# Explaining International Business Cycle Synchronization: Recursive Preferences and the Terms of Trade Channel

**Robert Kollmann**
**Université Libre de Bruxelles & CEPR**

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- **'World business cycle':**

**High cross-country correlations of GDP, Labor hours, investment**

- **Standard macro models cannot explain this!**

**▸Predict weak (or negative) transmission of country-specific shocks to foreign real activity**

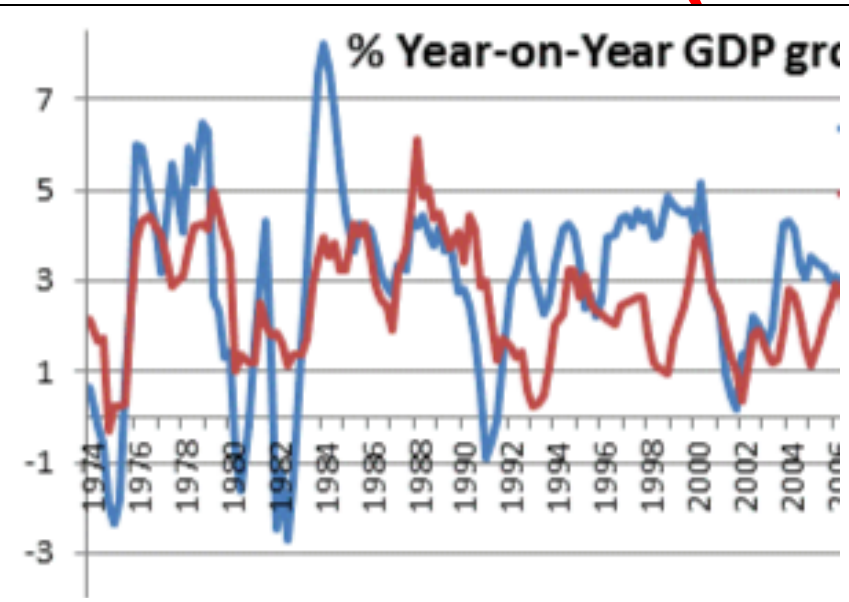
**▸Predicted cross-country correlations of GDP, I, Labor SMALLER than empirical correlations**

