#), which investigates returns to capital in Mexico using a detailed cross-sectional survey of firms with five or fewer workers. They find that marginal returns to capital are around 150% annually for firms with less than \$500 of capital. They cannot reject that returns to scale are everywhere decreasing. They also find that many firms have very little or no capital, suggesting that capital requirements do not pose barriers to entry.

Because they use cross-sectional data, they cannot control for the correlation of productivity with capital level. Therefore, I expect their estimates of returns to capital are seriously biased. Also, their framework does not allow them to examine if those entrepreneurs with very little capital are a special group uniquely able and willing to start a business with such little capital, whether due to their high entrepreneurial abilities, their low prospects for wage work, or their preferences for self-employment.

In contrast, panel data and economic modeling allow me to control for productivity. I use the wage earnings of those who never enter self-employment to bound their potential self-employment earnings. By estimating the full schedule of returns to assets, I can better understand the opportunities and constraints facing micro-enterprises. For instance, if firms only face high marginal returns for small increases in capital, lenders may be unable to profitably lend to them.⁴ On the other hand, if the average returns are high for a large increase in capital, particularly if there are increasing returns to scale (e.g. lumpy investments) beyond a certain threshold, then there may be unrealized potential for efficient loans.

2 Model

I use a Roy-type model of choice between wage work and self-employment in which self-employment profits depend on current assets and individual profitability⁵ in a flexible way.⁶ I allow the functional dependence of profits on assets and profitability to be fully non-parametric, assuming only that profits are increasing in both inputs. Profitability is allowed to be correlated in a general way with initial asset level and subsequent asset choices, and I will estimate the distribution of profitability conditional on initial assets (i.e. assets in the first year of data).

⁴For example, suppose a retail firm in León could earn \$336 more each year *with certainty* with just \$140 more capital (240% return of the scale estimated by [McKenzie and Woodruff \(2008\)](#)). Suppose a bank's financing costs are just 30% (\$42) but that it faces a quasi-fixed cost of \$300 (214% in this case) of screening the loan, monitoring it, and enforcing its repayment throughout the year. Then the lender's costs are higher than the returns to the firm and the loan will never be made.

⁵Following the literature on firm growth (for instance, Melitz and Ottaviano (2005)), I distinguish between productivity, a measure of technical efficiency, and profitability, a combination of productivity and favorable market conditions. I will focus on the latter since I only observe profit. Due to the short time duration and very limited observations in the longitudinal direction, I will assume individual profitability is basically fixed over time even though market conditions are clearly subject to change for different types of businesses in different locations.

⁶ I assume optimal allocation of labor and other inputs, given profitability and available assets.

2.1 Specification

Let the expected values of potential earnings in the wage and entrepreneurial sectors be given by

$$\begin{aligned} y^w(w_i, a_{it}, X_{it}^w) &= \exp(w_i + \beta^w X_{it}^w) \\ y^e(e_i, a_{it}, X_{it}^e) &= f(a_{it}, e_i + \beta^e X_{it}^e) \end{aligned}$$

where w_i denotes (the natural log of) the wage individual effect, e_i denotes entrepreneurial profitability, and a_{it} is assets. Let X_{it}^w and X_{it}^e be time-dependent⁷ factors that affect wage and entrepreneurial income (e.g. year effects, wage experience, self-employment experience). Denote the mode of assets in the sample \bar{a} and normalize $f(\bar{a}, e_i + \beta^e X_{it}^e) = \exp(e_i + \beta^e X_{it}^e)$ to fix the scale of entrepreneurial ability. Assume $f(a, e)$ is increasing in a and strictly increasing in e . This reduced form relationship between assets, profitability, and income can be understood as arising out of a model of capital choice with borrowing costs and constraints which is described in the next section.

Then let $d_{it} \in \{0, 1\}$ be the choice between wage work ($d = 0$) and self-employment ($d = 1$), given by:

$$d_{it} = \begin{cases} 0 & \text{if } y^w(w_i, a_{it}, X_{it}^w) \geq y^e(e_i, a_{it}, X_{it}^e) \exp(\beta^h Z_{it} + \nu_{it}) \\ 1 & \text{otherwise} \end{cases}$$

where Z_{it} are characteristics that affect hedonic (non-pecuniary) preferences for self-employment (e.g. number of young children, previous wage and self-employment experience) and ν_{it} is a zero-mean, Normal, i.i.d. preference shock. Agents are risk-neutral so they choose based on expected incomes only. However, the hedonic term $\beta^h Z_{it}$ allows for preferences for the less risky alternative in an ad hoc way.

