Groupe de Travail: International Risk-Sharing and the Transmission of Productivity Shocks

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The International Consumption Correlations Puzzle

- Obstfeld & Rogoff (2001): "If one believes that both domestic and international capital markets are well approximated by an Arrow-Debreu complete markets framework, then it is a puzzle that international consumption growth correlations are not much higher than they appear to be."

$\Rightarrow$ Under international efficiency and identical power utility:

$$\frac{P_t^*}{P_t} U_{C,t} = U_{C^*,t} \quad \Rightarrow \quad \frac{P_t^*}{P_t} = \left(\frac{C_t^*}{C_t} \right)^{-\sigma}$$

$\Rightarrow$ True with a complete set of state-contingent securities, even under PPP deviations caused by trade frictions and goods market imperfections

$\Rightarrow$ Positive correlation between RER and relative consumption if preferences are time-separable and the utility function features constant relative risk aversion

- Backus & Smith, 1993: Empirical evidence at odds with the assumptions

Table: Correlations between real exchange rates and relative consumptions

	Correlation			
	HP-filtered		First-Difference	
Country	US	RoW	US	RoW
Canada	-0.52	-0.31	-0.33	-0.18
France	-0.20	0.43	-0.20	0.02
Germany	-0.51	-0.27	-0.37	-0.06
Ireland	-0.39	0.72	0.03	0.56
Japan	0.05	0.25	0.00	0.14
UK	-0.51	-0.21	-0.39	-0.12
USA		-0.71		-0.54

$\Rightarrow$ Lack of risk-sharing explained by incomplete international financial markets

- But not sufficient, *per se*:
  - Baxter & Crucini, 1993: Provided shocks are not permanent, trade in international, uncontingent bonds leads to international risk sharing (Productivity shock $\rightarrow$ Consumption smoothing through lending $\rightarrow \uparrow$ consumption in both countries)
  - Cole & Obstfeld, 1991: Movements in the terms of trade provides an insurance against production risk independently of trade in financial assets (Productivity shock $\rightarrow$ ToT and RER depreciation $\rightarrow \uparrow$ consumption abroad and at home)

Motivation and results

- Build a model of the international business cycle with incomplete markets
- Study the general-equilibrium link between international price movements, relative wealth and international consumption risk sharing
- Explain the Backus-Smith correlation in terms of endogenous wealth effects
- Analytical results in a two-country endowment economy $\Rightarrow$ Under incomplete markets, the sign of the correlation between relative consumption and the real exchange rate depends on the price elasticity of tradables and the dynamics of endowment shocks
- Quantitative results in a model with incomplete markets, non-traded goods, distribution services produced with local inputs $\Rightarrow$ Realistic departures from PPP, *equilibrium* wealth effects in response to productivity shocks inducing international price movements $\Rightarrow$ Calibration predicting a negative correlation between the real exchange rate and relative consumption. Price response to productivity shocks lead to uninsurable effects on relative wealth.

An endowment economy setup

- 2-country, 2-good endowment economy, CRRA utility function
- Several hypotheses: complete markets, financial autarky, trade in bonds
- All goods traded
- CES agregator:

$$C = \left[a_H^{1/\omega} C_H^{\frac{\omega-1}{\omega}} + (1-a_H)^{1/\omega} C_F^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}, \omega > 0$$

$$\Rightarrow \quad C_H = a_H \left(\frac{P_H}{P} \right)^{-\omega}$$

$$\textit{with} \quad P = \left[a_H P_H^{1-\omega} + (1-a_H) P_F^{1-\omega} \right]^{\frac{1}{1-\omega}}$$