- **'International correlation puzzle'**

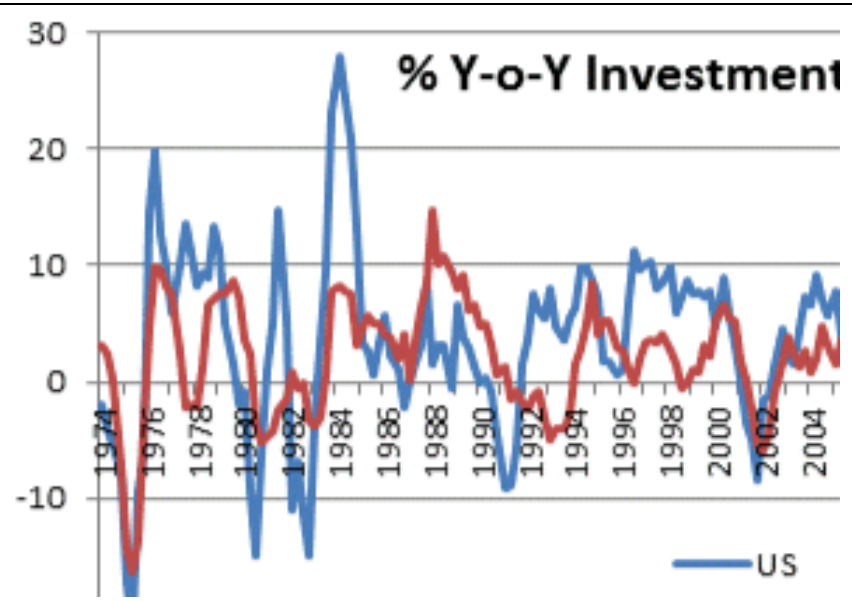
**Key challenge for (internat.) macro**

**E.g. Backus, Kehoe & Kydland (1992, 1994)**

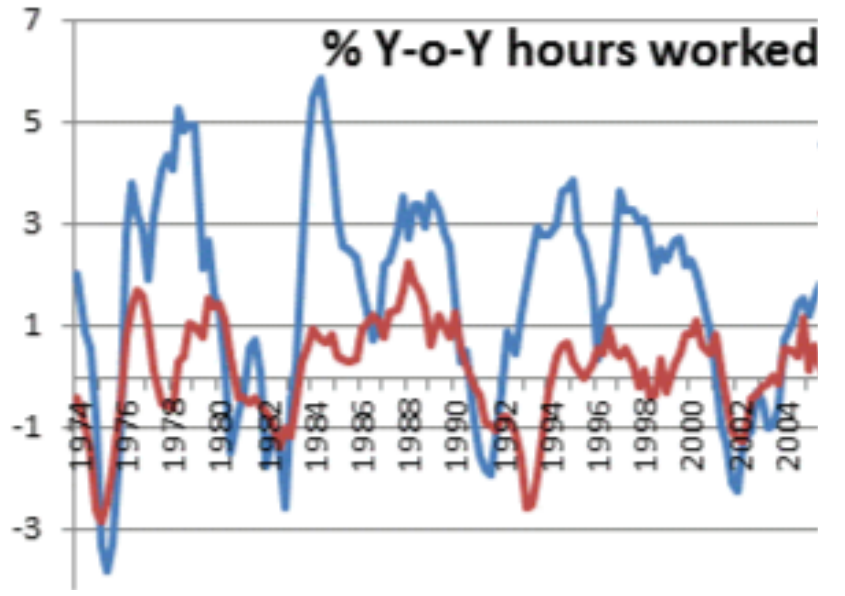
# US & 'ROW' (13 other OECD countries)




**Correlation: 0.65**




**Correlation: 0.62**

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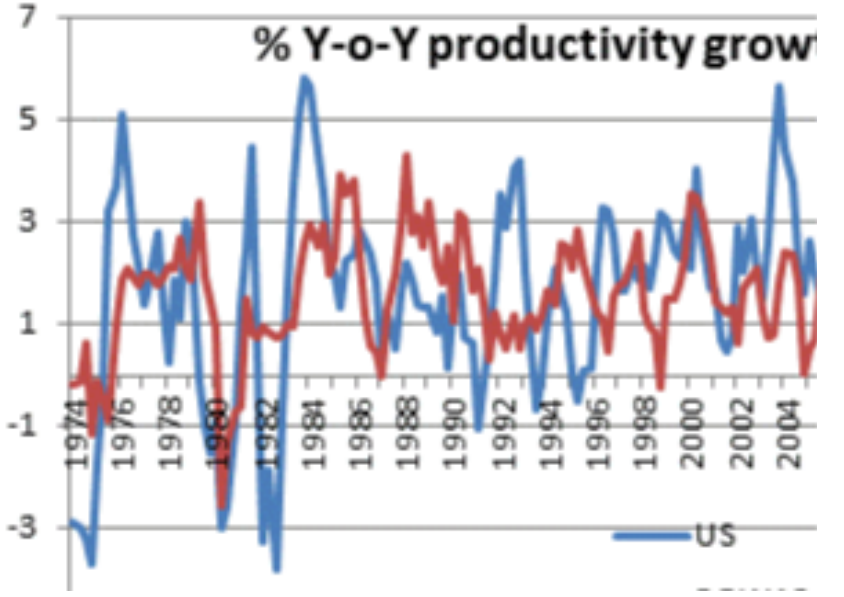


***Correlation: 0.39***

- **Not plausible that world business cycle is solely driven by common (world-wide) shocks.**

**►Supply shocks: TFP is LESS correlated across countries than GDP**

**►Demand shocks: Government purchases are LESS correlated across countries than GDP (YoY: 0.3)**

**Monetary policy shocks explain minor share of GDP**

**⇒ Mon.pol. cannot be driver of world business cycle**

**►Financial shocks: mattered during 2009-09 global financial crisis, but did NOT matter during rest of post-war history (for ADVANCED countries)**

**⇒ INTERNAT. BIZ CYCLE SYNCHRONIZATION MUST PARTLY BE ENDOGENOUS: SYNCHRONIZED DOMESTIC & FOREIGN RESPONSES TO COUNTRY-SPECIFIC SHOCKS**