Suppose the actual income realized subsequent to the choice of d_{it} is given by

$$y_{it} = \begin{cases} y^w(w_i, a_{it}, X_{it}^w) \cdot \varepsilon_{it}^w & \text{if } d_{it} = 0 \\ y^e(e_i, a_{it}, X_{it}^e) \cdot \varepsilon_{it}^e & \text{if } d_{it} = 1 \end{cases}$$

where ε_{it}^w and ε_{it}^e are multiplicative i.i.d. shocks to wage and self-employment income with unitary expected value. The independence of these income shocks with respect to individual effects and observed characteristics is critical for identification - heteroskedasticity is not allowed.

I have not yet examined whether this model can adequately account for the observed pattern of movement between wage and self-employment, particularly given the absence any

⁷That is, they may change between observed time periods. Otherwise, they would be indistinguishable from individual-specific productivity.

persistent random effect in hedonic preferences. Here, changes over time in an individual's expected income are only allowed as a result of observed characteristics:

- Wage income increases if productivity due to time-changing factors $\beta^w X_{it}^w$ increases
- Entrepreneurial income increases if assets a_{it} or $\beta^e X_{it}^e$ increases

And a given individual would only switch from wage work to entrepreneurship (or vice versa) over time if (some combination of):

- Potential wage or self-employment earnings changes sufficiently.
- Hedonic preferences $\beta^h Z_{it} + \nu_{it}$ change sufficiently.

There is an important dynamic element to the decision to start a business in that there are typically significant returns to experience. So an individual would be willing to switch to self-employment even before his expected self-employment income is higher than his potential wage income because he anticipates higher returns in the future. This static model of self-employment choice allows for such behavior as long as firm age is included in both X_{it}^e and Z_{it} .

2.2 Assets and Capital

Consider the following model of capital choice in the presence of a saving/borrowing interest rate spread, r_s/r_b , a fixed transaction cost of borrowing C_b , and a borrowing limit dependent on assets and productivity, $L(a, e)$. Assume $f^k(k, e)$ is strictly increasing in both k and e and twice differentiable with $\frac{\partial^2 f^k}{\partial k \partial e} > 0$ everywhere. Define:

$$\begin{aligned} k^*(a, e) &= \arg \max_k f^k(k, e) + (a - k)r_s - [C_b + (k - a)(r_b - r_s)]\mathbb{I}(k > a) \\ \text{s.t.} \quad &k - a \leq L(a, e) \end{aligned}$$

Thus we will have

$$\frac{\partial f^k(k^*, e)}{\partial k} \in \begin{cases} (0, r_s) & \text{if } k^* = 0 \\ \{r_s\} & \text{if } k^* < a \\ [r_s, \infty) & \text{if } k^* = a \\ \{r_b\} & \text{if } a < k^* < a + L(a, e) \\ [r_b, \infty) & \text{if } k^* = a + L(a, e) \end{cases}$$

Then let $f(a, e)$ from the previous section be defined as the reduced form:

$$f(a, e) = f^k(k^*(a, e), e)$$

It can be shown that $f(a, e)$ is weakly increasing in a and strictly increasing in e .

3 Identification

Recall that our purpose for this model is to help disentangle the effects of assets and heterogeneous productivities on self-employment earnings, that is, to identify $f(a, e)$. It is perhaps most natural to think of the relationship between productivities and assets as a question of the distribution of assets held by those of each productivity type. But it is more convenient, given that assets are directly observed, to specify the joint distribution of individual productivities conditional on assets, namely $G(w_i, e_i | a_{i0}, a_{i1}, \dots, a_{iT})$. Without imposing a parametric form on this distribution, we would only be able to achieve set-identification since many individuals are only observed in one occupation or the other. Instead we will limit ourselves here to non-parametrically identifying the distribution of e_i for those actually observed in self-employment at some time.

3.1 Identifying $f(a, e)$

To show identification of f , we need only consider individuals with more than one observation of self-employment earnings. For clarity of exposition, assume there are no changes in profitability over time: $\beta^e = 0$. (A proof of identification allowing for nonzero β^e will need to be added in an appendix.)

We assume observations of self-employment earnings, y_{it} , and assets, a_{it} , for just two time periods for each individual $t \in \{0, 1\}$ in the self-employed population. We have

$$\ln y_{it} = \ln f(a_{it}, e_i) + \ln \varepsilon_{it}^e$$

Assumption-1 Unlimited observations with $a_{i0} = a_{i1}$ are present in the population.