- Ressource constraints:

$$Y_H = C_H + C_H^*, \quad Y_F = C_F + C_F^*$$

Complete markets

- Perfect consumption insurance insulates relative wealth from price movements. Relative prices respond to output shocks:

$$\frac{Y_H}{Y_F} = Tot^{\omega} \frac{a_H + a_H^* \left[\frac{a_H^* + (1-a_H^*)\, Tot^{1-\omega}}{a_H + (1-a_H)\, Tot^{1-\omega}}\right]^{\frac{\omega-\sigma^{-1}}{1-\omega}}}{(1-a_H) + (1-a_H^*)\left[\frac{a_H^* + (1-a_H^*)\, Tot^{1-\omega}}{a_H + (1-a_H)\, Tot^{1-\omega}}\right]^{\frac{\omega-\sigma^{-1}}{1-\omega}}}$$

$$ES \Rightarrow \widehat{Tot} = \frac{\sigma}{\left[1-(2a_H-1)^2\right]\omega\sigma + (2a_H-1)^2}\left(\hat{Y}_H - \hat{Y}_F\right)$$

$$with \quad Tot \equiv \frac{P_F}{P_H}$$

- $\uparrow$ domestic relative output $\longrightarrow \uparrow Tot \longrightarrow$ Wealth effect in F
- Income effect always dominates substitution effect

Financial autarky

- Consumption expenditure equal current income in each period ($PC = P_H Y_H$)

$$\frac{\partial C_H}{\partial Tot} = \underbrace{\omega \frac{a_H(1-a_H)Tot^{-\omega}}{\left[a_H + (1-a_H)Tot^{1-\omega}\right]^2} Y_H}_{SE} \underbrace{- \frac{a_H(1-a_H)Tot^{-\omega}}{\left[a_H + (1-a_H)Tot^{1-\omega}\right]^2} Y_H}_{IE}$$

$$\frac{\partial C_H^*}{\partial Tot} = \underbrace{\omega(1-a_H^*)Tot^{1-\omega} \frac{a_H^*}{\left[a_H^* + (1-a_H^*)Tot^{1-\omega}\right]^2} Y_F^*}_{SE} \underbrace{+ a_H^* \frac{a_H^*}{\left[a_H^* + (1-a_H^*)Tot^{1-\omega}\right]^2} Y_F^*}_{IE}$$

$\Rightarrow$ Positive substitution effect. Income effect negative in the home country. Dominates the substitution effect if $\omega < 1$

Financial autarky (2)

$$\widehat{Tot} = \frac{\hat{Y}_H - \hat{Y}_F^*}{1 - 2a_H(1-\omega)} > 0 \text{ if } \omega > \frac{2a_H - 1}{2a_H} (< \frac{1}{2})$$

$\Rightarrow$ If the domestic income effect is weak enough, the demand for domestic goods increases when the relative price falls. A positive supply shock is then matched by an increase in the world demand at lower prices : $\uparrow$ *Tot* and positive international transmission

$\Rightarrow$ If the domestic income effect is strong (ω low and strong home bias), the demand for domestic goods falls when the relative price drops. A positive supply shock must be compensated for by an appreciation in the home terms of trade: $\downarrow$ *Tot* and negative international transmission

$\Rightarrow$ With incomplete markets, the scope for insurance against country-specific shocks is limited. Change in relative international prices lead to potentially strong wealth effects.

Financial autarky (3)

$$P_F C_F = P_H C_H^* \Rightarrow \widehat{RER} = \frac{2a_H - 1}{2a_H\omega - 1}(\hat{C} - \hat{C}^*)$$

- With incomplete markets, the scope for insurance against country-specific shocks is limited. Relative consumptions respond to international price movements
- In this setup, the relation between exchange rates and relative consumptions can have either sign. With home bias in consumption, it is negative if $\omega < 1/(2a_H) < 1$
- Matches the condition for efficient risk-sharing if $\omega = \frac{2a_H - \sigma - 1}{2a_H\sigma}$ (notably for $\omega = 1$ and $a_H = 0.5$ as in Cole & Obstfeld)

International trade in bonds

- Trade in bonds allows agents to smooth consumption
- Negative transmission mechanism in the short-run, if the elasticity of substitution is sufficiently larger than one (positive wealth effect in the long run)
- Additional assumptions to get analytical results: log utility, rate of time preferences around zero, permanent supply shock

$$\Rightarrow \widehat{Tot}_t = \underbrace{\frac{(\widehat{Y}_{Ht} - \widehat{\bar{Y}}_H) - (\widehat{Y}_{Ft} - \widehat{\bar{Y}}_F)}{1 - 4a_H(1-a_H)(1-\omega)}}_{\textit{SR negative effect}} + \underbrace{\frac{\hat{\bar{Y}}_H - \hat{\bar{Y}}_F}{1 - 2a_H(1-\omega)}}_{\textit{LR positive if } \omega>1}$$

