Hedging Labour Income Risk over the Life-Cycle

Fabio Bagliano, Raffaele Corvino, Carolina Fugazza, Giovanna Nicodano

University of Torino and Collegio Carlo Alberto

OEE - Paris, March 4th, 2020

Motivation: Theory vs.Measurement

Human wealth is similar to a risky asset, due to income shocks

$$\text{Total Wealth} = \text{Financial Wealth} + \text{Human Wealth}$$

→ Individual saving and investment decisions depend on labour income

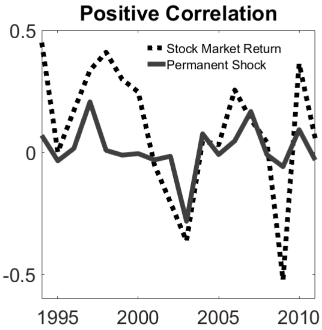
- A risk-averse saver may use stocks to reduce total wealth risk, hedging permanent income shocks (PIS)
  Constantinides and Duffie 1996, Heaton and Lucas 1996, Viceira 2001, Haliassos and Michaelides (2003), Angerer and Lam (2009)
- A saver should reduce her equity investment (Merton, 1969), and even stay out of the stock market (Bagliano et al. 2014) **only** if her PIS display positive correlation with stock returns
- Savers may update their estimates of correlation, based on realized PIS if there is learning about labour income (Chang et al.(2018))

→ Ex-ante and revised correlation should explain both stock market participation and asset allocation across cash, bonds, stocks.

Motivation: Income Shocks-Equity Return Correlation

Positive correlation ⇒ Stocks amplify income shocks

Negative correlation ⇒ Stocks help hedging income shocks



Motivation: Theory vs. Measurement

Measuring the income-hedging motive is challenging because of challenges in estimating unobserved correlation

1. Correlations should differ across individuals: large N

2. Limited time-series dimension of the data

   => estimates are imprecise and may not differ from zero

3. PIS shocks are not observable. Decompose stochastic income growth into temporary and permanent components

   - based on structural models. This requires a long time series of income data

     Carroll (1992, 1997); Meghir and Pistaferri (2004)
   - PIS in t is the equal weighted average of the stochastic income growth rates in years (t â 1), t and (t + 1)

     The transitory component at year t is the difference between the year t stochastic labor income growth and the permanent component of income growth at year t.

   => limited economic significance of correlation

Contribution

- We extend the specification of the labour income process due to Cocco Gomes Maenhout (2005) (CGM), to allow for individual (or clustered) correlations

  A Minimum Distance (MD) estimation of correlations, based on the restrictions of the CGM income process, exploits the large cross-sectional data dimension

  Clustered MD correlations matter for both participation and asset allocation, also in economic terms

- Bonaparte et al.(2014) (BKK) use sample (realized) individual correlations, explaining both participation choice and average frequency

  We reconstruct the dynamics of PIS through a Kalman Filter, and recursively update correlation estimates

  These revised correlation estimates explain the revised participation choice better than our MD estimates of correlation

This Presentation

1. Method
2. Empirical Analysis
   - Data
   - Results- with BKK as benchmark

     Individual and Clustered MD Correlations

     Explaining Participation and Asset Allocation

     Reconstructing the Dynamics of PIS

     Explaining Revised Participation with Revised Correlations

1. Method

- Labour income is the sum of three components (as in CGM): a deterministic one, associated to personal characteristics; a transitory shock and a permanent income shock (PIS).

  PIS have an aggregate and an idiosyncratic component

  We assume that the aggregate component of PIS co-moves with stock returns according to the individual (or cluster) correlation.

  ▸ Individual Correlations

- This implies that the PIS of any two savers co-move with each other, only because each moves with stock return.

  ==>We exploit the cross-sectional dimension of the data: N(N-1)/2 restrictions on a function of income shocks (DRES), allowing for the Minimum Distance estimation of N correlation coefficients

  ==> MD correlations and MD80 correlation

- We then use MD estimates and realized returns to measure PIS and recursively reconstruct the idiosyncratic PIS from DRES.

