Risk Premiums and Macroeconomic Dynamics in a Heterogeneous Agent Model

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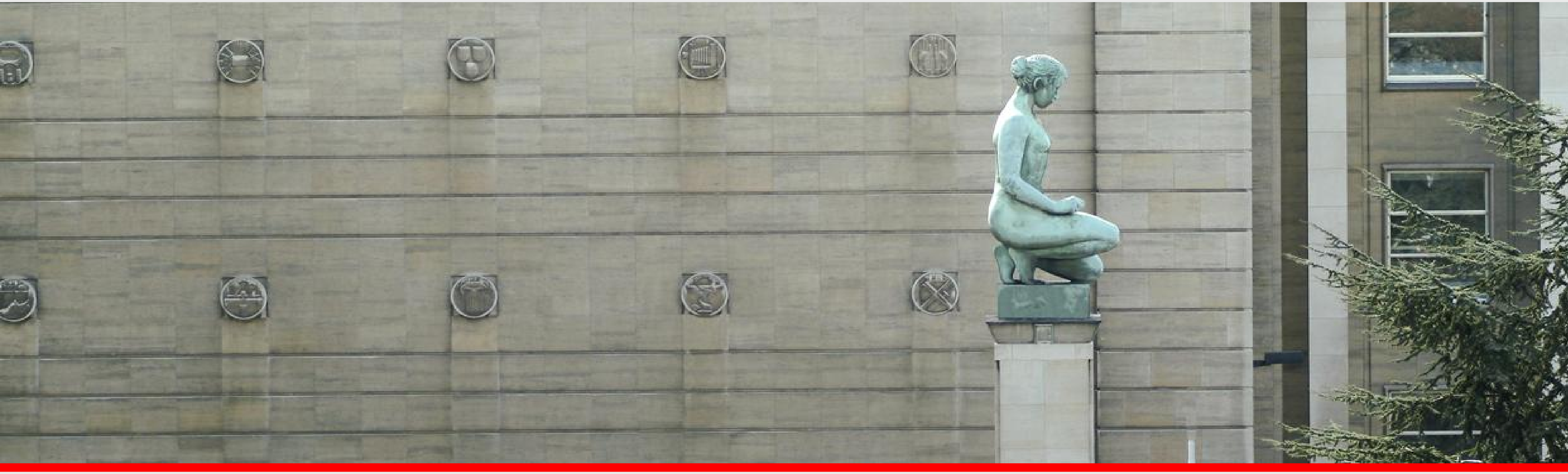

National Bank OF BELGIUM
Eurosystem

Motivation

- Search for a consistent framework for:
  - Macroeconomy: match volatility and correlations for Y, I, C, W, N
  - Finance: match average and time variation of risk premiums EP and TP
- This is crucial for monetary policy making to:
  - Recover information in asset prices
  - Identify and understand macroeconomic impact of risk premiums

Representative Agent Model

Standard representative agent model cannot simultaneously match macro and finance facts:

- Empirically smooth aggregate consumption is hard to reconcile with large risk premiums (Mehra and Prescott, 1985)
- In production economy many ways to perfectly smooth consumption (e.g. investment, labor) $\Longrightarrow$ no compensation/premium for risk (Jermann, 1998)
- No role for income distribution risk; only aggregate risk
- Improvements to the model include Boldrin et al. (2001), Lettau & Uhlig (2000), Uhlig (2007)

Heterogeneous Agent Model

We choose heterogeneous agent model:

- Shareholders' consumption more volatile than aggregate consumption
- Risk sharing results in wage rigidity and countercyclical wage share
- Countercyclical wage share implies volatile returns to capital and high equity premium
- For earlier work see Danthine and Donaldson (2002), Guvenen (2008)

Presentation Outline

- Model
- Overall results
- Impact of risk sharing
- Time-varying risk premiums
- Conclusion

Model Structure

- Standard model with sticky prices & monetary policy
- Heterogeneous agents:
  - Limited stock and bond market participation
  - Type 1, 2 & 3 agents: Shareholders, bondholders and workers
  - Different elasticity of intertemporal substitution/risk aversion (Vissing-Jorgensen, 2002)
  - Shareholders price the assets
- Incomplete markets with partial risk-sharing through:
  - Bond trading (shareholder-bondholder) à la Guvenen (2008)
  - Efficient labor contract (shareholder-worker) à la Danthine and Donaldson (2002)