International trade in bonds (2)

- Endowment shocks can generate a dynamic response of Tot that initially appreciate and depreciate in the LR :
  Supply shock $\longrightarrow$ Tot deterioration in the long-run, less than proportional if $\omega > 1 \longrightarrow$ LR $\uparrow$ in the relative value of domestic output $\longrightarrow$ Wealth effect generating a SR boom in consumption $\longrightarrow$ under Home bias, excess demand for domestic goods $\longrightarrow$ Appreciation of Tot (switches to depreciation when domestic output increases)

$$(\hat{C}_t - \hat{C}_t^*) = \widehat{RER}_t + \frac{2a_H(\omega - 1)}{2a_H - 1}\widehat{RER}$$

$\Rightarrow$ In the short-run, negative correlation between relative consumptions and RER

- Results generalize quite nicely to the full-fledge quantitative analysis

A full-fledged quantitative model

- 2 countries of equal size, each specialized in an intermediate tradable good
- A non-tradable good, consumed or used as input with the tradable good to produce a final good (non-traded)
- Perfect competition and technology using labor and capital in the T and N good sectors ($Y_i = Z_i K_i^{1-\alpha_i} L_i^{\alpha_i}, \quad i = H, N$ with Z_i an exogenous random disturbance)
- Distribution sector providing the consumer with the T good (domestically produced or imported) using N good as input ($P_{Ht} = \bar{P}_{Ht} + \eta P_{Nt}$, $P_{Ft} = \bar{P}_{Ft} + \eta P_{Nt}$). Distribution services generate LOOP deviations at the consumer price level
- Capital and labor are perfectly mobile across sectors

A full-fledged quantitative model (2)

- Consumer maximizes the expected value of her lifetime utility, where the discount factor is endogenous:

$$E\left\{\sum_{t=0}^{\infty} U(C_t,\ell_t)\exp\left[\sum_{\tau=0}^{t-1}-\nu(C_t,\ell_t)\right]\right\}$$

$$\text{with } C_t=\left[a_T^{1/\phi}C_{Tt}^{\frac{\phi-1}{\phi}}+a_N^{1/\phi}C_{Nt}^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$$

$$\text{and } C_{Tt}=\left[a_H^{1/\omega}C_{Ht}^{\frac{\omega-1}{\omega}}+(1-a_H)^{1/\omega}C_{Ft}^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}$$

- An international bond, which pays in units of home aggregate consumption and is zero in net supply

A full-fledged quantitative model (3)

- Budget constraint:

$$P_{Ht}C_{Ht}+P_{Ft}C_{Ft}+P_{Nt}C_{Nt}+B_{Ht+1}+\bar{P}_{Ht}I_{Ht} \leq W_t l_t+R_t K_t+(1+r_t)B_{Ht}$$

- Investment carried out in Home tradable goods, without distribution services (variant with imported investment goods):

$$K_{t+1} = I_{Ht} + (1-\delta)K_t$$

- Market clearing conditions: $l = L_H + L_N$, $K = K_H + K_N$, $Y_N = C_N + \eta C_H + \eta C_F$, $Y_T = I_H + C_H + C_H^*$, idem foreign, $B_{Ht+1} + B_{Ht+1}^* = 0$
- Domestic aggregate consumption taken as numeraire, $RER_t = P_t^*$

Calibration

- Taken from Stockman & Tesar (1995), calibration on US and OECD annual data

Risk aversion	$\sigma = 2$	
Consumption share	$\alpha = 0.34$	1/3 of time endowment at work
Substitutability H/F	$\omega = 0.85$	
Substitutability T/N	$\phi = 0.74$	Mendoza (1991)
Share of Home traded goods	$a_H = 0.72$	SS imports = 5% aggregate output
Share of N goods	$a_N = 0.45$	Share of N = 53%
Elasticity of the discount factor w/r to C and I	$\psi = 0.08$	SS real interest rate = 4%
Distribution margin	$\eta = 1.09$	Anderson & van Wincoop (2004)
Labor share in T	$\alpha_T = 0.61$	Stockman & Tesar (1995)
Labor share in N	$\alpha_N = 0.56$	Stockman & Tesar (1995)
Depreciation rate	$\delta = 0.10$	