**Problem: existing models do NOT generate strong endogenous internat. shock transmission**

**This paper: possible resolution of 'internat. correlation puzzle'**

***Simple* DSGE model in which *country-specific* TFP shocks induce**

- **positively correlated responses of domestic & foreign real activity**
- **realistic cross-country correlations of real activity**

- **Also: volatile real exchange rate**

# THE MODEL

## *Simple* two-country (Home, Foreign) structure:

- 2 traded goods
- Each country produces 1 traded good using domestic capital & labor (immobile)
- Local spending bias
- Complete financial markets
- Exogenous persistent TFP shocks

# Model DIFFERS from standard open econ models:

# Recursive intertemporal preferences (Nonexpected utility)

**Epstein, Zin, Weil [EZW]**

**VERY widely used in asset pricing literature; not much used in int'l macro**

**Standard int'l macro models: time-separable preferences, expected utility**

**Recursive preferences:**

- **stochastic discount factor more responsive**

**⇒ stronger real exchange rate & terms of trade response to shocks**

**⇒ Increase in 'Home' productivity triggers a strong 'Foreign' t.o.t. improvement**

**⇒Foreign labor demand↑ & Foreign investment↑**

**Will Foreign hours rise ?**

**Depends on labor supply response!**

**Foreign t.o.t. improvement↑⇒ Foreign WEALTH ↑**

- **With strong negative wealth effect on labor supply: Foreign hours ↓**
- **With MUTED labor wealth effect: Foreign L↑**

**⇒Foreign GDP ↑ ⇒ positive int'l comovement**

**With RECURSIVE preferences &**
**MUTED LABOR WEALTH EFFECT:**

- **model produces sizable cross-country correlations of GDP, Investment, Hours**

- **Can reproduce fact that cross-country correlations of Y,I,L are HIGHER than cross-country correlation of TFP**

- **Model also generates higher, more realistic real exchange rate volatility than conventional models**

**Muted labor wealth effect**

**Consider two mechanisms**

- **Greenwood, Hercowitz & Huffman [GHH] period utility: zero labor wealth effect**

**(compared to King, Plosser & Rebelo [KPR] period utility: negative labor wealth effect)**

- **real wage rigidity (in units of aggregate consumption)**

**& demand-determined labor input (workers off labor supply schedule)**

**Finding: real consumption wage rigidity induces especially powerful cross-country transmission, in conjunction with recursive preferences**

# Intuition: Consider persistent rise in Home TFP

To explain why Home TFP ↑ ⇒ Foreign GDP ↑
have to explain why

Home TFP ↑ ⇒ Foreign Labor ↑

- Terms of trade are key transmission channel:

Home TFP ↑ ⇒

⇒ Home real exchange rate (RER) depreciates

⇒ Home terms of trade (t.o.t.) ↓

⇒ Foreign t.o.t. ↑

⇒ Positive effect on Foreign Labor DEMAND

⇒ Positive substitution effect &
negative wealth effect on Foreign Labor SUPPLY

- **Foreign L ↑ if :**

**►STRONG effect on Foreign Labor DEMAND**

**►STRONG SUBSTITUTION effect on Foreign Labor SUPPLY**

**►WEAK WEALTH effect on Labor SUPPLY**

**Model with WEAK LABOR WEALTH EFFECT can generate STRONG rise in FOREIGN Hours & GDP IF Foreign t.o.t. improve strongly**

# Complete markets: Efficient risk sharing

$IMRS_H / IMRS_F \propto$ appreciation rate of Home RER

***IMRS*: intertemporal marginal rate of substitution in consumption**

**Under *time-separable* preferences: weak RER response to supply shock, as shock has weak effect on $IMRS_H / IMRS_F$**

**$\Rightarrow$ weak cross-country transmission**

- **With *recursive preferences*:**

**Home TFP ↑ triggers**

**STRONGER Foreign RER APPRECIATION &**

**Foreign terms of trade (t.o.t.) IMPROVEMENT**

- **With *weak wealth effect on labor supply*:**

**Stronger Foreign t.o.t. ↑ ⇒ Foreign labor ↑**

**Thus Home TFP ↑ ⇒ Home & Foreign GDP ↑**

**HOME & FOREIGN GDP, HOURS, INVESTMENT COMOVE POSITIVELY**

- **Recursive preferences:**

**coefficient of risk aversion (CRA) ≠ inverse of intertemporal elasticity of substitution (IES)**
**(Under 'standard' preferences: CRA=1/IES)**