For all individuals with unchanging assets, we observe both $\ln y_{i0} = \ln f(a_{i0}, e_i) + \ln \varepsilon_{i0}^e$ and $\ln y_{i1} = \ln f(a_{i0}, e_i) + \ln \varepsilon_{i1}^e$. Then, Kotlarski's Theorem⁸ says that the distributions of $\ln \varepsilon_{i0}^e$ and $\ln \varepsilon_{i1}^e$ are identified, which we assume are the same. (The distribution of $\ln f(a_{i0}, e_i)$ for those with $a_{i0} = a_{i1}$ is also identified, but that is not something we care about).

Now we can obtain the distribution of $f(a_{it}, e_i)$ for any subset of observations by deconvolution. Knowing the distributions of y_{it} and ε_{it}^e , we can recover the distribution of $f(a_{it}, e_i) = y_{it} - \varepsilon_{it}^e$.

Assumption-2 The subset of individuals observed with \bar{a} assets at some point in time includes the full support of entrepreneurial profitability types.

⁸Suppose you know the distributions of two random variables A_i and B_i , which are related in the following way: $A_i = C_i + D_i$ and $B_i = C_i + E_i$, where C_i , D_i , and E_i are mutually independent. Kotlarski proved that the distributions of C_i , D_i , and E_i are identified.

This is required since the scale of e_i is fixed by observations of income with assets \bar{a} . It serves as an example of a broader point about identification in this setting. The returns to assets \tilde{a} for an individual with profitability \tilde{e} can only be identified if some individual with profitability \tilde{e} is observed at some time with assets \tilde{a} .

Assumption-3 Every individual observation i is connected via asset changes to an equally profitable individual with \bar{a} assets in the following sense: there exists some ordered set of N other individuals $(n_{i1}, n_{i2}, \dots, n_{iN})$, all with the same profitability, e_i , such that for some set of time periods $(t_0, t_1, \dots, t_{2N})$, we have $a_{it_0} = a_{n_{i1}, t_1}$, $a_{n_{i1}, t_2} = a_{n_{i2}, t_3}$, $a_{n_{i2}, t_4} = a_{n_{i3}, t_5}$ and so on, with $a_{n_{iN}, t_{2N}} = \bar{a}$.

For example, if the subset of individuals observed with \bar{a} assets spans the full range of (e_i, a_{it}) pairs observed in the population, then Assumption 3 would be satisfied for all individuals with N at most 1. But it is more likely that individuals observed with \bar{a} assets at one point in time will only be observed with assets in some neighborhood of \bar{a} , so individuals with assets always outside of that neighborhood will need to be connected by observations of other intermediate individuals.

Now consider the distributions for the subset of observations with $a_{i0} = \bar{a}$ and $a_{i1} = \tilde{a}$ for some $\tilde{a} \neq \bar{a}$:

$$\begin{aligned} F^A(f(\bar{a}, e_i)|a_{i0} = \bar{a}, a_{i1} = \tilde{a}) \\ F^B(f(\tilde{a}, e_i)|a_{i0} = \bar{a}, a_{i1} = \tilde{a}) \end{aligned}$$

Since $f(a, e)$ is strictly increasing in e_i and the distributions condition on the same set on individuals, we know that the α quantile in F^0 (here denoted Q_α^A) corresponds to the same e_i as the corresponding quantile in F^1 (denoted Q_α^B). Recall that $f(\bar{a}, e) = e$ by normalization, so we can simply write $f(\bar{a}, Q_\alpha^A) = Q_\alpha^B$. Thus for every profitability type e present in the subset with $a_{i0} = \bar{a}$ and $a_{i1} = \tilde{a}$ (denoted $S_{\bar{a}\tilde{a}}^e$), we can identify $f(\tilde{a}, e)$.

