Hedging Labour Income Risk over the Life-Cycle

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Motivation

Individual saving and investment decisions depend on labour income profiles

→ Comovements between earnings shocks and stock market returns affect

- Propensity to participate to stock market
- Portfolio Choices / Asset Allocation (Deposits,Bonds,Stock,...

Although intuitive and theoretically founded...

- Empirical assessment of income-hedging motive is highly controversial
- Imprecise measurement of key quantities (such as the correlation...

In this paper, we

- Develop new estimation strategy
- Retrieve heterogeneity at individual level (of key quantities...
- Focus on stock market participation

Labour Income

Individual labour income may vary over time

- Age, education, etc...
- **Shocks** (Unexpected fluctuations)

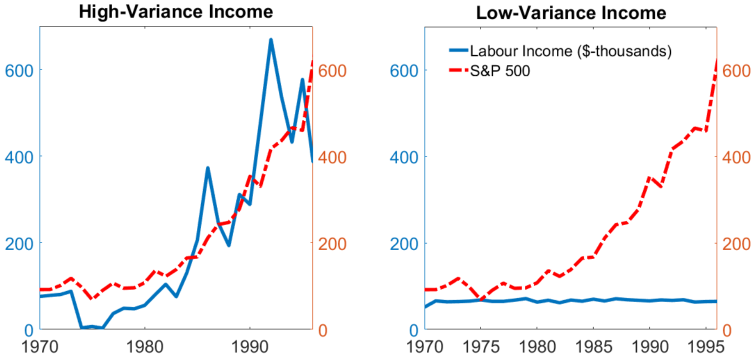
Shocks may alter the labour income

- Temporarily (*Transitory* Shocks)
  $\rightarrow$ Do not affect future labour income

- Permanently (*Permanent* Shocks)
  $\rightarrow$ Permanent effect on future labour income

Income Fluctuations

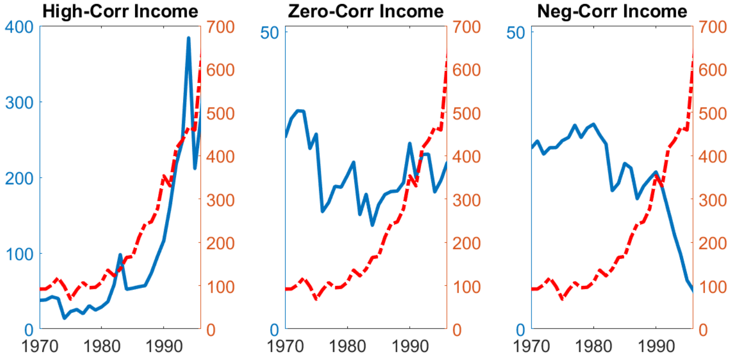
Shocks make labour income similar to a risky asset



Income-Market Correlation

Stock market may provide hedging opportunity (diversification)

$\rightarrow$ If income-stock correlation sufficiently low



Background

Total Portfolio = Financial Wealth + Human Wealth

→ Risk-averse investors can use stock market to reduce the risk of total portfolio (Constantinides and Duffie 1996, Heaton and Lucas 1996, Viceira 2001)

- Investments may help hedging individual permanent shocks (Haliassos and Michaelides (2003), Angerer and Lam (2009))
- Savers should reduce their investment in equities (Merton, 1969), or
- Stay out of the stock market (Bagliano et al. 2014)...

when permanent income shocks display positive correlation with stock returns

Positive correlation ⇒ Equities amplify impact of permanent earnings shocks

Estimation Problems

Permanent shocks are unobservable from the data

- We only observe total shocks to labour income
- Correlation permanent shocks - stock returns unobservable

Current approaches estimate correlation $\approx$ zero (Reduced-Form, OLS)
(Cocco, Gomes and Maenhout (2005))

$\rightarrow$ Two main issues

1. Limited availability of data
   (Surveys data, limited time-series dimension, frequency)
2. Heterogeneity across individuals
   (Different industry, occupation, education, etc...