**CRUCIAL: When CRA ≠ 1/IES: household's Intertemporal Marginal Rate of Substitution (IMRS) depends on (future) life-time utility**

**⇒ IMRS is volatile when shocks are persistent**
**[This is why EZW is popular in asset pricing!]**

- **Common assumption: CRA > 1/IES**

**⇒ increase in lifetime utility LOWERS IMRS.**

- **If Home productivity increase ↑**

**⇒ Home life-time utility ↑**

**⇒ Home IMRS ↓**

$IMRS_H / IMRS_F \propto$ appreciation rate of Home RER

**Result: under recursive preferences, Home productivity increase triggers STRONGER Foreign RER & terms of trade (t.o.t) deterioration (than with standard time-separable preferences)**

- **What mechanism induces stronger RER depreciation (under recursive preferences)?**

**Under recursive preferences, a rise in Home productivity triggers a large wealth transfer (risk sharing transfer) to Foreign**

**$\Rightarrow$ boosts demand for Foreign good**
**lowers demand for Home good**

**$\Rightarrow$ amplifies depreciation of Home RER**

**Thus: wealth transfer aligns relative IMRS & RER**

**RECURSIVE PREFERENCES**
**($\Rightarrow$ STRONG T.O.T. RESPONSE)**
**& MUTED LABOR WEALTH EFFECT**
**(GHH and/or RIGID WAGE)**
**ARE JOINTLY NEEDED FOR CROSS-COUNTRY BUSINESS CYCLE SYNCHRONIZATION**

**► With KPR period utility & flexible wage:**
**Assumption of RECURSIVE preferences LOWERS predicted cross-country correlation of Y & L**
**$\Rightarrow$ the "international correlation puzzle" gets worse**

**Intuition: with recursive preferences, Home TFP $\uparrow$ triggers wealth transfer Home $\rightarrow$ Foreign**
**This DAMPENS rise in Foreign Hours if labor wealth effect is NEGATIVE.**

# Literature

- **Vast finance literature uses EZW preferences**
- **Open economy macro-finance literature is slowly beginning to consider EZW preferences, but mainly considers endowment economies**

**Eg Kollmann (2009, 2015, 2016),**
**Colacito & Croce (2011,2013), Lewis & Liu (2015)**
**Gourio, Siemer & Verdelhan (2013,2015) Etc.**

**These papers show that EZW preferences can explain volatile real exchange rates**

●Contribution of THIS paper:
PRODUCTION economy
⇒ show that recursive (EZW) preferences help to RESOLVE international correlation puzzle.
IF assume weak wealth effect on labor (GHH and/or rigid wage)

Other papers on production economies with recursive preferences: Benigno, Benigno & Nisticò (2012), Colacito, Croce, Ho & Howard (2014), Mumtaz & Theodoridis (2015), Backus et al. (2016), Tretvoll (2016)
■ Different focus (RER volatility, risk shocks); models do not feature internat. transmission channel due to muted labor wealth effect

- **Open economy models with GHH preferences:**

**►No analysis of role of muted labor wealth effect for cross-country correlations of Y,I,L**

**►No recursive intertemporal preferences**

**E.g., Devereux et al. (1992), Correia & Rebelo (1995), Jaimovich & Rebelo (2008), Raffo (2010)**

# THE MODEL

- **Countries, *i*=H, F (Home, Foreign)**
- **Two traded goods, country *i* produces good *i***

**with local labor and capital:** $Y_{i,t}=(L_{i,t}\theta_{i,t})^{\omega}(K_{i,t})^{1-\omega}$

- **Country *i* final good:** $Z_{i,t}\equiv(y^{i}_{i,t}/(1-\alpha))^{1-\alpha}(y^{j}_{i,t}/\alpha)^{\alpha}, j\neq i,$

$y^{j}_{i,t}$ **: input *j* used by country i; local spending bias:** $0<\alpha<0.5$

**Final good used for consumption & investment:**

$Z_{i,t}=C_{i,t}+I_{i,t}, \quad K_{i,t+1}=(1-\delta)K_{i,t}+I_{i,t}$

- **Country i final good price:** $P_{i,t}=(p_{i,t})^{1-\alpha}(p_{j,t})^{\alpha}$

