Transmission of Productivity Shocks: Quantitative issues

EUI 2007

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Introduction

- Goal: reconsider the transmission mechanism analyzed in the first lecture in a quantitative framework.
- The focus is on wealth effects in general equilibrium under incomplete markets.
- Outline
  - First: define a few features of the international business cycle which are relevant for our analysis. US versus the rest of the industrial world (EU Japan and Canada). period 1970-2001.
  - Second: specify a model (a variant of Stockman and Tesar) and conduct experiments. Source: Corsetti Dedola Leduc (2006 version).

Introduction

- In what follows, data (as well as artificial time series) are all HP filtered.
- However, key results go through also when data (and artificial time series) are first-differenced. See paper for details
- Throughout numerical exercises, a first-order Taylor series expansion around the deterministic steady state is taken. The model is simulates using King and Watson [1998]'s algorithm. Model's statistics are computed by logging and filtering the model's artificial time series using the Hodrick and Prescott filter and averaging moments across 100 simulations. Consistently with the data, changes in all real aggregate variables (e.g. GDP) are computed using constant prices (precisely, relative steady state prices).

International business cycle: stylized facts

- International price volatility: level and ranking
  – Real exchange rates (RER) is more volatile than Terms of trade (TOT). Relative to St.Dev. of GDP, the st.dev. of RER and TOT is 3.90 and 1.68.
  – In models with only tradable goods, we have seen that RER and TOT are proportional. This suggests the need to have a richer model (nontradables).
  – Ranking is difficult to match in most models
- RER and TOT are positively correlated (.86)

International business cycle: stylized facts

- Correlation between relative consumption and RER is negative (-.71).
  - Same pattern emerges with the TOT (-.74).
  - This is at odds with model predicting high risk sharing, unless marginal utility is assumed to vary randomly (taste shocks).
- Correlation between relative output and RER/TOT is also negative (-.19; -.33)

International business cycle: stylized facts

- Output Consumption Investment and Employment are all positively correlated across countries (.68, .6, .25,.54)
- Consumption is less correlated than output
  - Most models predicts the opposite – this is one essential dimension of the ‘quantity puzzle’.

International business cycle: stylized facts

- Correlation between real (constant price) net export and GDP is negative (-.48).
  - Real means that this statistics abstracts from changes in the value of net exports due to equilibrium terms of trade movements
- Volatility of Import ratio (ratio of import to nonexported tradable output) is 4.94; Volatility of net export over GDP is .64
  - A possible issue with low elasticity is that imports may become too smooth.

International business cycle: stylized facts

- Nominal and real exchange rates are highly correlated (.9-1)
  - Correlation between nominal (real) exc. rate and tot is positive.
- Correlation between nominal exchange rate and import prices is positive but not perfect (.4)
  - Exchange rate pass-through on import prices incomplete (see future lectures)
- Correlation between nominal exchange rates and the CPI is close to zero or negative (local currency price stability).

Model

- 2 symmetric countries each specialized in the production of a traded and nontraded good.
- One pure-discount bond (incomplete asset markets). Without loss of generality, this is denominated in home currency.
- Firms either produce goods or distribute them:
  - Perfectly competitive firms in both sectors
  - Bringing one unit of traded goods to consumer requires η units of a the nontraded good (nontradability as an explanation for local currency price stability).

Firms' Problem

- Firms in the traded and nontraded goods sectors choose labor and capital to maximize profit:

$$\max_{L_H K_H} \pi_{\mathrm{H}} = \overline{P}_H Y_H - WL_H - RK_H$$

$$\max_{L_N K_N} \pi_{\mathrm{N}} = P_N Y_N - WL_N - RK_N$$

- Firms in the distribution sector buy traded goods and distribute them to consumers using nontraded goods:

$$P_H = \overline{P}_H + \eta P_N$$

$$P_F = \overline{P}_F + \eta P_N$$

Household's Problem

Households maximize:

$$\max\ E\sum_{t=0}^{\infty} U(C,l)\exp\sum_{\tau=0}^{t-1} -\nu(U[C,l])$$

subject to

$$P_H C_H + P_F C_F + P_N C_N + B'_H + P_H I_H \le Wl + RK + (1+r)B_H$$

$$I_H = K' - (1-\delta)K$$

$$C = [a_T^{1-\phi} C_T^{\phi} + a_N^{1-\phi} C_N^{\phi}]^{1/\phi} \qquad C_T = [a_H^{1-\rho} C_H^{\rho} + a_F^{1-\rho} C_F^{\rho}]^{1/\rho}$$

$$\omega = \frac{1}{1-\rho} \quad \text{elasticity of sub.}$$

On distribution Services

- Distribution is a realistic way to account for a low elasticity of consumer prices w.r. to the exchange rate.
- However, to the extent that the elasticity of substitution between tradable goods and distribution services is lower than one (the Cobb-Douglas case), distribution has also important implications for the trade elasticity.