$\rightarrow$ Our proposed solutions

1. Exploit the cross-sectional dimension
   (Large number of workers repeating across surveys)
2. Retrieve the individual dynamics of income components

Estimation Strategy

1. Model for individual Labour Income process (Cocco et al., 2005)
   - Model yields restrictions on both dimensions
   - Restrictions depend upon model parameters (variance/correlation)
   - Construct the empirical counterparts of the restrictions
   - Find value of parameters that minimizes distance (MD/GMM)

2. Rephrase income process in state-space form
   - Relation observable (total shocks) - latent (permanent shocks)
   - Evolution of permanent shocks over time
   - Use the parameters estimated in first step (individuals $\sim$ same distribution)
   - Estimate the state-space model to infer latent variable (KF)

The Model

$$\log(Y_{i,t}) = f(t, Z_{i,t}) + v_{i,t} + \epsilon_{i,t}$$

Deterministic Component: $f(t, Z_{i,t}) = \{$age, education, ...$\}$

Stochastic Component: $v_{i,t} + \epsilon_{i,t}$

- Transitory Component: $\epsilon_{i,t} \sim \mathcal{N}(0, \sigma_\epsilon^2)$

- Permanent Component: $v_{i,t} = v_{i,t-1} + u_{i,t}$

$\rightarrow$ Permanent Shocks (Systematic + Idiosyncratic): $u_{i,t} = \xi_t + \omega_{i,t}$

$$\omega_{i,t} \sim \mathcal{N}(0, \sigma_\omega^2), \xi_t \sim \mathcal{N}(0, \sigma_\xi^2)$$

$\rightarrow$ Systematic component correlates with stock market returns (ρ_{ξ,r_m})

- Variance of Permanent shock: $\sigma_u^2 = \sigma_\xi^2 + \sigma_\omega^2$
- Correlation with stock returns $\rho_{u,r_m} = \rho_{\xi,r_m} \frac{\sigma_\xi}{\sigma_u}$

Moment Conditions

Stochastic component of labour income: $e_{i,t} = v_{i,t} + \epsilon_{i,t}$

Total Shocks (TS) from t to $t+d$: $\Delta_d e_{i,t} = \sum_{s=t+1}^{t+d} u_{i,s} + \epsilon_{i,t+d} - \epsilon_{i,t}$

$\rightarrow$ We construct two sets of variance-covariance matrix for TS

1. One $[N - N]$ matrix
   - Main Diagonal: Variance of each individual's TS time series
   - Off-Diagonal: Covariances between individuals' TS time series

2. D $[(T-d) - (T-d)]$, with D max number of lags
   - Main Diagonal: Cross-sectional variance for each $t = 1, ..., T$ (Variance of the N total shocks for each time period)
   - Off-Diagonal: Cross-sectional covariances across periods (Covariance between N total shocks across different periods)

- Moment condition on covariance between individual shocks and stock returns

$\Rightarrow$ Stack the moment condition in one M-vector

$$\mathbf{G}(\theta) = [G_1(\theta), ..., G_M(\theta)]$$

$$\theta = \{\rho_{\xi,r_m}, \sigma_\xi, \sigma_\omega, \sigma_\epsilon, \sigma_r\}$$

Empirical Counterparts

Panel regression of labor income on demographic characteristics (Age, Education,...)

$\rightarrow$ Regression residuals form the empirical counterparts of $e_{i,t}$

$\Rightarrow$ Sample conditions for the two sets of matrices using $\Delta e_{i,t}$

Stack all sample conditions in one M-vector
then

$$\min_{\theta}(g_M - G_M(\theta))' I_M (g_M - G_M(\theta))$$

$\Rightarrow$ Perform numerically to find $\hat{\theta}$

Data

Data at the individual level from Panel Survey Income Dynamics (PSID)

- Survey on personal, demographic, and income characteristics of US households
- Annual data between 1968 and 1996, and every two years from 1997
- Data on stock market participation from 1999

→ First part: model estimation on data 1970-1996 (comparability)
→ Second part: participation analysis on data up to 2011

Sample Selection (Guvenen, 2009)

- Positive labor income and working hours in 20 out of 26 years
- Range of working hours within a year
- Between 20 and 64 years old
- Not beloning to the poverty sub-sample