Type 1, 2 & 3 Agents

$$\max_{C_{i,t},N_{i,t}} E_0 \sum_{t=0}^{\infty} \beta^t U_i\left(C_{i,t}, N_{i,t}\right) \qquad \text{with } i = 1, 2, 3$$

subject to:

$$C_{1,t} = \frac{W_t^s}{P_t} N_{1,t} + \underbrace{\frac{B_{1,t}}{P_t} - \frac{P_t^B}{P_t} B_{1,t+1}}_{Bond\ trade} + S_{1,t} \frac{\left(P_t^S + D_t\right)}{P_t} - \frac{P_t^S}{P_t} S_{1,t+1}$$

$$C_{2,t} = \frac{W_t^s}{P_t} N_{2,t} + \underbrace{\frac{B_{2,t}}{P_t} - \frac{P_t^B B_{2,t+1}}{P_t} \frac{1}{\phi(B_{2,t+1})}}_{Bond\ trade}$$

$$C_{3,t} = \underbrace{\frac{W_t^C}{P_t} N_{3,t}}_{Labor\ contract}$$

Firms

$$\max_{P_t(i), I_t(i), K_{t+1}(i)} E_t \left[\sum_{j=0}^{\infty} \beta^j \frac{U^C_{1,t+j}}{U^C_{1,t}} D_{t+j}(i) \right]$$

with

$$D_t(i) = \left[\begin{array}{c} \left(\frac{P_t(i)}{P_t}\right) Y_t(i) - \frac{W^s_t}{P_t}\left(N_{1,t}(i) + N_{2,t}(i)\right) - \underbrace{\frac{W^c_t}{P_t} N_{3,t}(i)}_{Labor\ contract} \\ -PAC_t(i) - I_t(i) + \frac{\left(P^{B_f}_t B_{f,t}(i) - B_{f,t-1}(i)\right)}{P_t} \end{array} \right]$$

subject to:

$$Y_t(i) = \mathbf{Z}_t K_t(i)^\theta N_t(i)^{(1-\theta)} - \phi = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t$$

$$K_{t+1}(i) = (1-\delta) K_t(i) + G\left(\frac{I_t(i)}{K_t(i)}\right) K_t(i)$$

Efficient Labor Contract

The wage contract solves bargaining problem:

$$\max_{C_{3,t},N_{3,t}} E_t \left\{ v_t U_1 \left(C_{1,t}, N_{1,t} \right) + \left(1 - v_t \right) U_3 \left(C_{3,t}, N_{3,t} \right) \right\}$$

subject to workers and shareholders budget constraint, and shocks to v_t (distribution risk). This results in FOC:

$$\begin{aligned} U_{1,t}^{C} &= \frac{\left(1 - v_t\right)}{v_t} U_{3,t}^{C} \\ \frac{W_t^s}{P_t} &= -\frac{U_{3,t}^{N}}{U_{3,t}^{C}} \end{aligned}$$

with

$$Insurance_t = \frac{W_t^c}{P_t} - \frac{W_t^s}{P_t}$$

Equilibrium

Goods market clearing condition:

$$Y_t = C_{1,t} + C_{2,t} + C_{3,t} + I_t + PAC_t$$

Bond market clearing condition:

$$\begin{aligned} B_{1,t} + B_{2,t} &= B_{f,t} \\ B_t^{long} &= 0 \end{aligned}$$

Equity market clearing condition:

$$S_t = 1$$

Labour market clearing condition:

$$N_{1,t} + N_{2,t} + N_{3,t} = N_t$$

Monetary policy:

$$(1 + R_t) = [(1 + \overline{R})\overline{\pi} \left(\frac{\pi_t}{\overline{\pi}}\right)^{r_\pi}]^{(1-r_\rho)} (1 + R_{t-1})^{r_\rho}$$

Calibration

- Standard calibration
- Greenwood, Hercowitz and Huffman (non-separable) utility function:

$$U_i\left(C_{i,t}, N_{i,t}\right) = \frac{\left(C_{i,t} - \psi_i N_{i,t}^{\phi}\right)^{1-\sigma_i}}{1-\sigma_i}$$

with $\sigma_1 = 4, \sigma_2 = 10, \sigma_3 = 10$.

- Technology proces:

$$\log(Z_t) = (1-\rho_z)\log(\overline{Z}) + \rho_z \log(Z_{t-1}) + \varepsilon_t^z.$$

- Bargaining power process:

$$\log(v_t) = (1-\rho_v)\log(\overline{v}) + \rho_v \log(v_{t-1}) + \varepsilon_t^v$$

- US economy estimates ε_t^v and ε_t^z are correlated $\Longrightarrow$ countercyclical bargaining power