- CRRA utility function with constant share of consumption and leisure (α and $(1-\alpha)$)
- Endogenous discount factor:

$$\nu(C_t, l_t) = \ln(1 + \psi[C_t^{\alpha}(1 - l_t)^{1-\alpha}])$$

- AR(1) productivity shocks, technology shocks identified with sectoral Solow residuals

Calibration of the Price elasticity

- Consumer price elasticity:

$$\widehat{P_{Ft}} - \widehat{P_{Ht}} = \frac{1}{\omega}(\widehat{C_{Ft}} - \widehat{C_{Ht}})$$

- Producer price elasticity:

$$\widehat{\bar{P}_{Ft}} - \widehat{\bar{P}_{Ht}} = \frac{1}{\omega(1-\mu)}(\widehat{C_{Ft}} - \widehat{C_{Ht}})$$

with $\mu = \eta \frac{P_N}{P_H}$ the size of the distribution margin in SS. μ reduces the substitution effect from a deterioration in the Tot and makes the Income effect less negative.

Calibration of the Price elasticity (2)

- Contrasted results in the empirical literature on the value of the price elasticity $\Rightarrow$ Aggregate estimates less than one (Hooper et al., 2000)/ Trade estimates around 4 (Bernard et al., 2003)

$\Rightarrow$ 2 strategies :

  - GMM estimates to match the volatilities of the Tot and the RER as well as the correlations between the RER and output ratio and the RER and net exports $\Rightarrow \omega = 0.85$
  - Calibration matching Bernard et al. (2003) estimates $\Rightarrow$ $\omega = 8$. Increase the persistence of shocks to generate stronger wealth effects

$\Rightarrow$ Allow to contrast results concerning wealth effects and the international transmission of productivity shocks in the high/low price elasticity cases

Strategy

- Simulation of the model using a first-order Taylor series expansion around the deterministic SS and the King & Watson (1998)'s algorithm
- Log and filter the model's artificial series using the HP filter. Average moments across 100 simulations
- Compare with the moments of the data with the USA as the home country and a trade-weighted aggregate of the OECD as the foreign country. Period 1970-2001.

Results with low trade elasticity

	Data	Baseline		with Taste shocks	
Statistics		Bond economy	Arrow-Debreu	Bond economy	Arrow-Debreu
σ relative to GDP					
RER	3.90	2.99	0.73	2.94	0.99
Tot	1.68	2.42	0.83	2.45	1.07
P_N/P_N^*	0.86	0.77	0.51	0.76	0.48
Cross-correlations					
RER and					
Relative GDPs	-0.19	-0.54	0.21	-0.55	-0.28
Relative consumptions	-0.71	-0.24	0.98	-0.30	-0.29
Real net exports	0.60	0.96	-0.62	0.93	0.57
Tot	0.52	0.99	0.16	0.99	0.59
Tot and					
Relative GDPs	-0.33	-0.55	0.87	-0.56	0.11
Relative consumptions	-0.74	-0.27	0.31	-0.40	-0.54
Real net exports	0.67	0.97	0.63	0.97	0.82

Results with low trade elasticity (2)

- Strong volatility of relative prices (direct consequence of the calibration strategy)
- Under incomplete markets, negative correlation between RER and relative consumptions $\Rightarrow$ Accounts for the Backus-Smith puzzle
- In the long-run, positive correlation. cf Euler equation for international bonds:

$$E_t(\widehat{RER}_{t+1} - \widehat{RER}_t) \approx E_t[(\widehat{U}^*_{ct+1} - \widehat{U}^*_{ct}) - (\widehat{U}_{ct+1} - \widehat{U}_{ct})]$$

- In the short-run, unexpected positive shocks can generate a negative correlation if they have large (endogenous) wealth effects through Tot and RER appreciations
- If the price elasticity is close to one, positive wealth effects on home and foreign consumptions similar to those of complete markets (Cole & Obstfeld, 1991). If the price elasticity is sufficiently lower than one, the wealth effect in the home country increases which generates the BS correlation.