Then we can trace out $f(a, e)$ for every observed a and e in the following way. For some new $\tilde{a}' \neq \tilde{a}$, take the subset of observations with $a_{i0} = \tilde{a}$ and $a_{i1} = \tilde{a}'$, and name the distributions of their expected earnings each time period as follows:

$$\begin{aligned} F^C(f(\tilde{a}, e_i)|a_{i0} = \tilde{a}, a_{i1} = \tilde{a}') \\ F^D(f(\tilde{a}', e_i)|a_{i0} = \tilde{a}, a_{i1} = \tilde{a}') \end{aligned}$$

Now, for every $e \in S_{\bar{a}\tilde{a}}^e$ for which we have seen $f(\tilde{a}, e)$ is identified, find the quantile of F^C , α' , for which $Q_{\alpha'}^C = f(\tilde{a}, e)$, if it exists. But then we can identify $f(\tilde{a}', e) = Q_{\alpha'}^D$ since the same quantile corresponds to the same e , as above. Then repeating this process for all observed combinations of assets observed for the same individual over time will allow identification of $f(a, e)$ for all observations, subject to the assumptions above.

3.2 Identifying the distribution of e_i for observed entrepreneurs

Notice that the identification of f did not require any assumptions about the correlation between e_i and either initial assets or changes in assets. There is reason to expect a positive correlation between e_i and initial assets, as well as a positive correlation between e_i and asset growth, conditional on initial assets. These likely correlations do not prevent the identification of f and thus they can, in turn, be identified in a straightforward manner.

4 Data

Table 1 details the construction of the preliminary sample used for the descriptive statistics to follow. (I now see it was a mistake to remove assets and earnings “outliers” as these are some of the most interesting observations.)

Table 2 shows the transition matrix between wage and self-employment in 2002 and 2005. The data also allow for reconstruction of earnings and assets for 2001 and 2004, but I have not yet cleaned it. Note that annual earnings are reported here, but it will be better to report in future the earnings from the last month before the survey, since these correspond more closely to the assets reported at the time of the survey (which may have changed over the course of the previous year).

The descriptive statistics in Table 3 are basically as would be expected.

Figure 1 represents the changes over time in assets and earnings for each of four transition categories, revealing a number of interesting and intuitive relationships. Among those working for a wage in 2002, those who switch to self-employment had both lower earnings and lower assets and enjoyed much less earnings growth. Among those self-employed in 2002, those who switched to wage work in 2005 started with less assets but higher earnings. However, in 2005, their median earnings are the same as those who stayed in self-employment, with a large divergence in their assets. On the whole, the picture is consistent with assets being important for self-employment income. It also suggests that the wage workers tend to report higher earnings and have lower assets.

Figure 2 shows the variation over time of individual assets in the data and the overlap of the individual variation, one necessary condition for identification Assumption 3. For each individual observation of assets in both 2002 and 2005, consider the interval $[a_{02}, a_{05}]$. Then, for each value of assets a , Figure 2 plots how many individual intervals include that point.

Clearly there are many important aspects of the data left to explore, including household composition, urban/rural and regional differences, the prevalence of migration and household changes, and differences across industry.

	25932	Total Individuals 15 years or older
-	18231	Not head of household
-	1624	Females
-	1370	Change households between 2002 and 2005
-	1900	Missing asset info
-	796	Missing occupation info
-	184	Missing earnings
-	737	Working without pay
-	8	Assets outliers (> \$210,000)
-	2	Earnings outliers (> \$34,000)
=	1080	Final sample size

Table 1: Sample Construction

Wage – Self Transition Matrix

	Wage in '05	Self in '05	
Wage in '02	744 68.9%	76 7.0%	820 75.9%
Self in '02	128 11.9%	132 12.2%	260 24.1%
	872 80.7%	208 19.3%	1080 100%

Table 2: Wage / Self-employment Transition Matrix

Sample Descriptive Statistics in 2002

	d = 0	d = 1
Age	38.8 (10.7)	45.3 (12.3)
HS or more	54.8%	38.5%
Hhld size	4.42 (1.69)	4.45 (2.07)
Urban	40.2%	30.4%
Debt	[41%] \$521 (1989)	[37%] \$790 (4059)
Assets	\$11,385 (18,244)	\$15,756 (22841)
- Land/buildings	[77%] \$8,174 (13,554)	[84%] \$11,886 (18,319)
- Motor vehicles / bicycles	[69%] \$1,374 (4,649)	[70%] \$1,714 (4,372)
- Appliances / electronics	[99%] \$1,332 (2,175)	[97%] \$1,598 (3,286)
Labor earnings	\$2,672 (3,144)	\$2,528 (2,943)
Non-labor income	[4%] \$113 (871)	[6%] \$357 (1815)
Observations	820	260

Table 3: Descriptive Statistics (Standard deviations are in parenthesis. The percentage of individuals with a positive amount is included in square brackets.)