Macro Dynamics

	Standard Deviation					
	σ_Y	σ_I	σ_C	σ_N	σ_W	$\sigma_{\frac{WN}{Y}}$
Data	**1.70**	**4.94**	**1.17**	1.34	0.78	2.34
Representative agent	**0.48**	**0.60**	**0.46**	0.84	1.15	0.31
Benchmark Model	**1.86**	**3.31**	**1.59**	0.82	0.63	2.37
	Correlation					
		$\rho_{I,Y}$	$\rho_{C,Y}$	$\rho_{N,Y}$	$\rho_{W,Y}$	$\rho_{\frac{WN}{Y},Y}$
Data		**0.76**	**0.79**	0.87	0.09	-0.19
Representative agent		**1.00**	**1.00**	-0.99	1.00	-0.50
Benchmark Model		**0.93**	**0.98**	0.94	0.55	-0.28

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Average Risk Premiums

	SR	EP	$y - R^f$	R^f	σ_{R^f}	σ_{R^S}
Data	**0.39**	6.11	1.34	1.19	2.84	15.50
Representative agent	**0.03**	0.09	-0.03	4.00	0.62	3.22
Benchmark Model	**0.24**	4.77	1.56	1.20	3.50	20.18

- Sharpe ratio $\simeq -\rho\sigma_{\triangle U_1^C}$
- Price of risk (Sharpe ratio) through shareholders' consumption volatility (Mankiw and Zeldes, 1991)

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- Equity premium $\simeq -\rho\sigma_{\triangle U_1^C}\sigma_{r^{stock}}$
- Amount of risk through profit volatility (equity)

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- Term spread $\simeq -\rho\sigma_{\triangle U_1^C}\sigma_{r^{long}}$
- Amount of risk through inflation risk

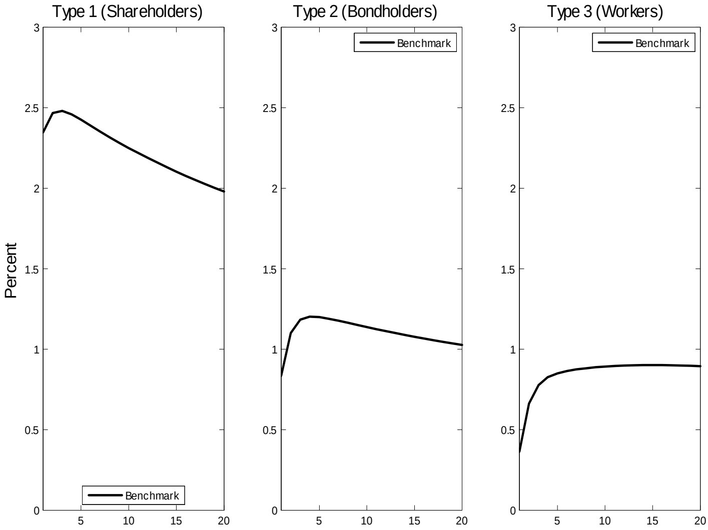
Risk Sharing

- Optimal risk sharing:

$$\frac{U^C_{1,t}}{U^C_{2,t}} = \frac{U^C_{1,t+1}}{U^C_{2,t+1}} = \mu$$

- Efficient labor contract:
  - Danthine Donaldson (2002)
  - Provides optimal aggregate risk sharing, but entails distribution risk
  - No direct allocative effects
- Bond trading:
  - Guvenen (2008)
  - Provides suboptimal aggregate risk sharing due to borrowing cost

Consumption Impulse Responses (Prod. Shock)



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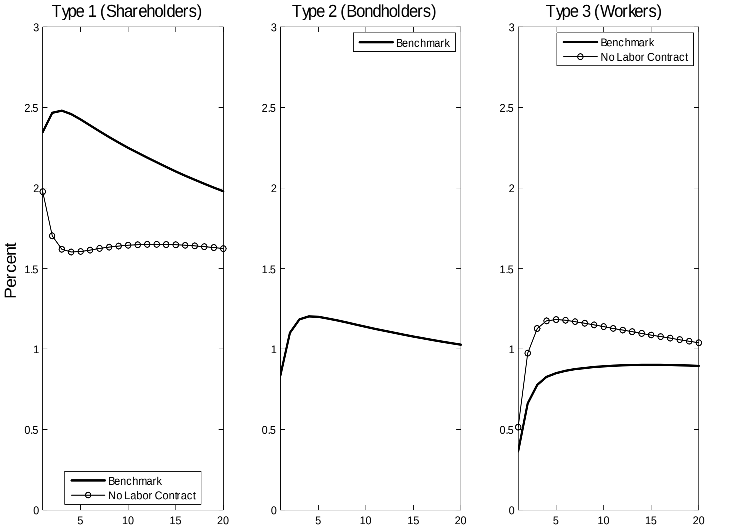

