Dual Sectors and Consumption Insurance in Developing Economies

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Income and Consumption Dynamics

- Core Question for Income-Consumption Dynamics:
  - How do income fluctuations translate into consumption fluctuations?

- In developed countries, most households are wage earners:
  - Income fluctuations mainly come from wage fluctuations.
  - Key question: how do wage fluctuations translate into consumption fluctuations?

- But, households in developing countries are very different, particularly in their income generating process.

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Households in Developing Countries

A Case of Thai Rubber Farmers

- Excerpt from *Emerging Thailand: The Spirit of Small Enterprise*, a film showcasing *Townsend Thai Project*

Households in Developing Countries

A Case of Thai Rubber Farmers

- Tapping starts early in the morning when internal tree pressure is high; latex drips for 3-4 hours
- After collected, rubber is air-dried and sold to manufacturers typically on the same day.

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- Long working hours and individual skills are highly involved in rubber production activities.
- Output also depends on climate; insufficient rain can greatly reduce rubber yield

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- No production during dry months
- The household takes on another job as construction workers during that period of the year

Income and Consumption in Developing Countries

- Rural households in developing countries generally have income from both paid labor work and home production activities
  - Most of them are small farmers, livestock owners, or small business owners who also take on wage earning jobs for extra income.
  - Their income fluctuations come from both wage fluctuations and productivity fluctuations.

- More appropriate questions to ask:
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Literature: Consumption Insurance Mechanisms

- How do households avoid changing consumption when facing economic shocks?
- Types of Shocks
  - Income Shocks (Blundell, Pistaferri, Preston, 2008)
  - Wage Shocks (Heathcote, Storesletten, Violante, 2014)
  - **This paper** : Wage and Productivity Shocks
- Types of Responses
  - Adjusting Assets
    - Through Savings and Borrowings
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- Research focusing on households in rural Thailand who have income from both labor work and home production activities

- Key mechanisms :
  - Income uncertainty from wage and productivity shocks
  - Consumption insurance from entering and reallocating working hours between two sectors

- Key questions :
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Preview of the Results

- Household consumption responds very little to both wage and productivity shocks
- Labor supplies in both sectors respond significantly to both wage and productivity shocks
- Labor supply responses play significant roles in consumption insurance from both types of shocks.

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Model Setting

- Consumption-Saving model where household chooses to supply working hours in wage labor market and home production activity

- Wage Labor Market: Fixed wage per hour

- Home Production Activity:
  Hours and Capital (Total Household Assets) as production inputs

- Household wages and productivities follow a joint Markov process
  - some certain skills (e.g. accounting) can be shared across wage jobs and home production activitities.

- Partial Equilibrium Setting:
  - Wage, Productivity, Interest Rate are exogenous
  - Villages are small relative to Thailand's economy; reasonable to consider them as small-open economies.

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Household's Problem

$$V(A,W,Z;X) = \max_{\{C,A,L^1,L^2,K\}} \{U(C,L^1,L^2;X) + \beta\mathbb{E}[V(A',W',Z';X) \mid W,Z]\}$$

s.t. $A' = R \cdot A + W \cdot L^1 + F(A, L^2; Z) - C$

$(W', Z') \in G((W,Z))$

$A' \geq 0$

- C consumption, L^1 labor market hours, L^2 production hours, X taste-shifters (characteristics)
- Labor Income : $W \cdot L^1$
- Production Income : $F(A, L^2; Z)$
- No borrowing

Household's Problem

- State variables : A, W, Z, X.
- Choice variables : C, L^1,L^2, A'
- Model implies choice variables as functions of state variables
- Objects of interest :
  - $\frac{d\,log(C)}{d\,log(A)}$, $\frac{d\,log(C)}{d\,log(W)}$, and $\frac{d\,log(C)}{d\,log(Z)}$
  - Similar derivatives on L^1, L^2
  - Elasticities of Consumption and Hours on Wage/Productivity Shocks

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Transmission of Shocks onto Hours

- Suppose leisure is a normal good

- Income Effects :
  - **Increase** in **Wage** or **Productivity** makes household works **less** hours on **both** sectors

- Substitution Effects
  - **Increase** in **Wage** makes household works **more** hours on **labor market** and **less** hours on **home production**
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- Overall Effects : Combination of above determines the direction of $\frac{d\,log(L^j)}{d\,log(W)}$ and $\frac{d\,log(L^j)}{d\,log(Z)}$ for $j = 1, 2$.