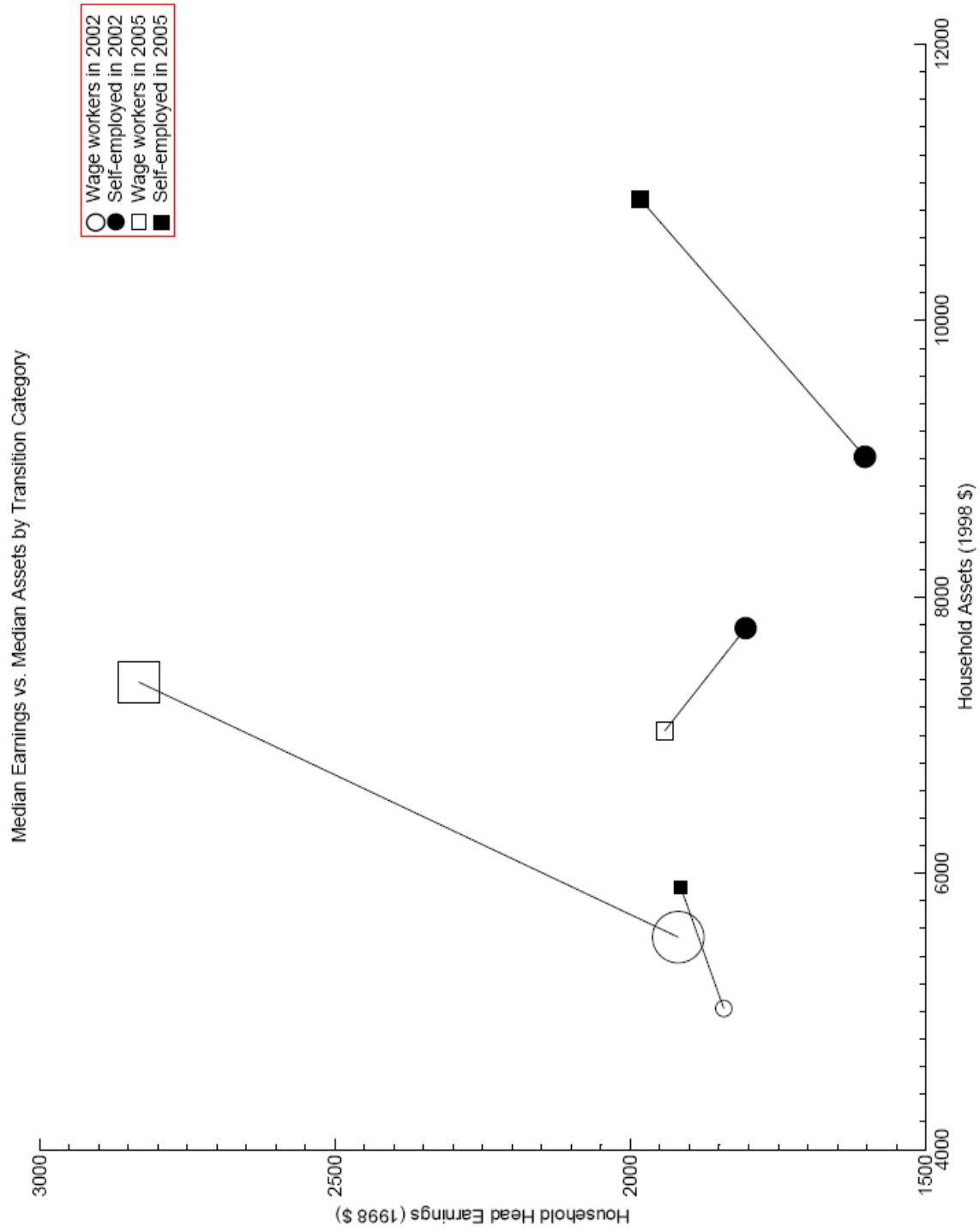


Figure 1: Income vs. Assets across Time and Transition Categories (The size of markers corresponds to the proportion of the sample in the represented transition category.)