⇒ 1107 individuals

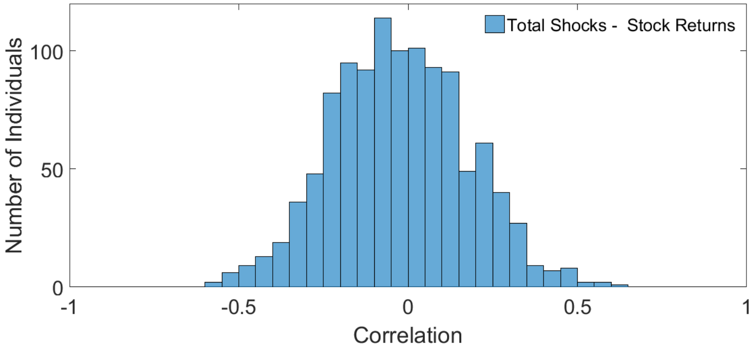
Results

- MD Estimates of $\rho_{\xi,r_m}, \sigma_\xi, \sigma_\omega, \sigma_\epsilon, \sigma_{r_m}$
- σ_u^2 and ρ_{u,r_m} computed by model equations
- US excess stock market returns from Kenneth French's website

	σ_ξ	σ_ω	σ_u	σ_ϵ	ρ_{ξ,r_m}	corr(u,r)	$\frac{\sigma_\xi}{\sigma_u}$	N
All	**0.030**	**0.122**	**0.126**	**0.347**	-0.225	-0.062	**0.274**	1107
Guevenen (2007)			***0.122***	***0.247***				
College	**0.055**	**0.141**	**0.152**	**0.356**	-0.270	-0.101	**0.374**	298
Cocco et al. (2005)			***0.130***	***0.242***		*-0.0175*		
Guevenen (2007)			*0.099*	*0.212*				
High School	**0.045**	**0.118**	**0.122**	**0.346**	-0.130	-0.043	**0.328**	809
Cocco et al. (2005)			***0.103***	***0.272***		*0.076*		
Guevenen (2007)			***0.105***	***0.228***				
White Collars	**0.054**	**0.134**	**0.145**	**0.349**	-0.264	-0.099	**0.374**	351
Blue Collars	**0.054**	**0.114**	**0.114**	**0.348**	-0.066	-0.027	**0.417**	379
Manufacturing	**0.045**	**0.109**	**0.122**	**0.302**	-0.169	-0.060	**0.355**	218
Non Manufacturing	**0.032**	**0.130**	**0.134**	**0.336**	-0.354	-0.092	**0.261**	430

Heterogeneity

Distribution of individual correlations



Individual Dynamics

The model is easily expressed in state-space form

- State Equation (unobservable permanent component diffusion)

$$v_{i,t} = v_{i,t-1} + u_{i,t}, u_{i,t} \sim \mathcal{N}(0, \sigma_u^2)$$

- Space Equation (relation permanent - total stochastic component)

$$e_{i,t} = v_{i,t} + \epsilon_{i,t}, \epsilon_{i,t} \sim \mathcal{N}(0, \sigma_\epsilon^2)$$

Run the linear KF to reconstruct $v_{i,t}$

- Use the model parameters estimates from previous step
- The KF is the BLUE under these assumptions

Kalman Filter

Initialize the filter with two arbitrary conditions on initial value and variance:

$$v_{i,0} \quad P_{i,0}$$

Use the state equations to estimate the one-step ahead value:

$$E_0[v_{i,1}] = v_{i,0}$$

$$E_0[P_{i,1}] = P_{i,0} + Q, Q = \sigma_u^2$$

Use space equation for making a forecast and compare with actual observation

$$h_{i,1} = e_{i,1} - E_0[e_1] = e_{i,1} - v_{i,0}$$

Update the initial estimate using the forecast error

$$\hat{v}_{i,1} = v_{i,0} + K * h_1$$

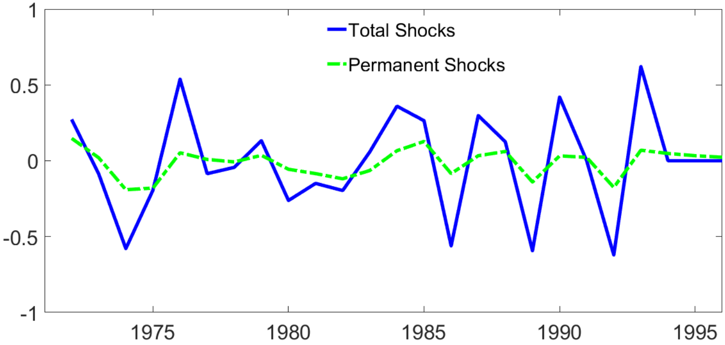
$$\hat{P}_{i,1} = (1 - K) * E_0[P_{i,1}]$$

where K is the key *Kalman gain* (weighs the forecast error in the estimate update)

$$K = \frac{E_0[P_{i,1}]}{E_0[P_{i,1}] + \sigma_\epsilon^2}$$

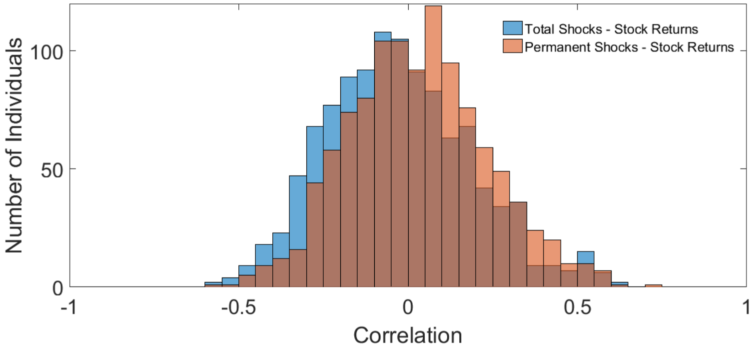
Example

Individual dynamics over time (Median-Variance Individual)



Heterogeneity (cont'd)

Distribution of individual correlations



Stock Market Participation: Probit Analysis

Dependent variable:

$$Y_{i,t} = 1 \text{ if individual } i \text{ owns stocks at time } t$$

	(1)	(2)	(3)	(4)	(5)	(6)
Age	**0.0088**		**0.0086**		**0.0081**	**0.0082**
Family Size	**-0.0416**		**-0.0413**		**-0.0425**	**-0.0422**
Marital Status	**-0.1399**		**-0.1391**		**-0.1392**	**-0.1397**
Education	**0.1651**		**0.1652**		**0.1661**	**0.1659**
Labor Income	**0.1912**	**0.3087**	**0.1914**	**0.3076**	**0.1906**	**0.1906**
Specifications of (Log)-Labor Income Shocks						
Total						
Standard Deviation		-0.0388	-0.0181			0.0486
Correlation		**-0.1003**	-0.0889			0.0648
Permanent (KF)						
Standard Deviation				**-0.5638**	**-0.3479**	**-0.4861**
Correlation				**-0.1177**	**-0.1515**	**-0.2045**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations = 6586						
Pseudo R^2	0.091	0.035	0.092	0.036	0.093	0.093

KF: Permanent Shocks obtained by Kalman Filter

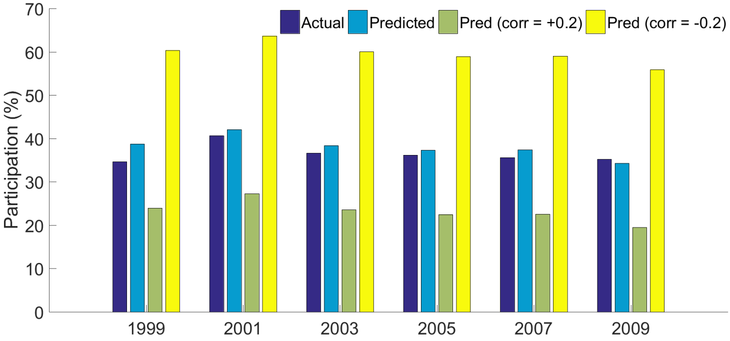
Probit Prediction

The probability individual i owns stock at time t

$$P(Y_{i,t}) = \Phi(\beta_i' * X_{i,t})$$

$X_{i,t}$ k-vector of regressors, β_i k-vector of coefficients, Φ PDF of standard normal

$\Rightarrow$ Predicted level of participation at t: $\frac{1}{N} \sum_{i=1}^{N} P(Y_{i,t})$



PSID Issues

Albeit standard and widely used, The PSID presents issues

- Data every two years from 1997
  $\rightarrow$ Problem to estimate labour income model

- Data on participation from 1999
  $\rightarrow$ Few observations to run Probit analysis (low pseudo R^2)

- Poor data on asset allocation
  $\rightarrow$ Challenging second level analysis on participation

Our approach flexible for similar datasets

$\Rightarrow$ Dutch Household Surveys (Bonaparte et al., 2014)

DHS Dataset

Annual surveys on Dutch households from 1993

→ Individual personal, income, wealth data

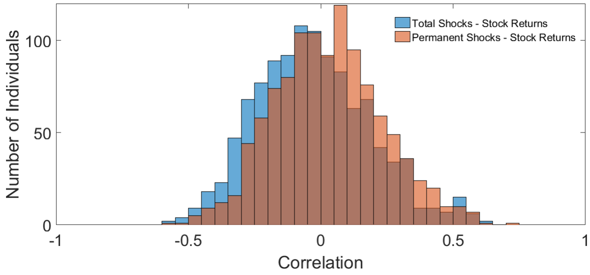
For comparability, we select until 2011
(Selection filters of Bonaparte et al., 2014)

Variable	Mean	Variable	Mean
Education	0.485	OwnSTK	0.127
Male	0.632	PropSTK	0.038
Unemployed	0.129	OwnMF	0.177
Retired	0.169	PropMF	0.062
Health	3.89	OwnSTKMF	0.332
RiskAversion	4.41	PropSTKMF	0.101
Ln(NetIncome)	9.75	OwnGF	0.045
HH size	2.42	PropGF	0.011
FinLiteracy	0.362	OwnBND	0.043
Age	53.9	PropBND	0.013

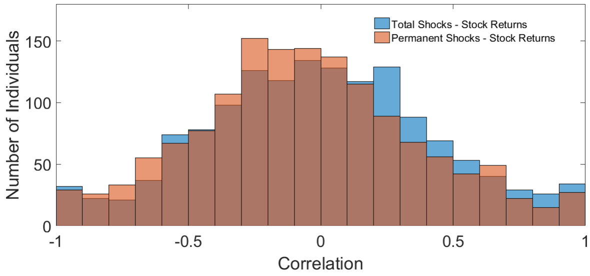
DHS vs PSID

Parameter	PSID	DHS
ρ_{ξ,r_m}	-0.225	-0.496
σ_ξ	0.030	0.026
σ_ω	0.122	0.107
σ_ϵ	0.347	0.251
σ_r	0.173	0.288
Var(Systematic Shocks)	0.001	0.001
Var(Idiosyncratic Shocks)	0.015	0.011
Var(Permanent Shocks)	0.016	0.012
Var(Transitory Shocks)	0.120	0.063
Corr(Permanent Shocks,Stock Returns)	-0.054	-0.117
N	1107	1456

Correlations Distribution



PSID



DHS

Stock Market Participation: Probit Analysis

Independent Variable	Stock or Mutual Funds				Stock Only			
St. Dev. (dy)	**-0.101**	**-0.138**	**-0.172**	**-0.163**	**0.139**	**0.258**	**0.250**	**0.230**
Corr(det,Rm)	**0.150**				**0.199**			
Corr(stoc,Rm)	**-0.299**				**-0.230**			
Corr(transBKK,Rm)		**-0.124**		**-0.154**		0.091		0.049
Corr(permBKK,Rm)		**-0.162**		-0.061		0.007		**0.121**
Corr(transKF,Rm)			**-0.129**	**-0.271**			**-0.136**	**-0.335**
Corr(permKF,Rm)			**-0.289**	**-0.311**			**-0.147**	**-0.283**
N	8,240	5,968	8,481	5,968	8,240	5,968	8,481	5,968
Pseudo R^2	0.259	0.262	0.260	0.265	0.268	0.280	0.264	0.284

- **det**: changes in deterministic component of labour income ($f(Z_{i,t})$)
- **stoc**: shocks to stochastic component of labour income ($e_{i,t}$)
- **trans**: shocks to transitory component of labour income ($\epsilon_{i,t}$)
- **perm**: shocks to permanent component of labour income ($u_{i,t}$)
  - **BKK**: Shocks obtained with approach of Bonaparte et al. (2014)
  - **KF**: Shocks obtained by Kalman Filter

Conclusions

This paper improves the assessment of diversification opportunities by

- developing estimation methodology to exploit cross-sectional dimension
  (to circumvent the short and limited time-series dimension)
- estimating individual dynamics of unobservable labour income components
  (great heterogeneity makes central moments not representative)
- relating stock market participation to individual income components
  (quantify impact of different components → counterfactual and prediction)

→ Implication for life-cycle portfolio choices
(reconsider optimal decisions of savings and investments)

→ Implication for pension funds allocation
(linking portfolio shares to the characteristics of labour income)

→ Implication for TDFs allocation
(switch riskier and safer assets as fund maturity approaches,
ideal for investment plans toward retirement)