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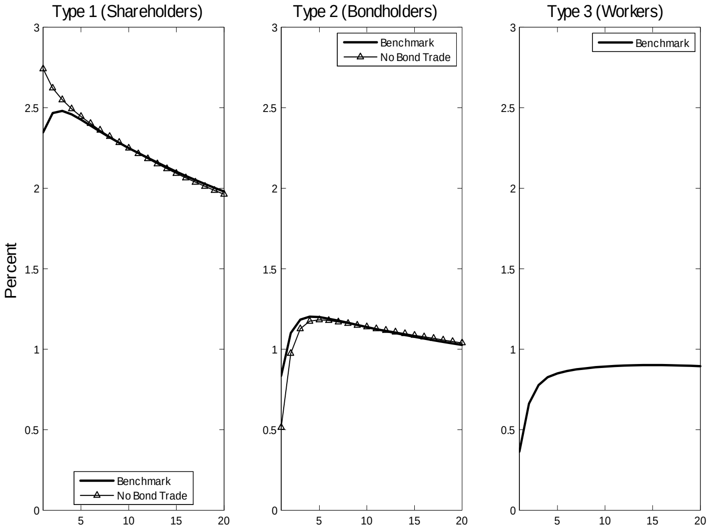
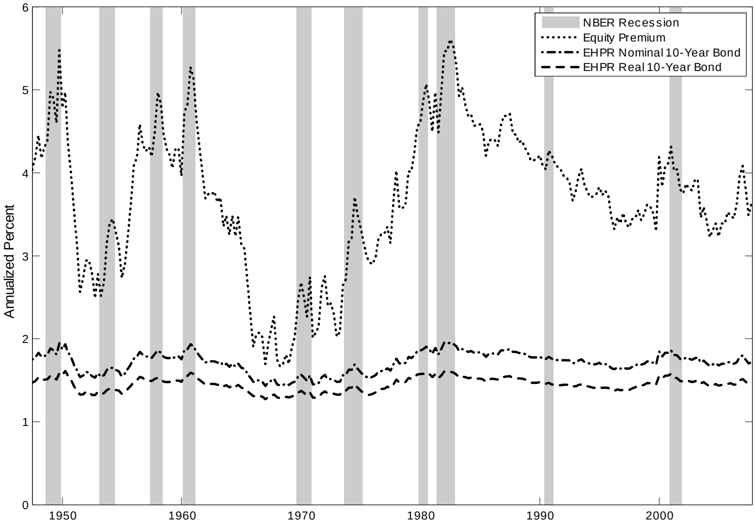


Time Varying Risk Premiums

Model produces realistic average premiums. What about time variation in risk premiums?

- Need third order approximation. We use Dynare^{++}
- Simulate model with historical productivity and distribution shocks 1947-2007
- Obtain countercyclical time variation in the equity premium, less so in the bond premium
- Explore other sources of time variation

Cyclicality of Risk Premiums



Predictability Regressions

- Finance literature regresses excess returns on price-dividend ratio (stocks) or yield spread (bonds)
- Countercyclical risk premiums generate predictability of excess returns
- We compare regressions on actual data and model implied data 1947-2007

Predictability Regressions

- **P/D regression stocks:**

$$r_{t,t+h} = \alpha + \beta(p_t - d_t) + \varepsilon_t \text{ with } H_0 : \beta = 0$$

- Campbell-Shiller regression bonds:

$$y_{n-1,t+1} - y_{n,t} = \alpha + \beta \frac{1}{n-1} \left(y_{n,t} - R_t^{nom}\right) + e_t \text{ with } H_0 : \beta = 1$$

Data		Model	
β	R^2	β	R^2
Stock Returns			
-1.34	**0.53**	**-1.26**	**0.63**
Nominal Bond Yields			
-3.80	0.03	0.98	0.01

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Other Sources of Time Variation

- Switches in monetary policy regime:
  - Regime with inflation target a function of actual inflation
  - Less inflation fighting regime

  $\Longrightarrow$ Higher inflation volatility regimes produce higher TP

- Changes in volatility of shocks (Great Moderation):
  - Break date 1984:4
  - 20% decline in distribution risk
  - 50% decline in productivity risk
  - Equity premium falls from 6.4% to 2.0%
  - Term spread falls from 2.1% to 0.6%

Conclusion

Heterogeneous agent model with distribution and productivity risk:

- Macroeconomic dynamics:
  - Match volatility and correlations for Y, I, C, W, N
- Finance:
  - Match average risk premiums SR, EP, TP
  - Match predictability regression equity
  - Matching predictability regression bonds remains a challenge
  - Potential role for shifts in monetary policy and distribution and productivity risk