  ==> KF correlations

  ▸ Moment Conditions

2. Data

Dutch Household Survey (DHS) (Bonaparte et al. (BKK)[JFE, 2014])

- Panel Data of Households (1993-2011), N=1456
- Personal Characteristics
- Investment Decisions

Variable	Mean	Standard Deviation	p10	Median	p90	N (n x T)
OwnSTK	0.12	0.32	0	0	1	14999
OwnMF	0.18	0.38	0	0	1	14999
OwnSTKMF	0.27	0.44	0	0	1	16976
Ln(NetWorth)	10.90	2.07	8.89	12.17	13.08	10116
Ln(NetIncome)	9.75	0.841	8.76	9.94	10.51	13694
Corr(d(LnInc),Rm)	-0.07	-0.41	-0.60	-0.08	0.50	27664
SD(d(LnInc))	0.39	0.49	0.06	0.21	0.96	27664
HH size	2.45	1.19	1	2	4	16945
Age	53.9	13.70	35	54	72	16945
Education	0.564	0.496	0	0	1	16945
Male	0.613	0.487	0	1	1	16945
Unemployed	0.117	0.322	0	0	1	16945
Retired	0.284	0.451	0	0	1	16945
Health	3.91	0.693	3	4	5	14809
RiskAversion	4.44	2.05	1	5	7	13833

Clusters

ρ_i, the ex-ante individual correlation parameter, may depend on ex-ante observable characteristics

Similar individuals should have similar correlations

$\Rightarrow$ We repeat the estimation of ex ante correlations on homogeneous **clusters** of individuals

$$\rho_i \Rightarrow \rho_j$$

Clustering variables

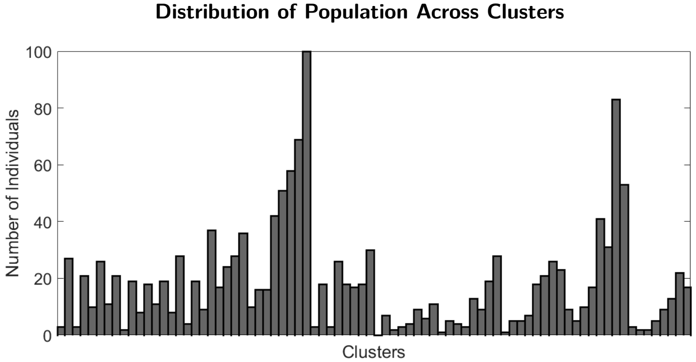
- are available for most waves
- forecast individual PIS
- are stable over time (i.e. Risk aversion, Gender, Education..)

Advantages:

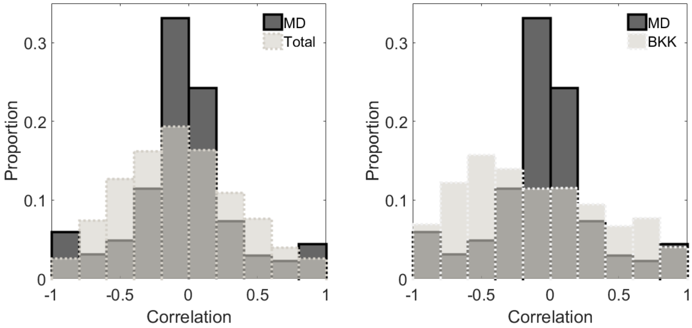
- Econometric: higher conditions/parameter ratio
- Economic: easier design of initial portfolios for new investors

Cluster Population

80 Clusters: Gender (2), Education (5), Urbanization (2), Financial Literacy (2), Risk Aversion (2)



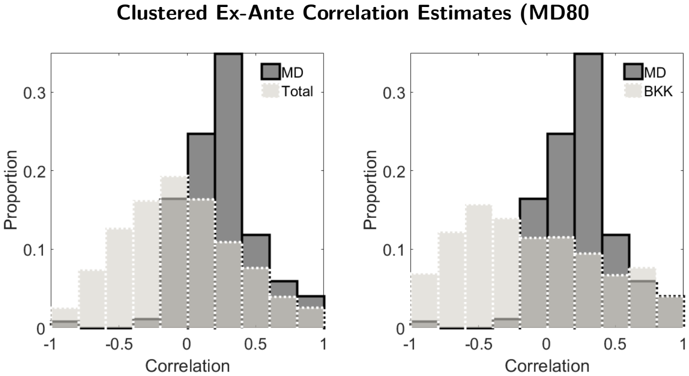
2.1 Results: Sample vs. MD (left) and BKK (right)