$\Rightarrow$ The lower the price elasticity, the higher Tot movements in response to productivity shocks, the higher the Home wealth effect with respect to the foreign one.

Results with low trade elasticity (3)

- Negative correlation between relative outputs and RER
- Consistent ranking of variability in international prices:

$$\widehat{RER}_t = (1-\mu)(2a_H - 1)\widehat{Tot}_t + \mu(\hat{P}^*_{Nt} - \hat{P}_{Nt}) + \Omega(\hat{q}^*_t - \hat{q}_t)$$

  with q the relative price of nontradables. Crucial role of deviations from the LOOP due to distribution services and movements in the price of N across countries in reproducing the empirical ranking of volatility. With $\mu \neq 0$ and $\Omega \neq 0$, RER also responds to fluctuations in the relative price of nontradables.
- Positive correlation of *Tot* and *RER* contrary to models where LOOP deviations come from sticky prices and LCP.

Results with low trade elasticity (4)

- Role of the distribution sector: Allow to fit the variability of international prices without having to impose very poor substitutability. Generate deviations from the LOOP. Not crucial to generate the negative Backus-Smith correlation.
- With taste shocks, wealth effects driven by productivity shocks keep playing a crucial role in explaining lack of risk sharing but the fit of the complete-market model improves. Consistent with the idea that the Backus-Smith puzzle can be explained by strong demand effects arising from shocks to fundamentals.
- Good business cycle properties (positive cross-country correlations of GDP, consumption, investment and hours, consumptions less correlated than outputs) except for the magnitude of the relative volatility of C, I and employment w/r to output

Results with high trade elasticity

Statistics	Data	Baseline	Persistent T shocks	Persistent ag. shocks
σ relative to GDP				
RER	3.90	1.17	1.60	0.35
Tot	1.68	0.48	0.70	0.39
P_N/P_N^*	0.86	0.55	0.67	0.06
Cross-correlations				
RER and				
Relative GDPs	-0.19	-0.20	-0.55	-0.69
Relative consumptions	-0.71	0.73	-0.12	-0.67
Real net exports	0.60	0.79	0.87	0.96
Tot	0.52	0.74	0.90	0.99
Tot and				
Relative GDPs	-0.33	0.45	-0.66	-0.71
Relative consumptions	-0.74	0.98	-0.33	-0.69
Real net exports	0.67	0.99	0.98	0.97

Results with high trade elasticity (2)

- Match the Backus-Smith correlation if shocks are persistent: Positive productivity shock $\longrightarrow$ Consumption smoothing $\longrightarrow \uparrow$ demand above supply in the short-run $\longrightarrow$ Tot and RER appreciation. Dynamic effects that crucially require a high trade elasticity (otherwise, $\uparrow$ world supply of Home tradables $\longrightarrow$ substantial drop in their prices $\longrightarrow \downarrow$ home wealth)
- Better performances in terms of international price volatility in the low elasticity case.
- Negative Backus-Smith correlation even without nontraded goods.

Conclusion

- Build a business cycle model with incomplete markets where limited international consumption risk sharing is due to large wealth (and demand) effects of productivity shocks through international price movements
- Two sets of conditions for a negative Backus-Smith correlation:
  - Low price elasticity (0.5) and high volatility of international prices $\Rightarrow$ Negative international consumption spillovers : $\uparrow$ productivity $\rightarrow \uparrow$ domestic supply $\rightarrow$ under Home bias, demand must $\uparrow \rightarrow$ Terms-of-trade appreciation driving up domestic wealth
  - High elasticity (4) and persistent shocks $\Rightarrow$ In the short-run, negative international consumption spillovers : $\uparrow$ productivity $\rightarrow$ Strong $\uparrow$ of domestic demand because of anticipated wealth effects (if intertemporal trade) $\rightarrow$ RER appreciation in the short-run
- Tot adjustment to productivity shocks widen the wedge between domestic and foreign wealth