Distribution Services and Volatility

- From intratemporal optimality conditions:

$$T\hat{O}T = \left(\hat{\bar{P}}_F - \hat{\bar{P}}_H\right) = \frac{1}{\omega(1-\mu)}\left(\hat{C}_H - \hat{C}_F\right)$$

where $\mu = \dfrac{\eta P_N}{P_H}$ is the distribution margin

$\omega(1-\mu)$ is the price-elasticity of imports

Effects of TOT's Changes on Consumption

- Without distribution:

$$\frac{\partial C_H}{\partial TOT} = \left(\underbrace{\omega}_{SE} - \underbrace{1}_{IE} \right) \frac{a_H (1 - a_H) \tau^{-\omega}}{\left[a_H + (1 - a_H) \tau^{1-\omega} \right]^2} Y_H < 0 \Leftrightarrow \omega < 1$$

- With distribution:

$$\frac{\partial C_H}{\partial TOT} = \underbrace{\omega (1 - \mu)(1 - a_H) \left(\frac{P_F}{P_H} \right)^{1-\omega}}_{SE} - \underbrace{(1 - a_H) \left(\frac{P_F}{P_H} \right)^{1-\omega} - a_H \mu}_{IE}$$

- ↑μ lowers the SE and makes the IE more negative

One implications of nontradables

- Note the real exchange rate

$$\hat{RER} = (1-\mu)(2a_H - 1)\hat{TOT} + \mu(\hat{P}_N^* - \hat{P}_N) + \Omega(\hat{q}^* - q)$$

Because of non tradable price movements, the model may fit the ranking of volatility between RER and TOT.

Endogenous discount factor

- This ensures that the model has a unique steady state. Alternative: costs of holding bonds (e.g. Heatcoate and Perri [2003]) or borrowing contraint (e.g. CKM). See Schmitt-Grohe and Uribe [2003]
- With incomplete markets, without these assumptions the wealth distribution in the deterministic steady state would be indeterminate and the first-order approximation around it would contain a unit root -- technically the model would possess a non-hyperbolic steady state. In turn, this unit root would imply that the wealth distribution in the approximate solution to the stochastic economy does not converge to a stationary distribution. This would occur despite the stationarity of the shocks, (which conversely implies that there exist an ergodic wealth distribution in the nonlinear stochastic economy -- under some further conditions, e.g. Chamberlain and Wilson [RED, 2000]).

Incomplete Asset Markets and Backus-Smith puzzle

- In a bond economy, the link between RER and relative consumption is less tight:

$$E_t\left[R\hat{E}R_{t+1} - R\hat{E}R_t\right] \approx E_t\left[\sigma\left(\hat{C}_{t+1} - \hat{C}_t\right) - \sigma\left(\hat{C}^*_{t+1} - \hat{C}^*_t\right)\right]$$

- The (expected) consumption growth rate differential is positively and strongly correlated with the (expected) real depreciation rate.
- The bond is traded after the resolution of uncertainty: It does not provide ex-ante insurance against country-specific income shock.
- On impact, the effect of a shock is similar to that under financial autarky.

Calibration

η: Distribution costs = 50% of consumer prices (Burstein, Neves, & Rebelo [2002])

a_H: Imports = 5% of GDP (average of US data 1960-2002)

a_T: Nontraded goods = 53% of consumption as in US data

φ: Tradables/nontradables elasticity of substitution set to 0.74 (Mendoza [1991])

σ: Utility is CRRA, with coefficient of relative risk aversion equal to 2

$$\nu\left(U[C,l]\right) = \ln\left(1 + \psi[C^{\alpha}(1-l)^{1-\alpha}]\right)$$

Shocks

- Symmetric stochastic process for productivity shocks Z_T,Z_N:
  - estimated for the US and OECD countries, annual data on manufacturing and services from OECD-STAN database