- **Home terms of trade & RER:**

$$q_{H,t}\equiv p_{H,t}/p_{F,t}, \quad RER_{H,t}\equiv P_{H,t}/P_{F,t}=(q_{H,t})^{1-2\alpha}$$

**Rise in q, RER: Home terms of trade (t.o.t.) improve & Home RER appreciates**

## ● Period utility

$$u_{i,t}(C_{i,t},L_{i,t})=\frac{1}{1-\sigma}[\psi_{i,t}(C_{i,t},L_{i,t})]^{1-\sigma} \quad \sigma>0,\ \sigma\neq 0$$

**► Standard period utility:**

**King, Plosser & Rebelo [KPR] (1988)**

$\psi_{i,t}=C_{i,t}\cdot\zeta(L_{i,t})$, **with** $\zeta'<0$

**(consistent with balanced growth)**

**► Greenwood, Hercowitz & Huffman [GHH] (1988)**

$\psi_{i,t}(C_{i,t},L_{i,t})=C_{i,t}+X_{i,t}\nu(L_{i,t})$, **with** $\nu'$, $\nu''<0$

$X_{i,t}=(X_{i,t-1})^{1-\eta}(\theta_{i,t-1})^{\eta}$, **with** $\eta=0.001.$

[$X_{i,t}$: **ensures balanced growth & stationary hours]**

$mrs_{i,t} \equiv -(\partial \psi_{i,t} / \partial L_{i,t}) / (\partial \psi_{i,t} / \partial C_{i,t})$.

**Household intra-temporal optimization:** $mrs_{i,t} = w_{i,t}$

$w_{i,t}$**: wage in consumption units ('consumption wage')**

**KPR:** $w_{i,t} = -C_{i,t} \cdot \zeta'(L_{i,t}) / \zeta(L_{i,t})$

**GHH:** $w_{i,t} = -X_{i,t} \nu'(L_{i,t})$

**KPR: offer wage is increasing in Consumption**

$\Rightarrow$ **a wealth increase REDUCED desired labor supply**

**GHH: labor supply does NOT depend on consumption. Wealth shock does not affect labor supply.**

- **Recursive EZW intertemporal preferences:**

$$U_{i,t}=\{(1-\beta)\cdot[\psi_{i,t}(C_{i,t},L_{i,t})]^{1-\sigma}+\beta\cdot[E_tU_{i,t+1}^{1-\gamma}]^{(1-\sigma)/(1-\gamma)}\}^{1/(1-\sigma)}$$

**$\sigma$: 1/IES intertemporal elasticity of substitution (IES)**

**$\gamma$: coefficient of risk aversion (CRA)**

**NB When $\gamma=\sigma$: time-separable utility**

**Intertemporal marginal rate of substitution (IMRS) depends on future life-time utility**

$$\rho_{i,t+1}\equiv\beta\frac{\partial u_{i,t+1}/\partial C_{i,t+1}}{\partial u_{i,t}/\partial C_{i,t}}\left(\frac{U_{i,t+1}}{(E_tU_{i,t+1}^{1-\gamma})^{1/(1-\gamma)}}\right)^{\sigma-\gamma}$$

► **Efficient risk sharing**

$$\rho_{H,t+1}/\rho_{F,t+1}=RER_{t+1}/RER_t$$

$$\rho_{i,t+1} \equiv \beta \frac{\partial u_{i,t+1}/\partial C_{i,t+1}}{\partial u_{i,t}/\partial C_{i,t}} \left( \frac{U_{i,t+1}}{(E_t U_{i,t+1}^{1-\gamma})^{1/(1-\gamma)}} \right)^{\overbrace{\sigma-\gamma}^{<0}} ; \quad \frac{\rho_{H,t+1}}{\rho_{F,t+1}} = \frac{RER_{H,t+1}}{RER_{H,t}}$$

**Standard assumption:** $\gamma > \sigma \equiv 1/IES$ **(preference for early resolution of uncertainty)**

- **Unexpected RISE in future life-time utility LOWERS IMRS: Consumption & life-time utility are 'substitutes'**

► **Positive TFP shock in country H:**

- **Relative consumption of country H ↑**
- **Relative life-time utility of country H ↑**
- **RER of country H depreciates strongly**