Correlation between PIS and stock returns

- is more concentrated around the mean, being driven by stock returns;
- has thicker tails, because there is no orthogonal temporary shocks as in both total and BKK-averaged income shocks.

Sample vs. MD-Clustered (left) and BKK (right)



2.2 Explaining Stock Market Participation and Asset Allocation

$P_{i,t} = 1$, if individual i owns stocks at time t

$W_{i,t} =$ share of individual's financial wealth invested in stocks

We explain $P_{i,t}$ with a Probit regression and $W_{i,t}$ with a Tobit regression, changing the component of labor income growth used to define the correlation with returns

- total labor income growths: Corr(tot,Rm)
- deterministic component of labor income growth: Corr(det,Rm)
- stochastic labor income growth (PIS and transitory): Corr(stoc,Rm)
- based on moving average transitory component: Corr(transBKK,Rm)
- based on moving average PIS: Corr(permBKK,Rm)
- based on Clustered MD PIS: Corr(permMDA80,Rm)
- based on MD PIS: Corr(permMDAll,Rm)

Relevance

a. strength of the income hedging motive

b. structural models vs. moving average for estimating PIS and correlation: does it make a difference? (DeBacker et al. 2013)

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	
Corr(tot,Rm)	
Corr(det,Rm)	
Corr(stoc,Rm)	
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	
Pseudo R^2	

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	**-0.092**
Corr(tot,Rm)	**-0.280**
Corr(det,Rm)	
Corr(stoc,Rm)	
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	7,585
Pseudo R^2	0.259

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	-**0.141**
Corr(tot,Rm)	
Corr(det,Rm)	0.107
Corr(stoc,Rm)	
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	8,501
Pseudo R^2	0.256

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	**-0.088**
Corr(tot,Rm)	
Corr(det,Rm)	
Corr(stoc,Rm)	**-0.319**
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	8,240
Pseudo R^2	0.259

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	-**0.092**
Corr(tot,Rm)	
Corr(det,Rm)	0.097
Corr(stoc,Rm)	-**0.316**
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	8,240
Pseudo R^2	0.259

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	**-0.183**
Corr(tot,Rm)	
Corr(det,Rm)	
Corr(stoc,Rm)	
Corr(transBKK,Rm)	-0.055
Corr(permBKK,Rm)	
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	5,968
Pseudo R^2	0.260

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	**-0.173**
Corr(tot,Rm)	
Corr(det,Rm)	
Corr(stoc,Rm)	
Corr(transBKK,Rm)	
Corr(permBKK,Rm)	**-0.084**
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	5,968
Pseudo R^2	0.261

Stock Market Participation

Dummy variable $P_{i,t} = 1$, if individual i owns stocks at time t

$\rightarrow$ Explaining $P_{i,t}$ with Probit regression onto

- Total income growth volatility St.Dev (dy)
- Income-Return Correlation (Income-Hedging motive)
- Personal Characteristics (Age, Gender, Education, Employment,...)