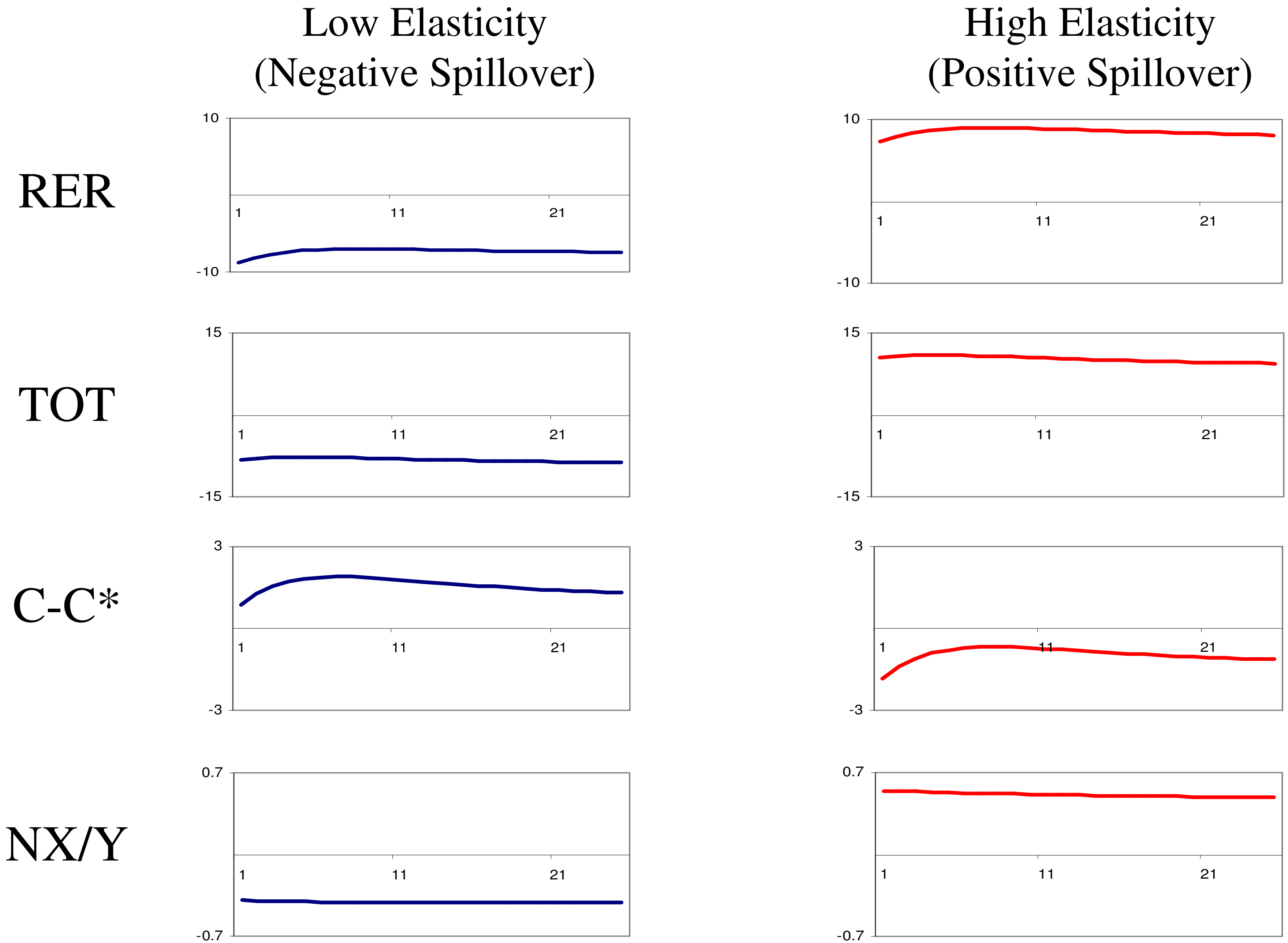
Calibrating ω

- Considerable uncertainty about aggregate trade elasticities (U.S. estimates from 0.4 to 2.5. see Hooper et al. 2000).
- If you set tradables elasticity of substitution ω set to match U.S. RER volatility relative to output:

$$\frac{\sigma(RER)}{\sigma(Y)} = 3.9$$

- 2 values for ω, implying two different transmission mechanisms (recall graph in first lecture):
  - positive for higher value of ω $\qquad Z^T \uparrow \Rightarrow TOT \uparrow \Rightarrow \frac{C}{C^*} \downarrow$
  - negative for lower ω. $\qquad Z^T \uparrow \Rightarrow TOT \downarrow \Rightarrow \frac{C}{C^*} \uparrow$

Responses to a Technology Shock in the Traded-Goods Sector



Calibrating ω 1

- An alternative is a simulated method of moments approach. Choose this parameter to minimize the distance, between model and data, of the following (equally weighed) four moments: the volatility of the real exchange rate, the volatility of the terms of trade, the correlation between the real exchange and the output ratio, and the correlation between the real exchange rate and net exports.
- Note: GMM estimators preserve important large-sample properties even if an optimal weighting matrix is not used. Specifically, GMM estimators remains unbiased and consistent, that is, in the limit, the estimator converge to the true value of ω --- see the textbook by Greene [1997], page 525. But in principle you can use an optimal weighting matrix, so to ensure that your estimators have the lowest variance (not efficient). This is clearly important for testing hypotheses, but for our purpose, what matters is that our estimate of ω be consistent.