⇒ **Relative price of good H ↓**

**Terms of trade of country H worsen,**
**Terms of trade of country F improve**

**Investment decisions:**

$$1=E_t\rho_{i,t+1}\{(p_{i,t+1}/P_{i,t+1})\cdot MPK_{i,t+1}+1-\delta\},\quad MPK_{i,t+1}\equiv(1-\omega)Y_{i,t+1}/K_{i,t+1}$$

**Labor demand:** $w_{i,t}$ **'consumption wage'**

$$(p_{i,t}/P_{i,t})\cdot MPL_{i,t}=w_{i,t},\quad MPL_{i,t}\equiv\omega Y_{i,t}/L_{i,t}$$

- **Flex-wage economy:** $(p_{i,t}/P_{i,t})\cdot MPL_{i,t}=w_{i,t}=mrs_{i,t}$

- **Sticky-wage economy (predetermined wage):**

$$(p_{i,t}/P_{i,t})\cdot MPL_{i,t}=w_{i,t}=E_{t-1}mrs_{i,t}$$

► $p_{i,t}/P_{i,t}=(p_{i,t}/p_{j,t})^{\alpha}$; $\alpha>0$: import share

**Terms of trade improvement *RAISES***
**marginal product of capital & labor, in final good units**
**⇒ investment and labor demand ↑**

# PARAMETERS

- **Preferences: $\beta$=0.99; Frisch labor supply elasticity: 2;**

**Intertemporal elasticity of substitution: IES=1.5;**

**Risk aversion:** $\gamma = 1/IES = 0.66$ **&** $\gamma = 50$

- **Technology:** $\omega = 0.65$ **[labor share];** $\alpha = 0.10$ **[import share]**

- **Productivity:**

$$\ln(\theta_{i,t+1}) - \ln(\theta_{i,t}) = -\kappa \cdot [\ln(\theta_{i,t}) - \ln(\theta_{j,t})] + \varepsilon^{\theta}_{i,t+1}, \quad \kappa = 0.001$$

**Fitted to quarterly US & ROW productivity (hours data), 1973-2013.**

**ROW: aggregate of 13 other OECD countries**

**Std($\varepsilon^{\theta}_{i,t+1}$) = 0.78%; Corr($\varepsilon^{\theta}_{H,t+1}, \varepsilon^{\theta}_{F,t+1}$) = 0.13**

**Internat. corr. of productivity < internat. corr of GDP**

# SOLUTION METHOD: Third-order approx.

# Historical statistics ('73q1-'13q4) [growth rates/1st diff.]

| | US | ROW | |
|---|---|---|---|
| **Standard deviations (%)** | | | |
| GDP | **0.81** | **0.59** | |
| **Standard deviations relative to GDP** | | | |
| Consumption | 0.66 | 0.74 | |
| Investment | **4.09** | **3.53** | |
| Hours worked | 0.89 | 0.71 | |
| Real exchange rate | **3.03** | n.a. | |
| **Cross-country correlations** | | | |
| GDP | | | **0.45** |
| Consumption | | | **0.35** |
| Investment | | | **0.34** |
| Hours worked | | | **0.43** |

# Predicted moments: Flexible wage

## Role of: KPR/GHH utility; risk aversion ($\gamma$)

| | Flexible wage | | | | |
|---|---|---|---|---|---|
| | KPR | | GHH | | |
| | $\gamma$=1/IES | $\gamma$=50 | $\gamma$=1/IES | $\gamma$=50 | Data |
| | (1) | (2) | (3) | (4) | (5) |
| **Standard deviations (%)** | | | | | |
| GDP | 0.82 | 0.85 | 0.90 | 0.84 | 0.81 |
| **Standard deviations relative to GDP** | | | | | |
| C | 0.22 | 0.25 | 0.48 | 0.39 | 0.66 |
| Labor | 0.61 | 0.63 | 0.67 | 0.61 | 0.89 |
| RER | **0.37** | **1.51** | **0.16** | **1.53** | 3.03 |
| **Cross-country correlations** | | | | | |
| GDP | **0.23** | **0.14** | **0.14** | **0.35** | 0.45 |
| C | **0.13** | **-0.02** | **-0.30** | **0.65** | 0.35 |
| I | **0.19** | **0.34** | **0.21** | **0.64** | 0.34 |
| Labor | **0.38** | **0.15** | **0.15** | **0.62** | 0.43 |
| **Hansen-Jagannathan bound** | | | | | |
| | **0.002** | **0.257** | **0.002** | **0.225** | |

- Recursive preferences: RER volatility ↑ HJ bound (std(IMRS))↑
- KPR utility (*negative* wealth effect on labor supply): recursive pref. worsen "international correlation puzzle"
- GHH utility (*zero* wealth effect on labor supply): recursive pref. induce higher cross-country correl.