	OwnSTKMF
Independent Variable	
St. Dev. (dy)	**-0.172**
Corr(tot,Rm)	
Corr(det,Rm)	
Corr(stoc,Rm)	
Corr(transBKK,Rm)	-0.073
Corr(permBKK,Rm)	**-0.094**
Corr(permMDA80,Rm)	
Corr(permMDAll,Rm)	
N	5,968
Pseudo R^2	0.262

Stock Market Participation

	OwnSTKMF						
Independent Variable							
St. Dev. (dy)	**-0.092**	**-0.141**	**-0.088**	**-0.092**	**-0.183**	**-0.173**	**-0.172**
Corr(tot,Rm)	**-0.280**						
Corr(det,Rm)		0.107		0.097			
Corr(stoc,Rm)			**-0.319**	**-0.316**			
Corr(transBKK,Rm)					-0.055		-0.073
Corr(permBKK,Rm)						**-0.084**	**-0.094**
Corr(permMDA80,Rm)							
Corr(permMDAll,Rm)							
N	7,585	8,501	8,240	8,240	5,968	5,968	5,968
Pseudo R^2	0.259	0.256	0.259	0.259	0.260	0.261	0.262

$$P(Y_{i,t}(\rho_i = \rho_L)) - P(Y_{i,t}(\rho_i = \rho_H)) = 5\%$$

$$\rho_L = -0.6; \rho_H = +0.5$$

i.e. a switch from 10th to 90th percentile of the correlation distribution

Stock Market Participation

	OwnSTKMF						
Independent Variable							
St. Dev. (dy)	**-0.092**	**-0.141**	**-0.088**	**-0.092**	**-0.187**	**-0.187**	**-0.176**
Corr(tot,Rm)	**-0.280**						
Corr(det,Rm)		0.107		0.097			
Corr(stoc,Rm)			**-0.319**	**-0.316**			
Corr(transBKK,Rm)					-0.032		-0.049
Corr(permBKK,Rm)						**-0.108**	**-0.113**
Corr(permMDA80,Rm)							
Corr(permMDAll,Rm)					**-0.135**	**-0.173**	**-0.163**
N	7,585	8,501	8,240	8,240	5,677	5,677	7,745
Pseudo R^2	0.259	0.256	0.259	0.259	0.258	0.265	0.265

$$P(Y_{i,t}(\rho_i = \rho_L)) - P(Y_{i,t}(\rho_i = \rho_H)) = 7\%$$

Stock Market Participation

	OwnSTKMF						
Independent Variable							
St. Dev. (dy)	**-0.092**	**-0.141**	**-0.088**	**-0.092**	**-0.202**	**-0.191**	**-0.148**
Corr(tot,Rm)	**-0.280**						
Corr(det,Rm)		0.107		0.097			
Corr(stoc,Rm)			**-0.319**	**-0.316**			
Corr(transBKK,Rm)					-0.064		-0.081
Corr(permBKK,Rm)						-0.079	**-0.089**
Corr(permMDA80,Rm)					**-0.336**	**-0.326**	**-0.337**
Corr(permMDAll,Rm)							
N	7,585	8,501	8,240	8,240	5,677	5,677	5,677
Pseudo R^2	0.259	0.256	0.259	0.259	0.264	0.263	0.264

$$P(Y_{i,t}(\rho_i = \rho_L)) - P(Y_{i,t}(\rho_i = \rho_H)) = 15\%$$

Asset Allocation

$W_{i,t}$ = share of individual's financial wealth invested in stocks

→ **Tobit Regression**

	PropSTK								
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
St. Dev. (dy)		0.019	0.076	0.076	0.093	0.050	0.087	0.051	0.093
Corr(tot,Rm)	**-0.092**	**-0.094**	**-0.049**						
Corr(det,Rm)				0.034					
Corr(stoc,Rm)				**-0.065**					
Corr(transBKK,Rm)					**0.057**		**0.051**		**0.057**
Corr(permBKK,Rm)					-0.006		-0.004		-0.005
Corr(permMDA80,Rm)						**-0.107**	**-0.128**		
Corr(permMDAll,Rm)								0.028	0.001
Corr(permKF,Rm)									
Controls	NO	NO	YES	YES	YES	YES	YES	YES	YES
N	13,283	11,371	7,434	7,431	5,577	7,581	5,577	7,581	5,577
Pseudo R^2	0.003	0.003	0.282	0.283	0.310	0.279	0.311	0.311	0.311

$$W_{i,t}(\rho_i = \rho_L) - W(Y_{i,t}(\rho_i = \rho_H)) \approx 10\%$$

=> Income hedging motives have a sizable impact on both stock market participation and asset allocation