Calibrating ω 1 cont.ued

- Matching the first two moments, addresses the following issue: if we choose ω such that our model gets close to the volatility of the real exchange rate and the terms of trade, do these relative price movements amplify wealth effects and the consumption risk of productivity shocks? It may well be possible that volatility in the data is not high enough to generate the mechanism illustrated in the first lecture.
- There are two transmission mechanisms through which price volatility can generate low risk sharing: the third moment helps discriminating between the two.
- Last, including the fourth moment mimics the comovements between relative prices and intertemporal trade in the data.

Calibrating ω 1 cont ued

- This procedure yields an estimate of ω equal to 0.85 (actually including the first two moments only give you values close to this).
- Given the calibrated value of μ, the implied trade price elasticity is below 1/2, well within the range of available macro estimates, but at odds with some micro evidence.

- Note however that there are mechanisms (different from the ones studied in lecture 1) that could generate a negative correlation between the real exchange rate and relative output. In principle a negative correlation could arise because of strong Balassa-Samuelson effects.

Calibrating ω: 2

- How about the role of shock persistence? Experiment: set the trade elasticity equal to 4 based on the estimates in the trade literature, namely, by Bernard, Eaton, Jensen, and Kortum [2003]. Given the size of the distribution sector, this means ω=8.
- With this value, the estimated shocks (reported in Table 3 of the Codele paper) are not persistent enough to generate strong wealth effects. Hence, following the literature on incomplete markets (e.g. Baxter [1995]), carry out two sets of experiments. First, run simulations raising the persistence of the process driving tradables productivity shocks to 0.99, while shutting down technological spillovers to keep the process stationary.

Calibrating ω: 2

- Second, as a further check to isolate the effects of shocks persistence with high elasticity, use the aggregate shock process as in Baxter [1995], assuming that productivity shocks hit symmetrically both tradable and nontradables. The autoregressive coefficient of this aggregate productivity shock is 0.994, implying an annualized value of 0.98, while the variance and covariance matrix is the same as in Backus et al. [1995].

- In what follows, we first look at the results from the calibration using the simulated method of moments (model 1); then the results from calibration 2.

Results model 1: Exchange Rates, Prices

	Data	Model	
		$\omega = 0.85$	Arrow Debreu
$\rho(RER, C/C^*)$	-0.71	-0.24	.98
$\rho(TOT, C/C^*)$	-0.74	-0.27	.31
$\rho(RER, Y/Y^*)$	-0.19	-0.54	0.21
$\sigma(TOT)/\sigma(Y)$	1.68	2.42	.83
$\sigma(NTC)/\sigma(RER)$	(.35-.44)	.45	
$\sigma(P_N/P_H)/\sigma(Y)$	.86	.77	.51

Wealth effects

Table 5. Wealth Effects of a Home Productivity Shocks in the Tradable Sector (in percent)

	Home Consumption	Foreign Consumption	Home Hours Worked	Foreign Hours Worked
$\omega = 0.85$				
$\eta = 0.5$				
Bond Economy (Benchmark)	0.06	-0.02	-0.40	0.17
Arrow-Debreu Economy	0.09	0.002	-0.22	-0.01
$\eta = 0$				
Bond economy	0.04	0.01	-0.19	-0.05
Arrow-Debreu Economy	0.04	0.01	-0.20	-0.04

Method: see Baxter and Crucini (from King

International Business Cycles

	Data	Model	
		$\omega = 0.85$	Arrow Debreu
$\rho(C,C^*)$	0.60	0.30	0.37
$\rho(Y/Y^*)$	0.68	0.38	0.39
$\rho(I,I^*)$	0.25	0.45	0.45
$\rho(L,L^*)$	0.54	0.45	0.49
$\rho(NX,Y)$	-0.48	-0.38	0.21
σ(import ratio)	4.94	1.62	.55

Some sensitivity for model 1

- No distribution:
  - model still works but calibrated elasticity is very low;
  - behavior of real exchange rate and prices is not in line with facts
- Taste shocks:
  - Do not affect baseline specification with incomplete markets
  - Do improve Arrow-Debreu Economy

Results: No Distribution/taste shocks

	Data	Model	
		$\omega = 0.16$	Arrow Debreu+TS
$\rho(RER, C/C^*)$	-0.71	-0.03	-.29
$\rho(TOT, C/C^*)$	-0.74	.05	-.54
$\rho(RER, Y/Y^*)$	-0.19	-0.25	-0.28
$\sigma(TOT)/\sigma(Y)$	1.68	2.47	1.07

Specification 2: Shock persistence

How persistent shocks must be to generate ‘enough wealth effects’ consistent with facts?

The estimated process is not persistent enough.

Raising the autoregressive coefficient close to .99 (while shutting down cross-country spillovers) creates strong wealth effects (BS correlation is -.12), provided trade elasticity is large enough (above 4).

Dynamics adjustment of output (hump shaped) and TOT and RER (appreciation is followed by depreciation).

A useful synthesis

Figure 2. Trade elasticity and Backus-Smith puzzle with highly persistent shocks