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Why Reduced-Form?

- Recall : key quantities to be estimated are elasticities of consumption and hours on wages and productivities.

- These quantities can be estimated without fullying specifying functional forms for utility function

- Challenges for misspecification with structural approach for $U(C, L^1, L^2; X)$
  - Separability of consumption and labor hours in both sectors in household preference
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Reduced-Form Specification

Reduced-Form Model

- $c_t = \Theta'_{c,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^c$
- $a_{t+1} = \Theta'_{a,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^a$
- $D_t^1 = 1\{\delta_{l1,D1} D_{t-1}^1 + \delta_{l1,D2} D_{t-1}^2 + \Phi'_{l1,X} X_t + \phi_{l1,A} a_t + \phi_{l1,w} w_t + \phi_{l1,z} z_t + \zeta_t^{l1} > 0\}$
- $l_t^1 = D_t^1 \cdot [\Theta'_{l1,X} X_t + \eta_{l1,A} a_t + \eta_{l1,w} w_t + \eta_{l1,z} z_t + \epsilon_t^{l1}]$
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- Linear decision rules in log for consumption, assets, hours (among participants), and taste-shifters.
- Probit rules for participations
- Household subscript i omitted
- Linear coefficients $\eta_{p,q}$ capture key derivative effects

Reduced-Form Specification

- Wages and productivities are assumed to jointly evolve as a VAR(1) process:
  - $\begin{bmatrix} w_{i,t+1} \\ z_{i,t+1} \end{bmatrix} = \begin{bmatrix} \mu'_{w,X} X_{i,t} \\ \mu'_{z,X} X_{i,t} \end{bmatrix} + \begin{bmatrix} \rho_{1,1} & \rho_{1,2} \\ \rho_{2,1} & \rho_{2,2} \end{bmatrix} \begin{bmatrix} w_{i,t} \\ z_{i,t} \end{bmatrix} + \begin{bmatrix} \epsilon^w_{i,t} \\ \epsilon^z_{i,t} \end{bmatrix}$
- Initial wages and productivities are assumed to have normal joint distribution:
  - $\begin{bmatrix} w_{i,1} \\ z_{i,1} \end{bmatrix} \sim \mathcal{N}(\begin{bmatrix} \mu_{1,w} \\ \mu_{1,z} \end{bmatrix}, \begin{bmatrix} \sigma^2_{1,w} & \rho_{w1,z1}\sigma_{1,w}\sigma_{1,z} \\ \rho_{w1,z1}\sigma_{1,w}\sigma_{1,z} & \sigma^2_{1,z} \end{bmatrix})$
- Coefficients $\rho_{1,2}, \rho_{2,1}$ can suggest whether wages and productivities are co-evolving.

Reduced-Form Specification

- All error terms in the reduced-form specification, except the pairs $(\epsilon^{l1}_{i,t}, \zeta^{l1}_{i,t})$ and $(\epsilon^{l2}_{i,t}, \zeta^{l2}_{i,t})$, are assumed to be independent.
- This assumption allows for equation-by-equation estimation of the reduced-form system.
- This assumption is strong in a sense that any common factor that could impact a pair of model variables must be included in the controls $X_{i,t}$.
- Hence, the set of controls need to account as much as possible for household heterogeneities.