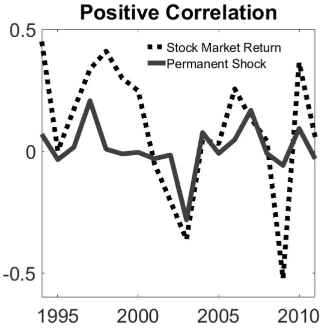
2.3 Reconstructing the Individual Dynamics of PIS

- Uncertainty and learning about labour income rationalize the age profile of stock investments (Chang et al.(2018).
- Savers may update their estimates of correlation, based on realized PIS, if there is learning

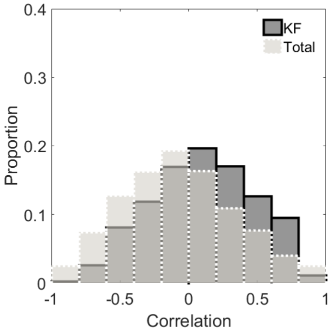
$\rightarrow$ We exploit the co-movements with stock market to infer the PIS, $u_{i,t}$

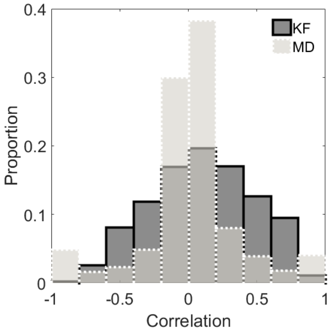
▸ Kalman Filter

Realized Permanent Shocks



Revised Individual Correlations





→ More dispersed compared to one obtained by MD

(KF based on sample realization of ex-ante correlation)

2.5 Explaining Participation Frequency

We now consider how the participation choice evolves over time for the same individual
Counting variable Z_i = number of waves individual i owns stocks

→ **Poisson Regression**

	NperiodsSTKMF								
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
St. Dev. (dy)	-0.050	-0.052	**-0.130**	**-0.079**	**-0.134**	**-0.076**	**-0.128**	**-0.052**	**-0.080**
Corr(tot,Rm)	**-0.171**								
Corr(det,Rm)		**0.255**							
Corr(stoc,Rm)		**-0.182**							
Corr(transBKK,Rm)			-0.038		-0.041		-0.036		-0.021
Corr(permBKK,Rm)			**-0.070**		**-0.069**		**-0.071**		**-0.095**
Corr(permMDA80,Rm)				-0.031	-0.049				
Corr(permMDAll,Rm)						-0.015	-0.011		
Corr(permKF,Rm)								**-0.195**	**-0.269**
N	1,147	1,147	730	1,199	730	1,199	730	1,199	730
Pseudo R^2	0.252	0.257	0.278	0.248	0.278	0.248	0.278	0.251	0.283

→ What matters for the revised decision to stay in the market is the **updated correlation** between PIS and returns

Conclusions

This paper improves the measurement of income hedging needs

showing their statistical and economic significance

supporting implications of life cycle theory with learning about uncertain income

- new estimation method exploiting both theoretical restrictions and the larger cross-sectional dimension of data
- three alternative measures of correlations between PIS and stock returns
- one measure better explains stock market participation, asset allocation and participation frequency

Applications

- Improved design of portfolios/ target date funds
  Link portfolio shares of a new investor to the ex ante characteristics of the cluster she belongs to
  Revising her portfolio shares after measuring her realized permanent income shocks

Income Process with Individual Correlations

log-Labour income $\log(Y_{i,t})$ is a deterministic function of observable characteristics (age, sex, education, etc..) plus a stochastic component

