Demand Shocks and Open Economy Puzzles

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Motivation

A standard international real business cycle model with technology shocks fails to generate the following stylized facts

- International consumption correlation is small than output correlation (Quantity anomaly)
- The real exchange rate (RER) is negatively correlated with relative consumption (Backus-Smith puzzle)
  - $corr(RER, cH/cF) < 0$; Agents consume more of domestic goods when they are more expensive

A model with demand shocks has the potential to solve these puzzles, but it fails to produce the observed comovement of output and TFP

This paper

- We pose a standard two-country real business cycle model with goods market friction
- With only demand shocks, the model can account for simultaneously,
  - Quantity anomaly
  - Backus-Smith puzzle
  - Comovements of output and TFP

The logic

- Demand shocks like productivity shocks
  - In order to transform produced goods into used goods, households must exert (search) effort
  - Such efforts are not accounted for in NIPA
  - Increase in search effort implies increased measured productivity
- Solving international puzzles in a two-country, two-good setup: increase in domestic demand leads to
  - Domestic boom: output and TFP increase
  - Increase in domestic consumption and consumer prices
  - Appreciation of real exchange rate
  - Foreign output and TFP also increase

Literature

- Backus-Smith puzzle:
  - Demand shocks (Stockman and Tesar 1995)
  - Endogenous discount factor and low elasticity between home and foreign goods (Corsetti, Dedola, and Leduc 2008)
  - Non-tradable goods (Engel and Wang 2011)
  - Labor wedge from home production (Karabarbounis 2012).
  - Capacity utilization: (Raffo (2010))
- Search frictions in international setup: (Alessandria (2009) and Drozd and Nosal (2012))

A two-country, two-good economy with shopping friction

- Two countries $j = 1, 2$ each with a continuum of firms, measure one
- Firms in country j produces $F^j = z^j f(n^j)$
- Current utility of households

$$u\left(c^{jj}, c^{jj^*}, d^{jj}, d^{jj^*}, n^j, \theta^j\right)$$

  - Consumption from home c^{jj} and from foreign c^{jj^*}
  - Search shopping effort for home good d^{jj} and for foreign good d^{jj^*}
  - θ^j is a preference shock

Search friction

- Households have to send costly shoppers to search for goods from each country; Unfound goods perish
- Competitive search: agents choose which market to search
- A market is characterized by (p, Q, F)
  - Price p
  - Market tightness Q: average measure of firms per shoppers
  - Output F

Aggregate state $S = (\theta, B)$

- $\theta = \{(\theta^j, z^j)_{j=1,2}\}$ denotes shocks
- B is the share of mutual fund held by country 1.

Matching technology

- Matching of country j households with country i firms

$$M^{ji} = A(D^{ji})^{\alpha} \ (T^{ji})^{1-\alpha}$$

  - D^{ji}: measure of country j shoppers for country i firms
  - T^{ji}: measure of country i firms found by country j shoppers

- