Inflation, Demand for Liquidity, and Welfare

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MACROECONOMICS AFTER THE (FINANCIAL) FLOOD:
Conference in memory of Albert Ando (1929-2002)

Bank of Italy

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The views expressed are those of the authors and not of the Bank of Canada, the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Introduction

- We want to measure the costs of inflation.
- Most previous studies use representative-agent models and aggregate evidence to measure the cost.
  - Dotsey and Ireland (1996), Lucas (2000), and many more.
- Heterogeneous behavior and micro evidence can be important. Welfare cost varies considerably across households:
  - Mulligan and Sala-i Martin (2000), Doepke and Schneider (2006a) and Doepke and Schneider (2006b), Meh and Terajima (2008), Erosa and Ventura (2002), Chiu and Molico (2010).

Our Spin

1. To jointly account for age and income differentials in money holdings paying attention at time and cohort variation in people's ability to handle monetary transactions.

2. To try to shed light on the issue of whether the pass of time by economizing in money use gives us different answers about the cost of inflation.

Other literature

- Lucas (2000) points out an importance of using micro data to estimate the gains/costs of inflation.
- Mulligan and Sala-i Martin (2000) and Attanasio et al. (2002) use micro data to estimate the welfare cost of inflation.
- Dotsey and Ireland (1996) analyze a general equilibrium model of money demand with an intermediation cost of credit transaction technology.
- Erosa and Ventura (2002) incorporates heterogeneity over household income.
- Chiu and Molico (2010) uses a search model of demand for money.
- Heer and Maußner (2011) analyze the effects of inflation on distributions of both income and wealth.
- Heer et al. (2007) document that the money-age profile is hump-shaped and money is weakly correlated with income and wealth.
- Ragot (2010) documents that the distribution of money across households is more similar to that of financial assets than of consumption.
- Alvarez and Lippi (2009) introduce precautionary motives to the Baumol-Tobin model of cash-inventory management.

To get the welfare implications of inflation

1. We build an OLG model with within-age heterogeneity where money and credit are used for transactions.
2. We calibrate the model including age, cohort, and time effects on the willingness to consume and on the ability to make transactions with money or credit determining different money-consumption ratios.
3. We propagate the model under different inflation scenarios.

• We need to get information about people's willingness and ability to hold cash for transactions across, ages, cohorts, time and and income/wealth classes.

• Fortunately, we have the right type of (Canadian) data a detailed (repeated) cross-section of money holdings and in some years jointly with consumption.

Summary: Features of data holdings

- Money-consumption ratio is higher for older and poor households.
  - 4 times higher for old households (aged 76-85) relative to that for young (aged 26-35)
  - 3.5 times higher for the poorest 20% of households relative to the richest 20%
- Age differences qualitatively remain once we control for cohort and time effects.

Findings: Model Calibration and Cohort Effects

- Age- and cohort-specific transaction cost captures age profile of money holding well.
- Cohort effects account for 12 to 22% of the observed cross-sectional age differences in money-consumption ratios.

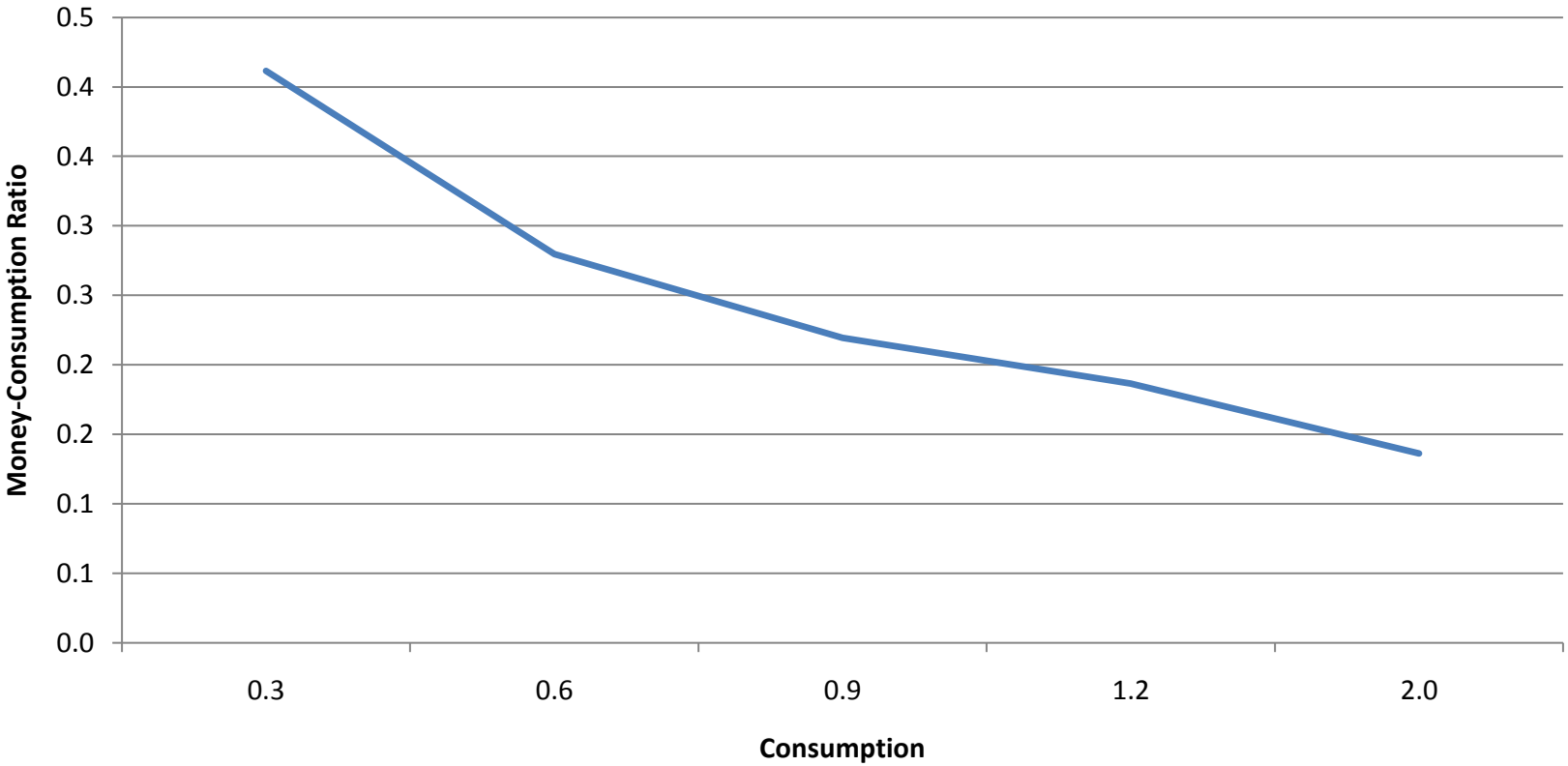
Findings: Cost of Inflation

- Inflation $\uparrow$ from 1.92% to 10% $\Rightarrow$ aggregate consumption $\downarrow$ by 1.34%
  - Seignorage $\uparrow$ by 0.79% of consumption
  - Net consumption decrease of 0.55%
- Distributional effects are summarized as follows,
  - Cohorts who are alive at the time of the increase in inflation bear 40% or larger welfare costs than those that are born later.
  - Poor households bear 2.5 times as large welfare costs than their rich peers.

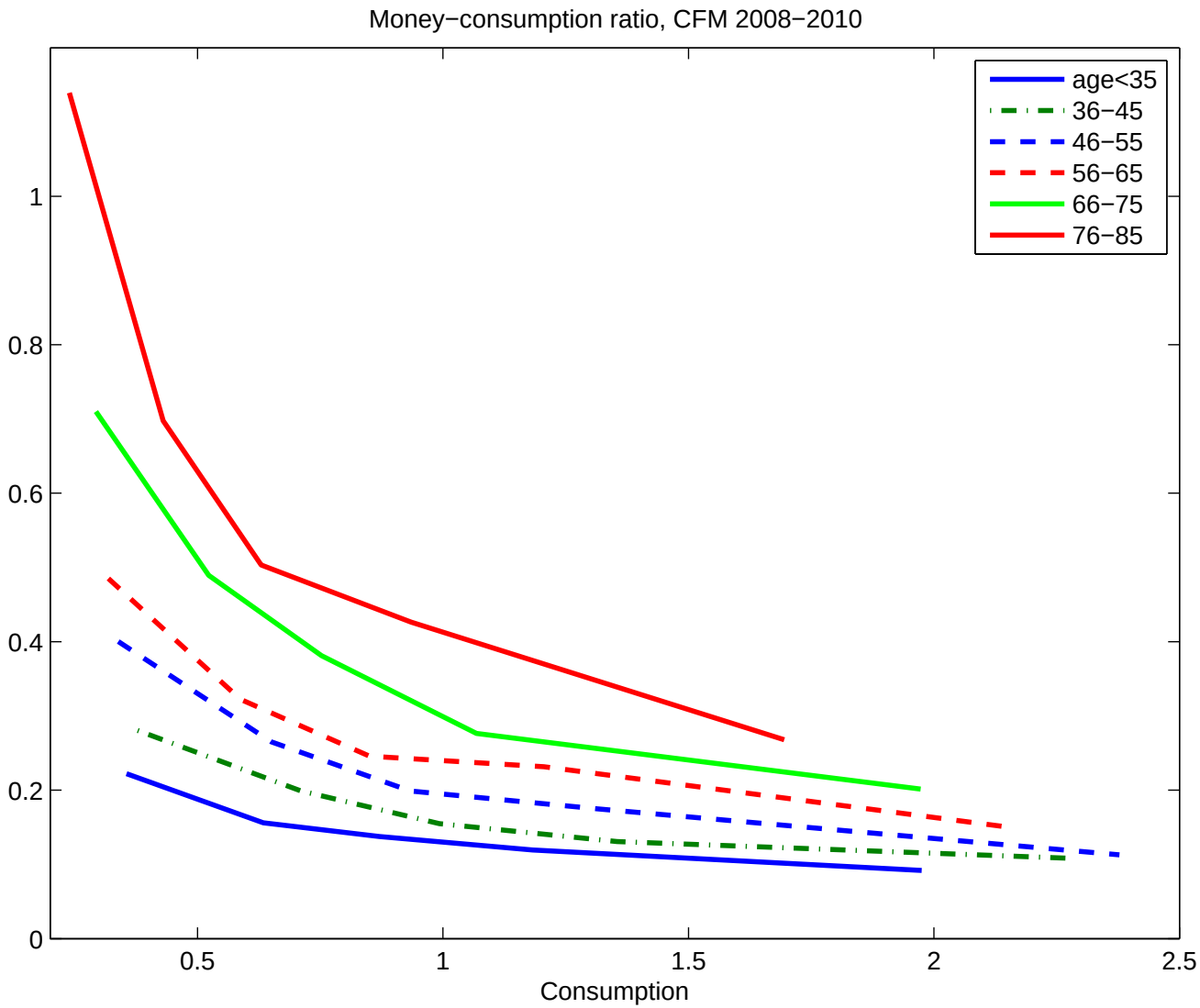
Data: Two Household Surveys

- Our main data sources are two household surveys (repeated cross-section)
- Canadian Financial Monitor (CFM), 1999-2010, by Ipsos Reid
  - "Money" holdings information available for all years
  - Consumption information available only for 2008-2010
- Survey of Household Spending (SHS), 1999-2009, by Statistics Canada
  - no information on money holdings
  - consumption information available for all years
- Money: checking account and some savings accounts (for transactions)
- Consumption: durables (excluding housing), non-durables, and service

Money-Consumption Ratio by Consumption, CFM 2008-10



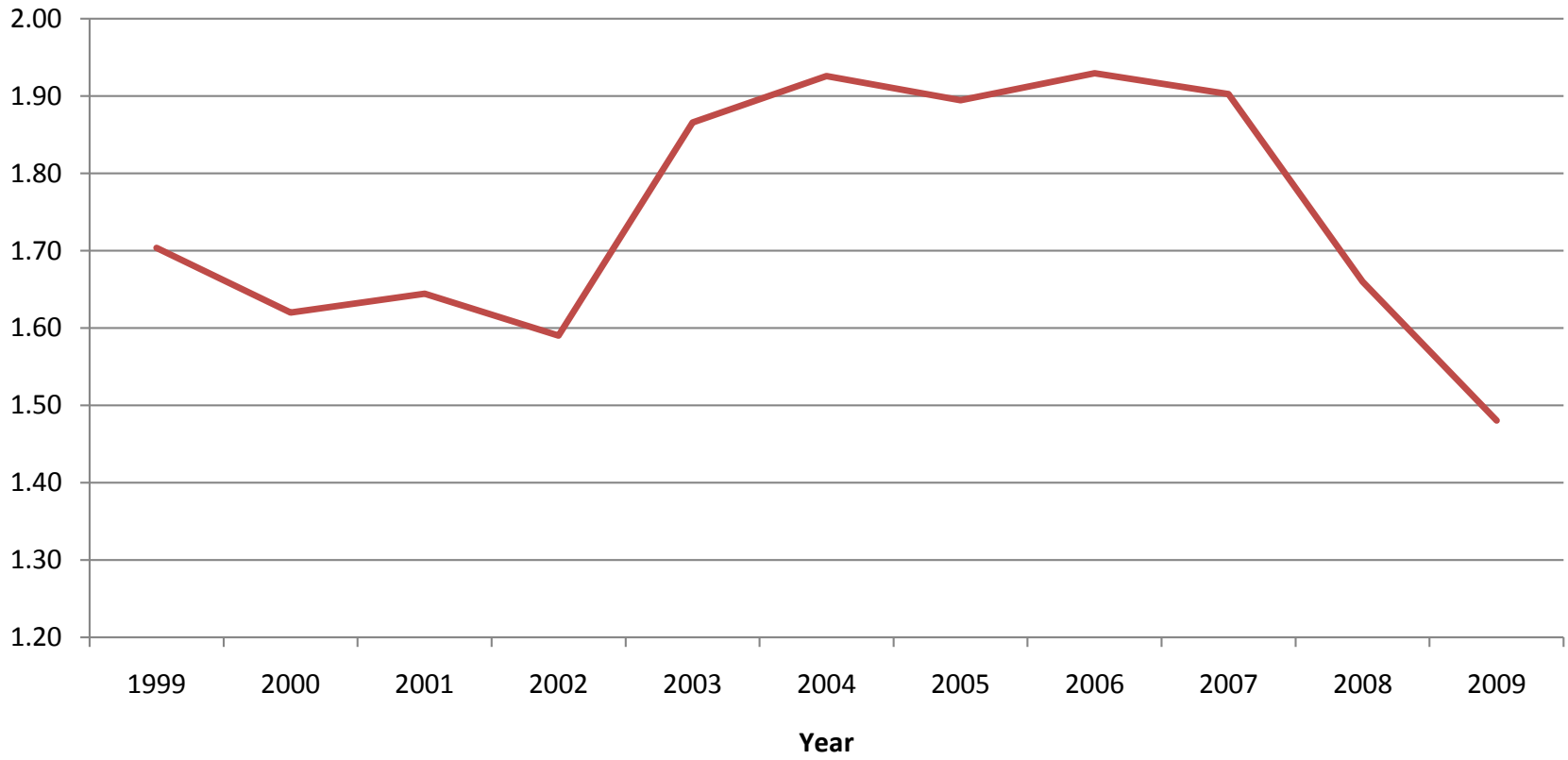
Money-Cons Ratio by Consumption & Age, CFM 2008-10



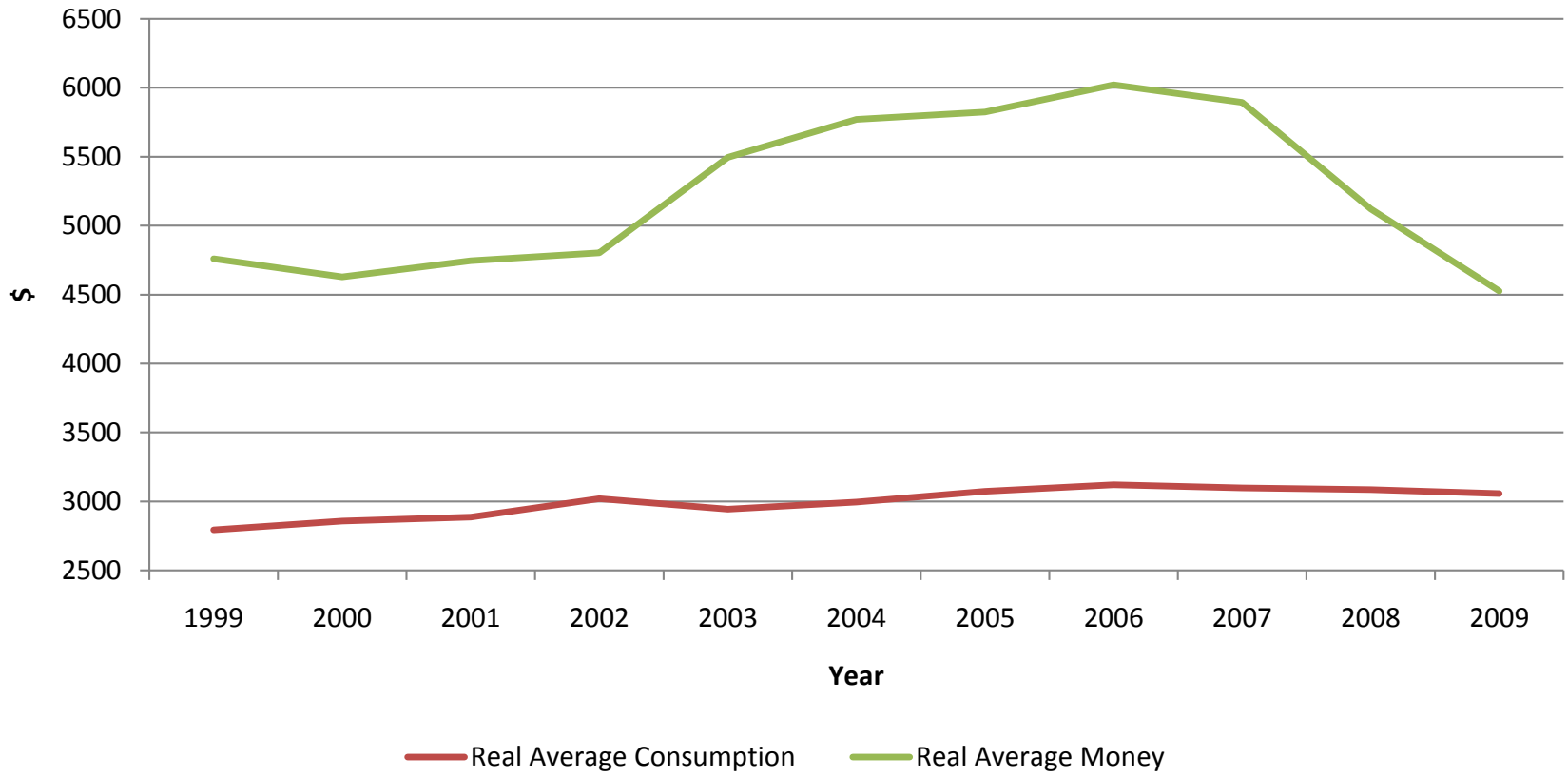
Why does Money/Consumption ratio increase with age?

- Is it an age effect? (Dumber, lazier,)
- Or a Cohort effect? New cohorts are better at managing money.
- Or a combination?

In Addition, Time Effects Mixed with Cohort Effects



It is more the Money Holdings than Consumption



The Model

- We build on Erosa and Ventura (2002) who did the seminal work to study the distribution of welfare costs of inflation:
  - An infinitely-lived agent model with costly credit transaction.
  - Study distribution of welfare cost over income.
  - But they abstract from life-cycle effects of inflation which is our focus or from changes over time.

Our OLG Model, age $i \in 1, \cdots I = 7$

- Agents differ in cohort ($h \in \{1, \cdots\}$) and earnings ($j \in \{1, \cdots, J = 5\}$).

- Consumption can be purchased with money and costly credit. Only transaction demand for money. Household's problem:

$$\max_{\{c_{hij}, s_{hij}, m_{h,i+1,j}, a_{h,i+1,j}\}} \sum_{i=1}^{I} \beta_{ij} \frac{c_{hij}^{1-\sigma}}{1-\sigma} \qquad \text{s.t.}$$

$$c_{hij}(1 - s_{hij}) \leq m_{hij}, \qquad \text{cash goods}$$

$$c_{hij} + w_t \cdot \underbrace{\int_0^{s_{hij}} \gamma_{hi}(x)dx}_{\text{credit-transaction cost}} + a_{h,i+1,j} + (1+\pi_t)m_{h,i+1,j} \leq$$

$$[1 + r_t(1-\tau_{at})]a_{hij} + m_{hij} + (1-\tau_{zt})w_t z_{ij};$$

$$a_{h,1,j} = 0, \; m_{h,1,j} = \underline{m}.$$

Transaction technology

$$\gamma_{hi}(x_t) = \gamma_i \, \eta^h \cdot \left(\frac{x_t}{1 - x_t} \right)^{\theta_i}$$

- Fixed cost with respect to consumption and variable with respect to money-credit ratios
- Age effects: γ_i and θ_i
- Cohort effects: we assume cohort effects (η^h) on credit transaction costs to proportionally change with cohort

Government Budget Constraint and Inflation

- Government budget constraint (G–exogenous government spending):

$$G_t = (1+\pi_t)\, M_{t+1} - M_t + \tau_{zt}\, w_t\, Z + \tau_{at}\, r_t\, A_t$$

- Exogenous inflation rates $\{\pi_t\}$ and capital income tax rates $\{\tau_{at}\}$.

- Labour income tax rates $\{\tau_{zt}\}$ are endogenous to balance the budget.

- Aggregate consistency:

$$M_t = \sum_{ij}^{IJ} m_{hijt}, \quad A_t = \sum_{ij}^{IJ} a_{hijt} \quad \text{and} \quad Z = \sum_{ij}^{IJ} z_{ij}.$$

Calibration strategy I

- Think of the equilibrium path of this model being made of two parts.
  1. Before 2009, restricted by observables.
  2. After 2009, a combination of assumptions over policy, certain equilibrium objects (world wide real rates of return), restrictions implied by equilibrium and budget constraints.

- So calibrating the model requires both to look forward and backward (24 cohorts born between 1939 to 2179 with a 10-year model period) and it needs a long run steady state to which the economy converges to.

- The current baseline converges to a path with the same inflation rate as now (1.9%), the same age distribution of both people and skills, and the same implied world rate of return. Along this path labor income taxes are set to balance the budget each period.

Calibration strategy II

- We want the model economy to replicate some key patterns of 2009:
  1. The consumption age-class distribution (30).
  2. The money-consumption age-consumption patterns (6).
  3. The money-consumption age-class-consumption average gradient (6).
  4. The overall change in the average money-consumption ratio between 1999 and 2009.

- Use the money-consumption ratio derived from the model as moments to be matched with data:

$$\frac{m_{hij}}{c_{hij}} = \frac{1}{1 + \left[\widetilde{R}_t c_{hij}/(w_t \gamma_i \eta^h)\right]^{1/\theta_i}}$$

Calibration: List of parameters

- 35 household labour endowments, $\{z_{ij}\}_{i=1,j=1}^{I,J}$
- 30 discount factors, $\{\beta_{ij}\}_{i=2,j=1}^{I,J}$
- 12 age-dependent credit-transaction cost parameters: 6 γ_i's and 6 θ_i's
- 1 cohort-effects parameter, η
- 5 aggregate parameters over time: π_t, r_t, $\tilde{R}_t$, τ_{at} and G_t

Calibration without solving the model: Parameters and moments

- 35 labour endowments: $\{z_{ij}\}_{i=1,j=1}^{I,J}$ to follow the age-profile of CFM labour earnings with an adjustment that their PV is the same as that of consumption.
- 5 agg. parameters: $\pi_t = \pi_t^{data}$, $r_t = r_t^{data}$, $\tilde{R}_t = \tilde{R}_t^{data}$, $\tau_{at} = \tau_{at}^{data}$, and $G_t = G_t^{data}$ over time

	1939	1949	1959	1969	1979	1989	1999	2009
Inflation (%)	2.37	4.00	1.75	5.60	8.11	3.36	2.02	1.92
Nominal interest rate (%)	4.96	4.50	5.60	7.53	12.50	9.70	5.50	4.11
Government expenditure (% of GDP)	26	26	26	27	26	25	22	24
Capital income tax rate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

  - After that these also remain constant at their 2009 level.

Calibration that requires solving the model: Parameters

- 30 discount factors, $\{\beta_{ij}\}_{i=2,j=1}^{I,J}$
- 12 age-dependent credit-transaction cost parameters: 6 γ_i's and 6 θ_i's
- 1 cohort-effects parameter, η
- The wages are set constant (via constant world rates of return and free movement of capital) w_t after 2009.
- τ_{zt} is solved to balance the G-budget until 2179 and set constant afterwards.

Calibration solving the model: Moments I

- 30 household consumption at $t = 2009$: $\{c_{ij}\}_{i=2,j=1}^{I,J}$
- 6 age-i average household money-consumption ratios at $t = 1$:

$$\frac{1}{J} \sum_{j} \left\{ \frac{m_{ij,2009}^{data}}{c_{ij,2009}^{data}} \right\}_{j=1}^{J}$$

- 6 age-i averaged slope of household money-consumption ratios over consumption at $t = 2009$:

$$\frac{1}{J} \sum_{j} \frac{\left[\left(\frac{m_{i,j+1,2009}^{data}}{c_{i,j+1,2009}^{data}} - \frac{m_{ij,2009}^{data}}{c_{ij,2009}^{data}} \right) \right]}{\left(c_{i,j+1,2009}^{data} - c_{ij,2009}^{data} \right)}$$

Calibration solving the model: Moments II

- The ratio of overall averaged money-consumption ratios between 1999 and 2009:

$$\frac{\frac{\overline{m_{1999}}}{\overline{c_{1999}}}}{\frac{\overline{m_{2009}}}{\overline{c_{2009}}}}$$

- Government budget equations over time:

$$G_t^{data} = (1 + \pi_t^{data})\, M_{t+1} - M_t + \tau_{zt}\, w_t\, Z + \tau_{at}^{data}\, r_t^{data}\, A_t$$

- Labour demand over time:

$$w_t = f_L(K_t, L_t)$$

gl

Calibration results

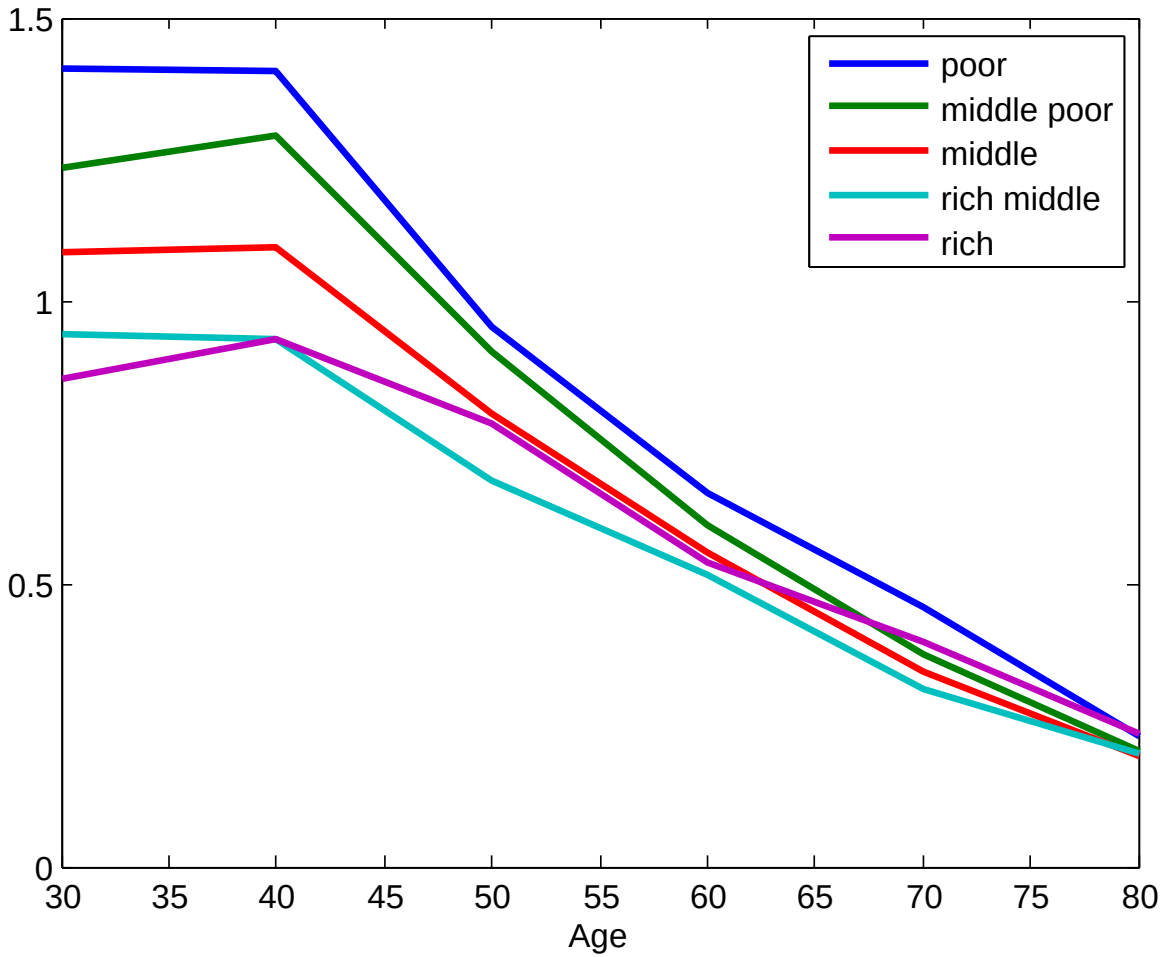
Parameter	Value	Target	Data	Model
γ_2	0.0044	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{2,j}$	0.1455	0.1384
γ_3	0.0167	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{3,j}$	0.1747	0.1777
γ_4	0.0417	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{4,j}$	0.2304	0.2405
γ_5	0.0461	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{5,j}$	0.2869	0.3005
γ_6	0.1104	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{6,j}$	0.4117	0.4313
γ_7	0.1284	$\frac{1}{5}\sum_j \left(\frac{m}{c}\right)_{7,j}$	0.6069	0.5877
θ_2	1.9073	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{2,j} / \Delta c_{2,j}$	-0.1021	-0.0995
θ_3	1.6672	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{3,j} / \Delta c_{3,j}$	-0.1231	-0.1262
θ_4	1.4857	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{4,j} / \Delta c_{4,j}$	-0.1970	-0.2050
θ_5	1.4661	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{5,j} / \Delta c_{5,j}$	-0.2557	-0.2673
θ_6	1.2169	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{6,j} / \Delta c_{6,j}$	-0.4615	-0.4780
θ_7	1.2000	$\frac{1}{4}\sum_j \Delta\left(\frac{m}{c}\right)_{7,j} / \Delta c_{7,j}$	-0.9359	-0.9367
η	0.8150	$\frac{\overline{m_{1999}}}{\overline{c_{1999}}} / \frac{\overline{m_{2009}}}{\overline{c_{2009}}}$	0.96	0.9608

Calibration results: η

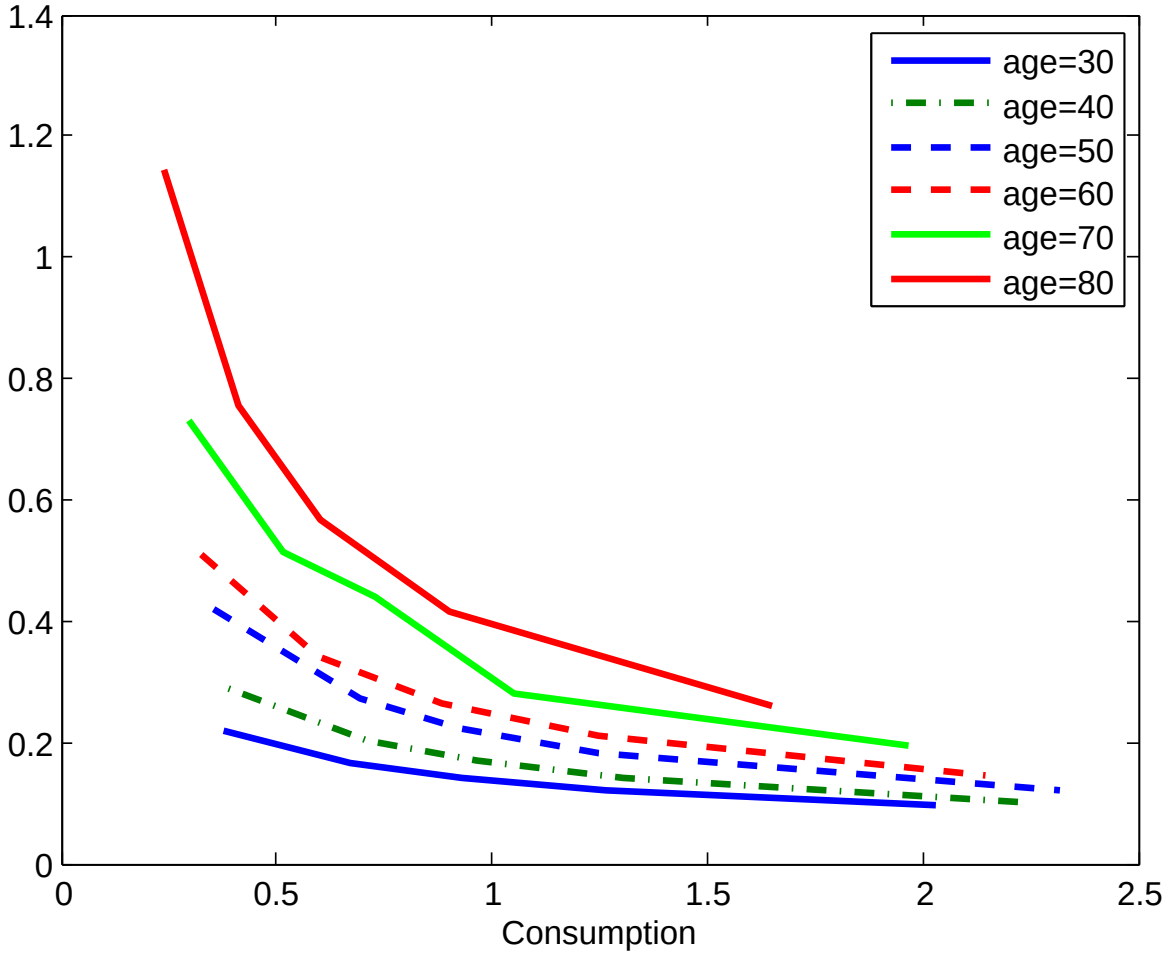
- $\eta = 0.815$ implies that credit-transaction technology improves by about 18% for each new cohort every 10 years.

- A measure of financial innovation.

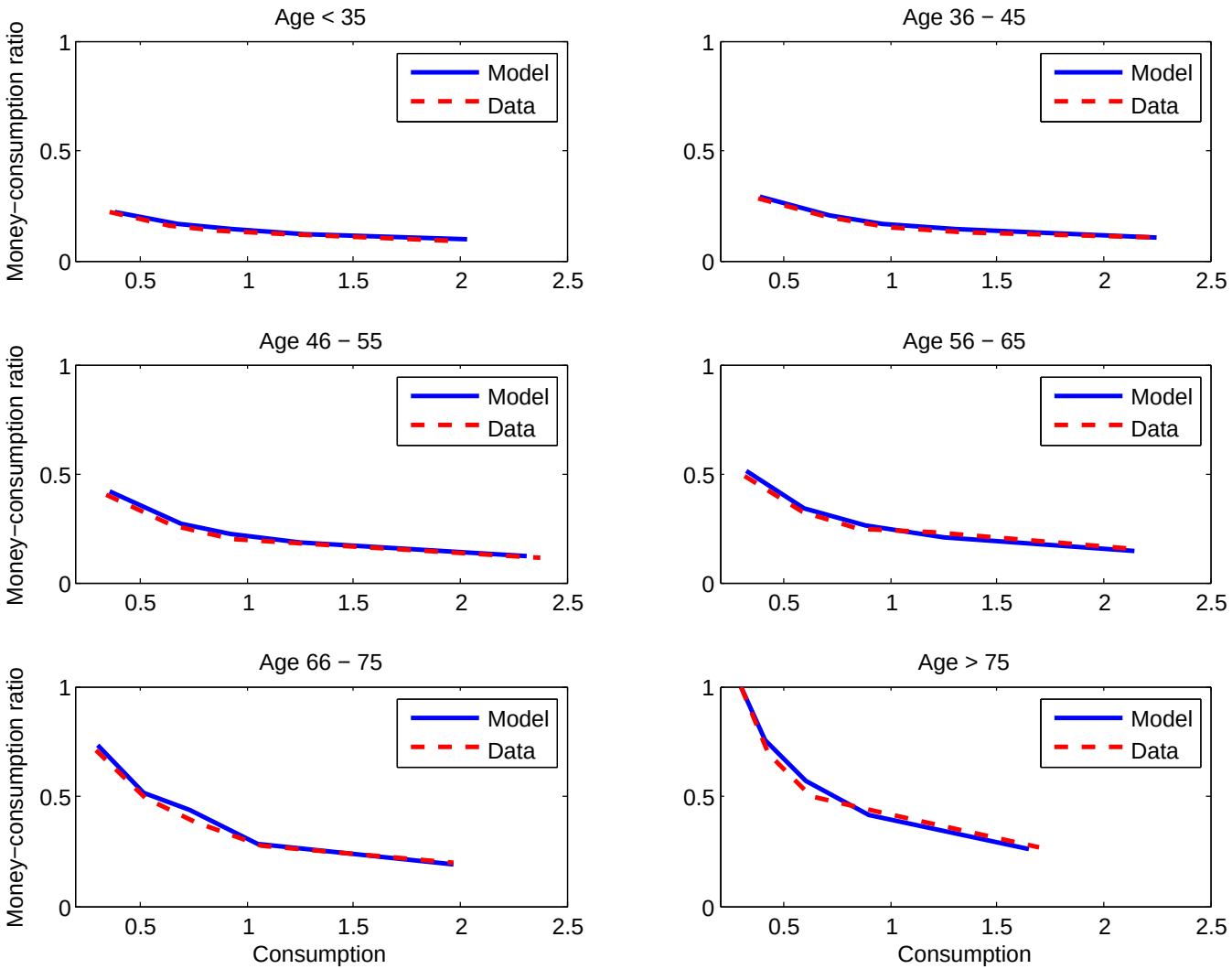
Calibration results: β's



Calibration results - Money-consumption ratios



Calibration results - Money-consumption ratios

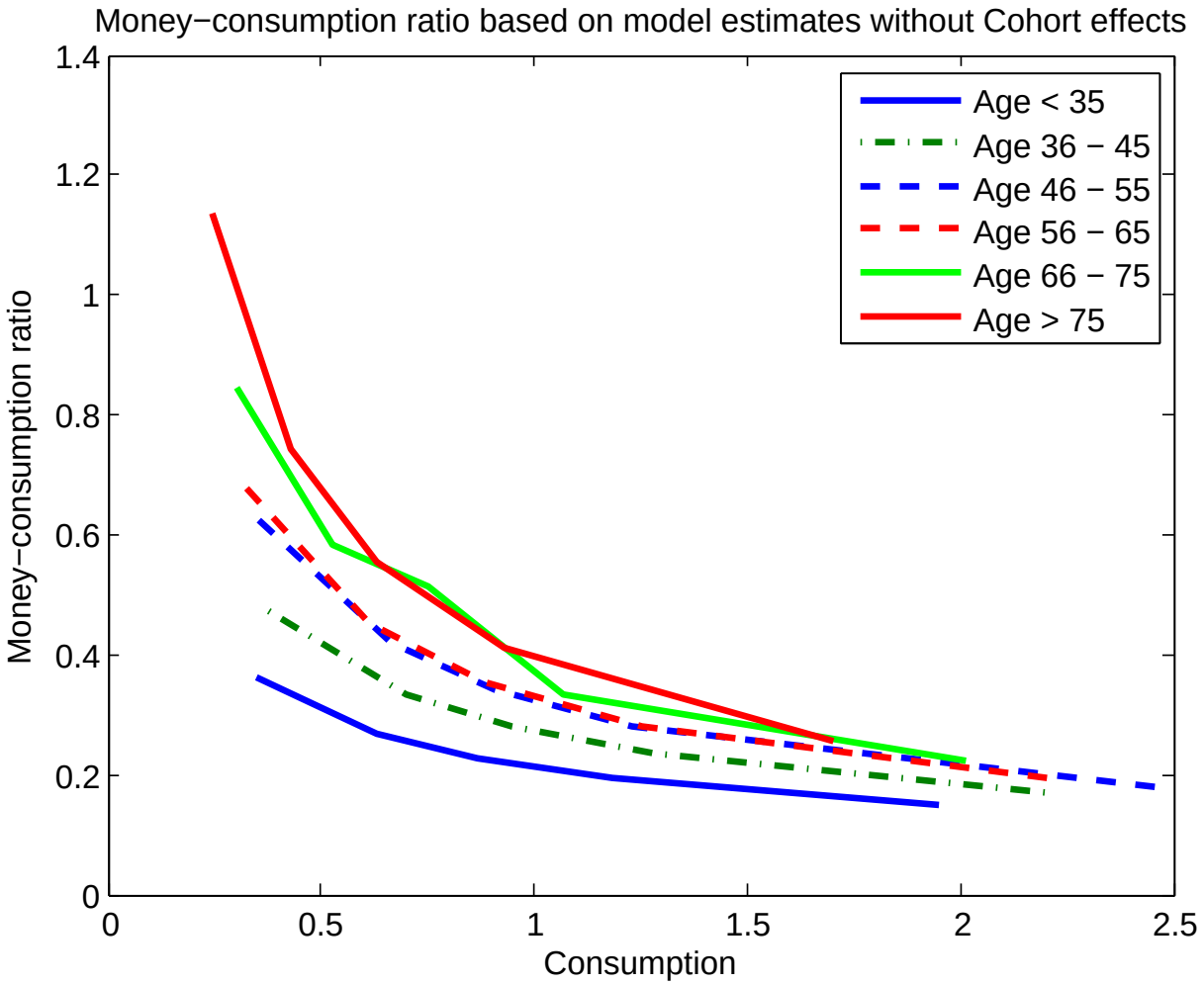


Taking out cohort effects

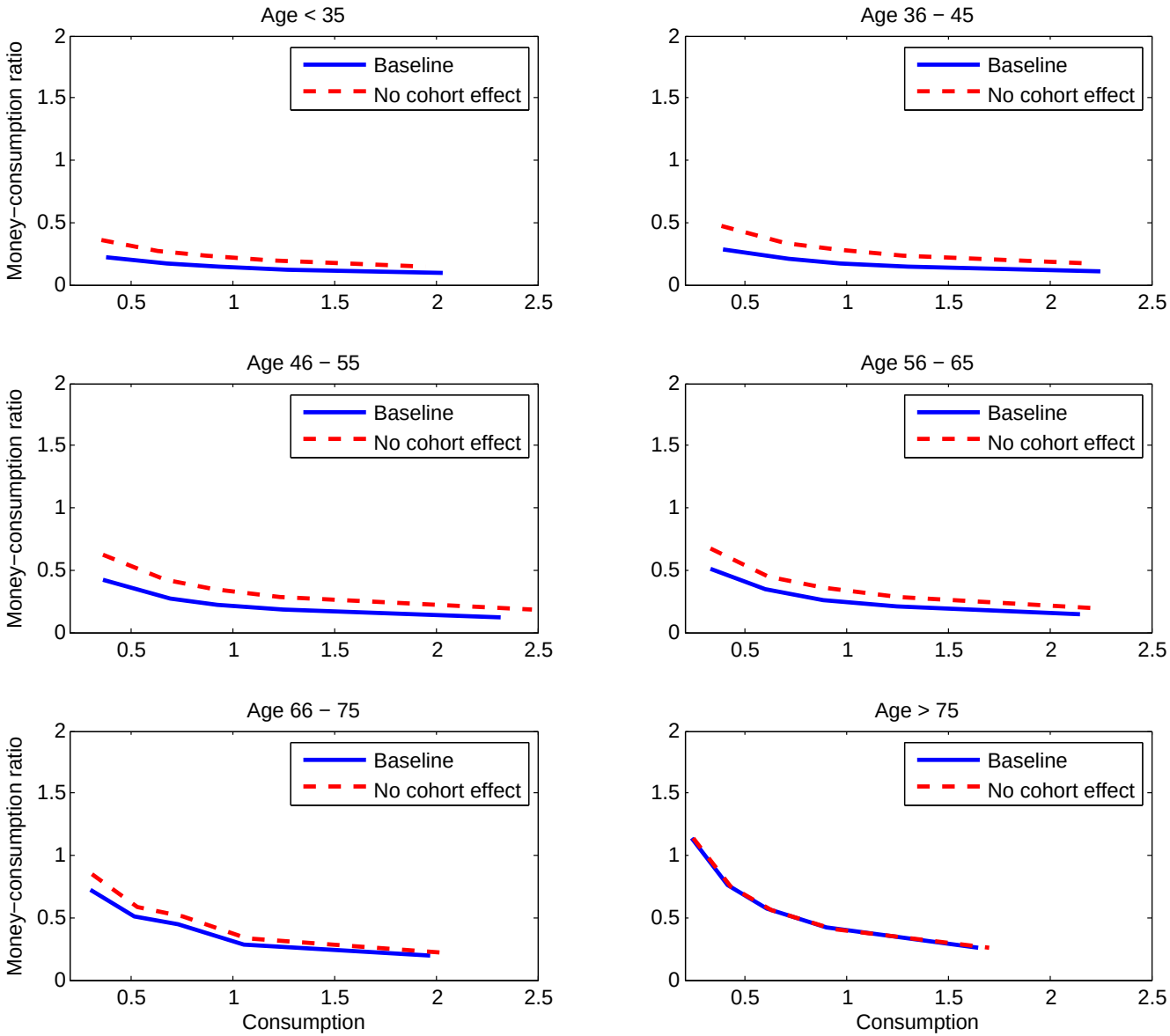
- Set the cohort index, h, to be the same for all cohorts at that of "Age $>$75" in 2009.

- Simulate the model and observe money-consumption ratios in 2009.

MC ratios without cohort effects in 2009



MC ratios without cohort effects in 2009



MC ratios without cohort effects in 2009

- Variations in money-consumption ratios across age groups are smaller without cohort effects.
- By how much?

Age difference in MC ratios in 2009

	<35	36-45	46-55	56-65	66-75	>75
			With cohort effects			
Poor	-0.807	-0.749	-0.632	-0.554	-0.362	0.000
Poor-Middle	-0.781	-0.733	-0.642	-0.547	-0.322	0.000
Middle	-0.753	-0.703	-0.608	-0.537	-0.223	0.000
Middle-Rich	-0.712	-0.661	-0.563	-0.498	-0.328	0.000
Rich	-0.634	-0.605	-0.537	-0.441	-0.255	0.000
Average	-0.737	-0.690	-0.596	-0.515	-0.298	0.000
			Without cohort effects			
Poor	-0.681	-0.584	-0.451	-0.403	-0.257	0.000
Poor-Middle	-0.639	-0.554	-0.439	-0.394	-0.218	0.000
Middle	-0.590	-0.499	-0.388	-0.364	-0.077	0.000
Middle-Rich	-0.527	-0.432	-0.320	-0.316	-0.188	0.000
Rich	-0.412	-0.337	-0.310	-0.244	-0.126	0.000
Average	-0.570	-0.481	-0.382	-0.344	-0.173	0.000
			Contribution from cohort effects			
Average Difference	0.168	0.209	0.215	0.171	0.125	0.000

- 12% to 22% of 2009 cross-sectional MC variations across age are accounted for by cohort effects.

Welfare Analysis

- Inflation increases from 1.92% in 2009 to 10% in 2019.
- Welfare losses (% of consumption) are:

Aggregate 1.34		Erosa-Ventura (2002) 1.44% of income			Lucas (2000) <1% of income		
		of which seignorage is					
0.79%		0.88%					
		so net effect is					
0.55%		0.56%					
In 2009							
80-y.o.	70–y.o.	60-y.o.	50-y.o.	40-y.o.	30-y.o.	20-y.o.	10-y.o.
0.000	1.80	1.98	1.87	1.81	1.64	1.49	1.30
Poor	Poor-Middle	Middle	Middle-Rich	Rich			
2.35	1.80	1.71	1.30	0.94			

Conclusion

- We have revisited one of the oldest questions in Economics.

- We have been concerned with both the actual money holdings of households, and their cross-sectional and aging patterns.

- We have worried about how technical change, or perhaps increases in saviness (like that of the secular increase in measured IQ) shape the answer.

- We have got a similar answer to our illustrous forebears: Inflation is quite painful.

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