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

that is given by a transitory component and a random walk

$$\log(Y_{i,t}) = f(t, Z_{i,t}) + \epsilon_{i,t} + v_{i,t-1} + u_{i,t},$$

with shocks $u_{i,t}$, the PIS, given by aggregate and idiosyncratic components

$$\log(Y_{i,t}) = f(t, Z_{i,t}) + \epsilon_{i,t} + v_{i,t-1} + \xi_{i,t} + \omega_{i,t},$$

where $corr(u_{i,t}, r_t)$=$corr(r_t, \xi_{i,t)} = \rho_i$

$$\xi_{i,t} = \sigma_u \rho_i (r_t/\sigma_r) \sim \mathcal{N}(0, \sigma_u^2 \rho_i^2); \omega_{i,t} \sim \mathcal{N}(0, \sigma_u^2 (1 - \rho_i^2)$$

$$\Rightarrow u_{i,t} \sim \mathcal{N}(0, \sigma_u^2)$$

▸ Choleski Decomposition

This simplifies to the CGM labour income process if, for all i,

$$\rho_i = \rho.$$

▸ Back

Choleski Decomposition

The stock market return is proportional to an aggregate shock

$$r_t = \sigma_r W_t$$

Permanent and transitory shocks are given by

$$u_{i,t} = \sigma_u W^p_{i,t}$$
$$\epsilon_{i,t} = \sigma_\epsilon W^q_{i,t}$$

The relationship between shocks is given by

$$\begin{bmatrix} W_t \\ W^p_{i,t} \\ W^q_{i,t} \end{bmatrix} = Chol\left(\begin{bmatrix} 1 & \rho_i & 0 \\ \rho_i & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \right) \begin{bmatrix} B_t \\ B1_{i,t} \\ B2_{i,t} \end{bmatrix}$$

Back

1.1 Model-Implied Moment Conditions

The labour income process implies that the shocks to labour income of any two savers co-move with each other, only because each moves with stock return.

→ [N x N] symmetric matrix (covariances across individuals' shocks)

$$\begin{bmatrix} C(1,1) & C(2,1) & C(3,1) & . & . & C(N,1) \\ C(2,1) & C(2,2) & . & . & . & . \\ C(3,1) & . & . & & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ C(N,1) & . & . & . & . & C(N,N) \end{bmatrix}$$

- Co-movements across individuals' shocks are due to aggregate shocks, only

  ⇒ Off-diag entries informative on $\{\rho_i\}_{i=1}^{N}$

$$\begin{bmatrix} C(i,j) = \sigma_u \sigma_r \rho_i \rho_j & i \neq j \\ C(i,j) = \sigma_u^2 + 2\sigma_\epsilon^2 & i = j \end{bmatrix}$$

⇓

N parameters

$(N(N-1))/2$ conditions

(Over)-Identified model

1.2 Minimun Distance Estimation

We estimate

1. the deterministic component of labour income through a Panel Regression of income on Age, Sex, Education

$$\log(\hat{Y}_{i,t}) = \hat{f}(t, Z_{i,t}),$$

2. the stochastic component as the Regression Residuals

$$\log(Y_{i,t}) = \hat{f}(t, Z_{i,t}) + \hat{e}_{i,t},$$

3. the Permanent Income Shocks as the first difference of the residuals, $dres$

$$dres_{i,t} = \Delta\hat{e}_{i,t},$$

4. Find value of $\theta = \left\{\{\rho_i\}_{i=1}^{N}, \sigma_u, \sigma_\epsilon, \sigma_r\right\}$ that minimizes Q

$$Q(\theta) = (g_M - G_M(\theta))' I_M (g_M - G_M(\theta)),$$

where $\{g_m(\theta)\}$ and $\{G_m(\theta)\}_{m=1}^{M}$ are sample and model-implied moment conditions respectively

Back

Kalman Filter

The model is easily expressed in state-space form

Space-measurement equation (Observable)

$$e_{i,t} = v_{i,t} + \epsilon_{i,t},$$

where $\epsilon_{i,t} \sim \mathcal{N}(0, \sigma_\epsilon^2)$

Space-transition equation (Unobservable)

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

$u_{i,t} = \sigma_u \left(\rho_i (r_t / \sigma_r) + \eta_{i,t} \right)$

$\eta_{i,t} \sim \mathcal{N}(0, \sigma_u^2 (1 - \rho_i^2))$

$\rightarrow$ Idiosyncratic shocks

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:

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

$$E_0[P] = P + Q, Q = \sigma^2$$