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Group Heterogeneity

- In order to account for household heterogeneities as much as possible, the set of controls $X_{i,t}$ needs to include fixed effects.
- Using household fixed effects of 571 households will result in incidental parameter problem in estimation of probit equations.
- As a solution, I use 4 grouped fixed effects where the groups are determined by k-mean clustering method.
- Clustering moments: average assets, average consumption, participation rates in both sectors, and demographics

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- Townsend Thai Project Monthly Survey
  - A panel of 720 households from 16 villages in 4 provinces; started in 1998, over 200 months
- Information used in this project :
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Data: Source

- Townsend Thai Project Monthly Survey
  - A panel of 720 households from 16 villages in 4 provinces; started in 1998, over 200 months
- Information used in this project :
  - Consumption
  - Assets(Financial,Physical)
  - Income and Working Hours (Paid Jobs, Production Activities)
  - Demographics (Family Size, Age, Gender, Education Level)
- Selected Sample :
  - balanced panel of 571 households from month 9-152
  - aggregated to 'economic year' level where each year is Apr-Mar of calendar year

Data: Notable Patterns

- Regional Patterns:
  - More urbanized regions have higher consumption, assets, income, and longer working hours

- Patterns over time:
  - Smooth consumption
  - Assets accumulation
  - Decreasing participation but longer working hours in labor market
  - Relatively flat participation and working hours in home production

- These patterns need to be accounted for in estimation through region-time effects.

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Computing Wages

- Market Income and Market Hours aggregated across all household members in each year.

- Wage computed from
  - (Labor Market Income) / (Labor Market Hours)

- Issue : No estimate for non-participants

- Solution : Mincer-type regression to predict unobserved wages

$$w_{i,t} = \beta'_{village(i)} X_{i,t} + \sum_{\tau=1}^{12} \gamma_{village(i),\tau} \cdot 1_{\{t=\tau\}} + \epsilon_{i,t}$$

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Measuring Productivities

- Assume Cobb-Douglas Production Function: $Y_{i,t} = e^{z_{i,t}} A_{i,t}^{\alpha} L_{i,t}^{\psi}$
- Log productivity follows process:

$$z_{i,t} = \Lambda_{i.t} + \rho w_{i,t-1} + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_{\tau} \cdot 1_{\{t=\tau\}} + \nu_{i,t}$$

- $\Lambda_{i.t}$: component unexplained by characteristics, known to HH, unknown to econometrician
- Taking log and combine two expressions yield

$$y_{i,t}^2 = \underbrace{\Lambda_{i.t} + \rho w_{i,t-1} + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_{\tau} \cdot 1_{\{t=\tau\}} + \nu_{i,t}}_{z_{i,t}} + \alpha a_{i,t} + \psi l_{i,t}^2$$

- Goal: estimate above expression and compute $\hat{z}_{i,t} = y_{i.t} - \hat{\alpha} k_{i.t} - \hat{\psi} l_{i,t}$.

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Measuring Productivities

- Estimation approach follows Ackerberg, Caves, Frazer 2015 (ACF)

- Assumes $\Lambda_{i.t}$ follows a Markov process:
  - $\Lambda_{i,t} = \mathbb{E}[\Lambda_{i,t} \mid \Lambda_{i,t-1}] + \zeta_{i,t}$
  - where $\mathbb{E}[\zeta_{i,t} \mid a_{i,t}] = 0$ and $\mathbb{E}[\zeta_{i,t} \mid l_{i,t-1}] = 0$
  - Labor is free-input
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Measuring Productivities: ACF Method

- Timing :
  - $a_{i,t}$ chosen at $t-1$,
  - $l_{i,t}$ chosen at, t
  - $m_{i,t}$ chosen at $t-0.5$

- Timing implies HH choose $m_{i,t} = f_t(a_{i,t}, l_{i,t}, \Lambda_{i,t})$
  This function is increasing in $\Lambda_{i,t}$

- Inverting the function above yield $\Lambda_{i,t} = f_t^{-1}(a_{i,t}, l_{i,t}, m_{i,t})$

- Plugging everything back in original production function,

$$y_{i,t}^2 - \alpha a_{i,t} - \psi l_{i,t}^2 = f_t^{-1}(a_{i,t}, l_{i,t}, m_{i,t}) + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_\tau \cdot 1_{\{t=\tau\}}$$

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  - Obtain $\hat{\Lambda_{i,t}} = \hat{f_t}^{-1}(a_{i,t}, l_{i,t}, m_{i,t})$
- Step 2:
  - Use $\{\hat{\Lambda_{i,t}}\}$ to estimate $\Lambda_{i,t} = \mathbb{E}[\Lambda_{i,t} \mid \Lambda_{i,t-1}] + \zeta_{i,t}$
  - Obtain $\hat{\zeta}_{i,t}$, these residuals are estimates for $\zeta_{i,t}(\alpha, \psi)$
    Note that these are functions of (α, ψ)
- To estimate (α, ψ), use moment conditions based on $\mathbb{E}[\zeta_{i,t} \mid a_{i,t}] = \mathbb{E}[\zeta_{i,t} \mid l_{i,t-1}] = 0$
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Measuring Productivities: Production Function Estimates

- Labor and Capital Elasticities:

Coefficients	Estimates
Log(Hours)	0.541*** (0.093)
Log(Total Assets)	0.361** (0.020)

- Other significant estimates for controls: Education
  - Productivities peak among households with lower secondary education level
  - Education improves productivity,
  - But higher educated households specialize in skills unrelated to production activities

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Measuring Productivities

- Again, key issue is no productivity estimate for non-participants
- Possible solution: Mincer-type regression similar to wages
- But, productivities vary much more than wages at household levels.
- More robust approach: treat unobserved productivities as hidden state variables and perform joint estimation with the reduced-form model coefficients

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Joint Estimation: State-Space Model Approach

- Unobserved States:
  - (log) productivity: $z_{i,t}^{(s)}$
  - probit indices for participations in both sectors: $v_{i,t}^{1,(s)}, v_{i,t}^{2,(s)}$
- Model Parameters: $\Omega^{(s)}$
  - reduced-form coefficients; mostly elasticities of interest
  - joint-distribution parameters for wage/productivity
- Estimation Procedure : Markov Chain Monte Carlo Method
  - Update $\Omega^{(s)}$ (using previous guess of unobserved states)
  - Draw unobserved states from posterior via Gibbs sampling
  - Alternate between above two steps until stationary (1000 iterations).

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Parameter Update Step

- Estimate $\Omega^{(s)}$ using observed data and previous guess of hidden states $\{z_t^{(s-1)}, v_t^{1,(s-1)}, v_t^{2,(s-1)}\}$

- Consumption and future asset equations estimated via OLS:
  - $c_t = \Theta'_{c,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^c$
  - $a_{t+1} = \Theta'_{a,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^a$

- Hours and participation estimated via Heckman selection
  - $D_t^j = 1\{\delta_{l1,D1} D_{t-1}^1 + \delta_{l1,D2} D_{t-1}^2 + \Phi'_{l1,X} X_t + \phi_{l1,A} a_t + \phi_{l1,w} w_t + \phi_{l1,z} z_t + \zeta_t^{lj} > 0\}$
  - $l_t^j = D_t^j \cdot [\Theta'_{l1,X} X_t + \eta_{l1,A} a_t + \eta_{l1,w} w_t + \eta_{l1,z} z_t + \epsilon_t^{lj}]$

  (for $j = 1, 2$)

- Compute joint initial distribution for wage/productivity and estimate the process via OLS:
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  - $$\begin{bmatrix} w_{t+1} \\ z_{t+1} \end{bmatrix} = \begin{bmatrix} \mu'_{w,X} X_t \\ \mu'_{z,X} X_t \end{bmatrix} + \begin{bmatrix} \rho_{1,1} & \rho_{1,2} \\ \rho_{2,1} & \rho_{2,2} \end{bmatrix} \begin{bmatrix} w_t \\ z_t \end{bmatrix} + \begin{bmatrix} \epsilon_t^w \\ \epsilon_t^z \end{bmatrix}$$

Parameter Update Step

- Estimate $\Omega^{(s)}$ using observed data and previous guess of hidden states $\{z_t^{(s-1)}, v_t^{1,(s-1)}, v_t^{2,(s-1)}\}$
- Consumption and future asset equations estimated via OLS:
  - $c_t = \Theta'_{c,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^c$
  - $a_{t+1} = \Theta'_{a,X} X_t + \eta_{c,A} a_t + \eta_{c,w} w_t + \eta_{c,z} z_t + \epsilon_t^a$
- Hours and participation estimated via Heckman selection
  - $D_t^j = 1\{\delta_{l1,D1} D_{t-1}^1 + \delta_{l1,D2} D_{t-1}^2 + \Phi'_{l1,X} X_t + \phi_{l1,A} a_t + \phi_{l1,w} w_t + \phi_{l1,z} z_t + \zeta_t^{lj} > 0\}$
  - $l_t^j = D_t^j \cdot [\Theta'_{l1,X} X_t + \eta_{l1,A} a_t + \eta_{l1,w} w_t + \eta_{l1,z} z_t + \epsilon_t^{lj}]$

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Hidden State Update Step

- Draw $\{z_t^{(s)}, v_t^{1,(s)}, v_t^{2,(s)}\}$ given $\{z_t^{(s-1)}, v_t^{1,(s-1)}, v_t^{2,(s-1)}\}$ and $\Omega^{(s)}$

- Via Gibbs Sampling, I can draw each $z_{i,t}, v_{i,t}^1, v_{i,t}^2$ one by one i.e.
  - Draw $z_t^{(s)}$ from $z_t^{(s-1)} \mid z_{-t}^{(s-1)}, v^{1,(s-1)}, v^{2,(s-1)}$
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  - Draw $v_t^{2,(s)}$ from $v_t^{2,(s-1)} \mid z^{(s-1)}, v^{1,(s-1)}, v_{-t}^{2,(s-1)}$

- In this system, all posterior distributions above are normal and hence convenient to compute

- Use 100 iterations in each Gibbs Sampling step.

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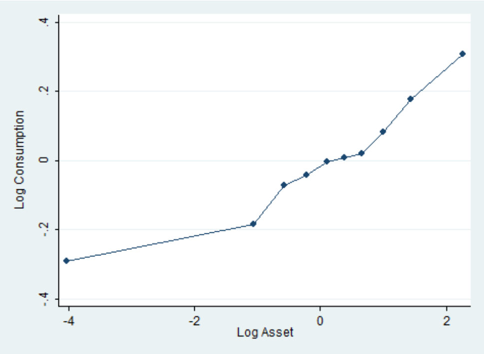
Qualitative Patterns: Consumption on Assets/Wages/Productivities



- Consumption is increasing in assets, wages, and productivities

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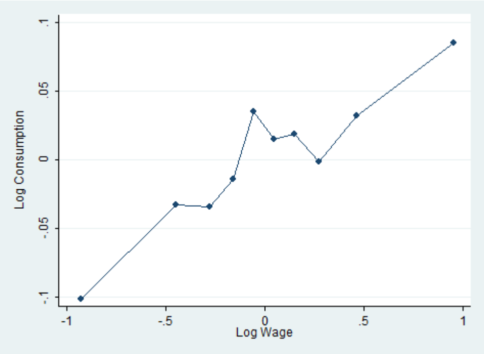

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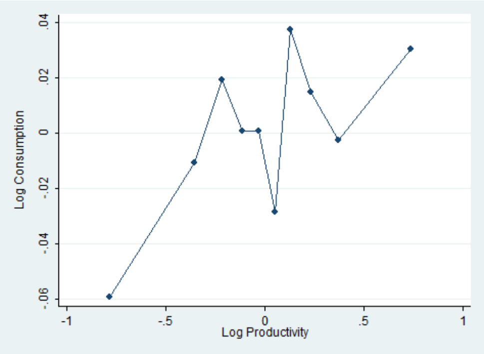