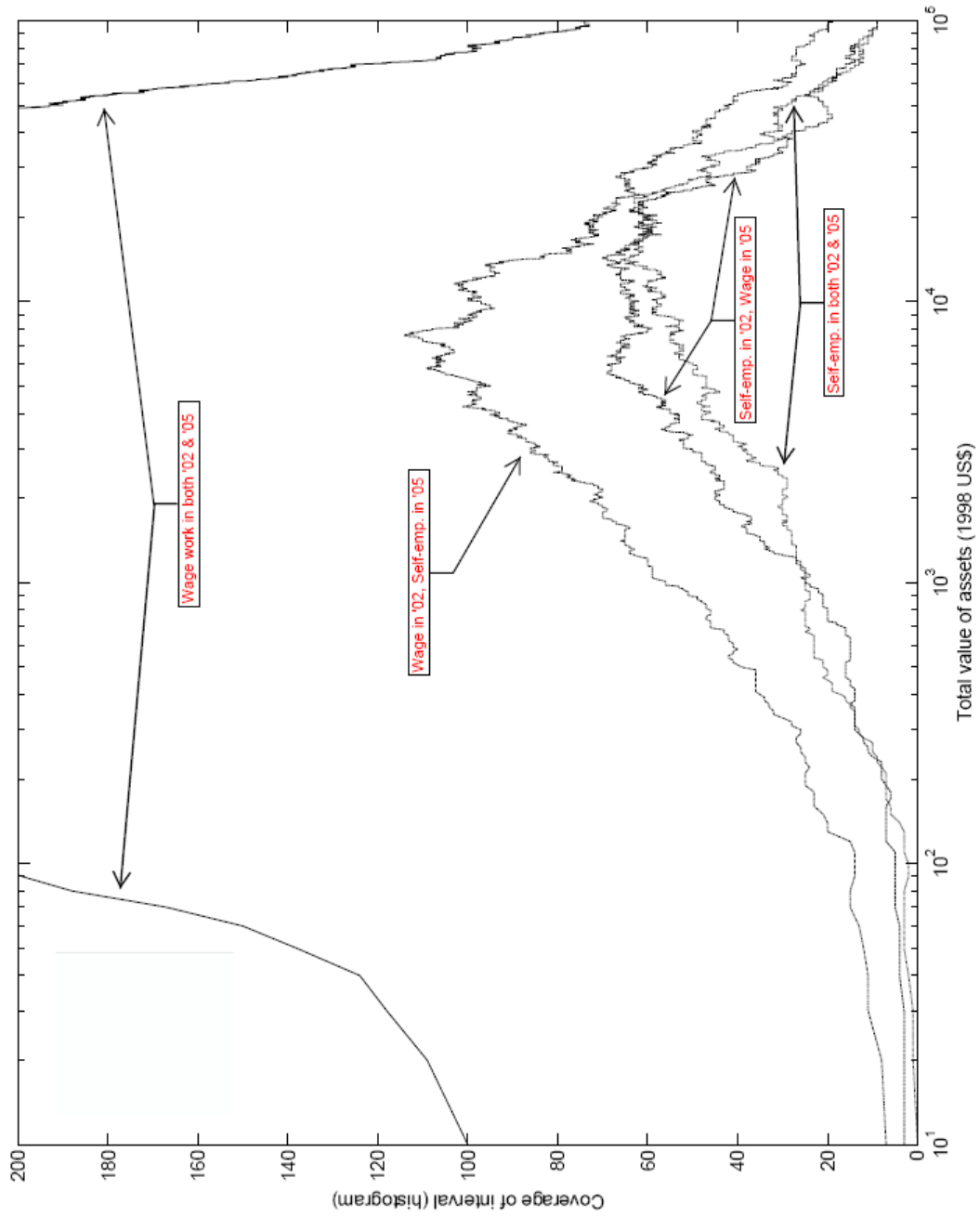


Figure 2: Coverage of Asset Change Intervals

5 Estimation

Specify $f(a_{it}, e_i + \beta^e X_{it}^e)$ as $f(a_{it}) \exp(e_i + \beta^e X_{it}^e)$. Specify ε income shocks as Normal. Assume $(w_i, e_i) | a_{i0} \sim BVNormal((\mu_w(a_{i0}), \mu_e(a_{i0})), \Sigma)$, with $\mu_w(a_{i0}), \mu_e(a_{i0})$ specified as affine functions of a_{i0} :

$$\mu_j(a_{i0}) = \beta_0^{\mu_j} + \beta_1^{\mu_j} a_{i0}$$

Specify X and Z variables..

Appendix: A General Proof of Nonparametric Identification

Can identify $f(a, e)$ non-parametrically but cannot in general identify the full distribution of w_i, e_i , as in the case of the Roy model. However, I can identify the sectoral productivities of those observed in each sector and infer upper bounds on their productivities in sectors they are not observed in, which amounts to set identification.

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