HJ bound=std(IMRS)/E(IMRS); Sharpe ratio=E(Rx)/std(Rx); SR≤HJ. Rx: excess return; historical SR equity: 0.22

# Predicted moments: Flexible wage vs. Rigid wage

## Role of: KPR/GHH utility; risk aversion ($\gamma$)

| | Flexible wage | | | | Predeterm. wage | | |
|---|---|---|---|---|---|---|---|
| | KPR | | GHH | | KPR | GHH | |
| | $\gamma$=1/IES | $\gamma$=50 | $\gamma$=1/IES | $\gamma$=50 | $\gamma$=50 | $\gamma$=50 | Data |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| **Standard deviations (%)** | | | | | | | |
| GDP | 0.82 | 0.85 | 0.90 | 0.84 | 1.36 | 1.36 | 0.81 |
| **Standard deviations relative to GDP** | | | | | | | |
| C | 0.22 | 0.25 | 0.48 | 0.39 | 0.48 | 0.72 | 0.66 |
| Labor | 0.61 | 0.63 | 0.67 | 0.61 | 1.07 | 1.03 | 0.89 |
| RER | **0.37** | **1.51** | **0.16** | **1.53** | **0.95** | **0.95** | 3.03 |
| **Cross-country correlations** | | | | | | | |
| GDP | **0.23** | **0.14** | **0.14** | **0.35** | **0.52** | **0.47** | 0.45 |
| C | **0.13** | **-0.02** | **-0.30** | **0.65** | **0.69** | **0.69** | 0.35 |
| I | **0.19** | **0.34** | **0.21** | **0.64** | **0.70** | **0.54** | 0.34 |
| Labor | **0.38** | **0.15** | **0.15** | **0.62** | **0.73** | **0.61** | 0.43 |
| **Hansen-Jagannathan bound** | | | | | | | |
| | **0.002** | **0.257** | **0.002** | **0.225** | **0.257** | **0.225** | |

HJ bound=std(IMRS)/E(IMRS); Sharpe ratio=E(Rx)/std(Rx); SR≤HJ. Rx: excess return; historical SR equity: 0.22

# Impact responses (%) to 1 std Home TFP innovation

| | Flexible wage | | | | Predet. wage |
|---|---|---|---|---|---|
| | KPR | | GHH | | GHH |
| | $\gamma$=1/IES | $\gamma$=50 | $\gamma$=1/IES | $\gamma$=50 | $\gamma$=50 |
| $Y_H$ | 0.81 | 0.84 | 0.89 | 0.80 | 1.22 |
| $Y_F$ | 0.04 | **0.00** | 0.00 | **0.09** | **0.23** |
| $C_H$ | 0.08 | -0.07 | 0.31 | 0.03 | 0.59 |
| $C_F$ | -0.03 | **0.12** | -0.19 | **0.09** | 0.27 |
| $Labor_H$ | 0.46 | 0.51 | 0.60 | 0.45 | 1.09 |
| $Labor_F$ | 0.06 | **0.00** | 0.00 | **0.15** | **0.35** |
| $RER_H$ | -0.22 | **-1.00** | -0.01 | **-0.99** | **-0.99** |
| $NX_H/Y_H$ | -0.06 | **0.04** | -0.11 | **0.07** | **0.03** |

# Conclusion

● Paper has developed simple DSGE model that solves the 'international correlation puzzle':

► Country-specific productivity shocks generate sizable cross-country correlations of GDP, investment, Labor.

► Real exchange rate is volatile

● Key ingredients (BOTH are needed!)

► recursive intertemporal preferences ($\Rightarrow$volatile RER)

► weak wealth effect on labor supply ($\Rightarrow$positive international shock transmission, via t.o.t. channel)

# THANK YOU !