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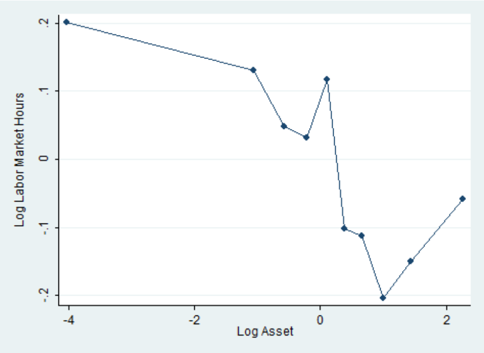
Qualitative Patterns: Market Hours on Assets/Wages/Productivities



- Market hours decrease with assets, increase with wages, and decrease with productivities

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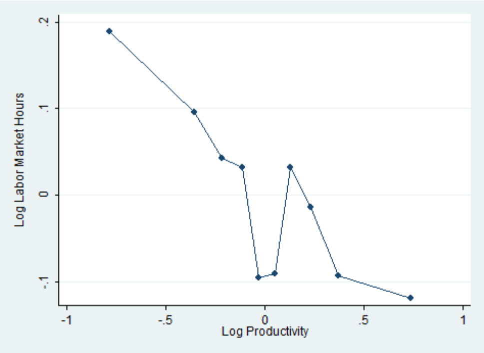

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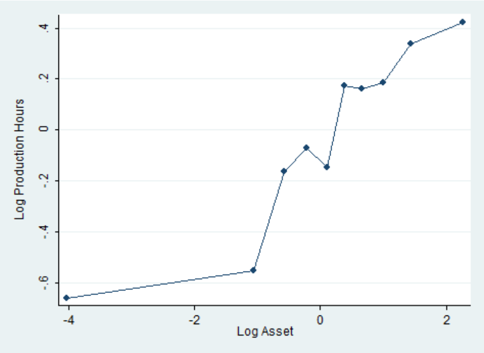

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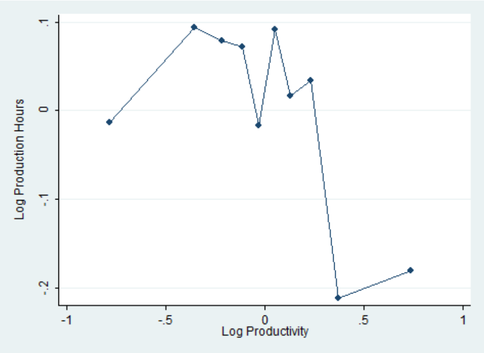

- Production hours increase with assets, decrease with wages, and decrease with productivities

Key Parameter Estimates: Wage/Productivity Process

Parameter	Estimates (s.e.)
$\rho_{1,1}$ (Future Wage Elasticity in Current Wage)	0.849*** (0.000)
$\rho_{1,2}$ (Future Wage Elasticity in Current Productivity)	0.008*** (0.002)
$\rho_{2,1}$ (Future Productivity Elasticity in Current Wage)	0.032** (0.012)
$\rho_{2,2}$ (Future Productivity Elasticity in Current Productivity)	0.435*** (0.016)

- Wages and productivities indeed co-evolve over time.

Key Parameter Estimates: Consumption Rule

Parameters	Estimates (s.e.)
$\eta_{c,a}$ (Consumption Elasticity in Assets)	0.849*** (0.000)
$\eta_{c,w}$ (Consumption Elasticity in Wage)	0.008*** (0.001)
$\eta_{c,z}$ (Consumption Elasticity in Productivity)	0.032*** (0.003)

- 99.2% of wage shocks and 96.8% of productivity shocks are insured!

Key Parameter Estimates: Market Hours Rule

Parameter	Estimates (s.e.)
$\eta_{l1,a}$ (Labor Market Hours Elasticity in Assets)	0.001*** (0.000)
$\eta_{l1,w}$ (Labor Market Hours Elasticity in Wage)	0.083*** (0.002)
$\eta_{l1,z}$ (Labor Market Hours Elasticity in Productivity)	-0.081*** (0.007)

- Labor market hours on wage shocks: substitution effect dominates
- Labor market hours on productivity shocks: substitution effect dominates

Key Parameter Estimates: Production Hours Rule

Parameter	Estimates (s.e.)
$\eta_{l2,a}$ (Production Hours Elasticity in Assets)	0.037*** (0.000)
$\eta_{l2,w}$ (Production Hours Elasticity in Wage)	-0.112*** (0.002)
$\eta_{l2,z}$ (Production Hours Elasticity in Productivity)	-0.146*** (0.010)

- Production market hours on wage shocks: substitution effect dominates
- Production market hours on productivity shocks: income effect dominates

Key Parameter Estimates: Market Participation (Probit)

Parameter	Estimates (s.e.)
$\phi_{l1,a}$ (Assets Effect)	-0.021*** (0.000)
$\phi_{l1,w}$ (Wage Effect)	-0.081*** (0.000)
$\phi_{l1,z}$ (Productivity Effect)	0.014 (0.010)
$\delta_{1,1}$ (Past Parcitipation in Labor Market Effect)	1.593*** (0.000)
$\delta_{1,2}$ (Past Parcitipation in Production Effect)	-0.042*** (0.006)

- Market participation decreases in asset
- Income effects dominate for extensive margin response to wage shocks
- Past participations have large impact on current participation

Key Parameter Estimates: Production Participation

Parameter	Estimates (s.e.)
$\phi_{l2,a}$ (Asset Effect)	0.028*** (0.002)
$\phi_{l2,w}$ (Wage Effect)	-0.081*** (0.012)
$\phi_{l2,z}$ (Productivity Effect)	0.296*** (0.030)
$\delta_{2,1}$ (Past Parcitipation in Labor Market Effect)	0.074*** (0.015)
$\delta_{2,2}$ (Past Parcitipation in Production Effect)	2.328*** (0.017)

- Production participation increases in asset
- Substitution effects dominate for both wage/productivity shocks on the extensive margin
- Past participations have large impact on current participation

Recap

- Household consumption responds very little to both wage and productivity shocks
  - more than 99% of shocks are insured on consumption
- Labor supplies in both sectors respond significantly to both wage and productivity shocks
  - substitution effects dominate mostly for intensive margin except for production hours on productivity shocks
  - extensive margin mostly governed by past participations
- Final key question: how much of consumption insurance is accounted for by labor supply responses?

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Insurance Decomposition: Wage Shocks

- How much insurance from asset adjustment and from labor supply response?

- Decomposing wage shocks on consumption: $\frac{\partial c}{\partial w} = \frac{\partial y}{\partial w} - \frac{\partial (S/Y)}{\partial w}$
  - $\frac{\partial y}{\partial w}$: effect of log wage change on income
  - $\frac{\partial (S/Y)}{\partial w}$: effect of log wage change on savings

- Suppose θ is the share of labor market income, then I can further decompose
  - $\frac{\partial y}{\partial w} = \theta \frac{\partial y^1}{\partial w} + (1-\theta)\frac{\partial y^2}{\partial w}$ where
  - $\frac{\partial y^1}{\partial w} = \frac{\partial (w+l^1)}{\partial w} = 1 + \eta_{l1,w}$ and
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- Total effects of wage shock: $\eta_{c,w} = \frac{\partial c}{\partial w}$
- Extensive margin labor supply responses: choose θ between 0 and 1
- Intensive margin labor supply responses: choose $\eta_{l1,w}, \eta_{l2,w} \neq 0$
- Residual response: adjusting savings through asset channel
- 1% wage shock induce 0.008% consumption change ... 0.992 ppt insured
  - 0.72 ppt insured from choosing to participate in both sectors (extensive margin)
  - 0.02 ppt insured from adjusting hours in both sectors (intensive margin)
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- Non-linear reduced-form specification
  - Allow for heteregenous elasticities across the range of state variables
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Thank you!

Thank you so much for inviting me here today!

I am happy to answer any remaining questions.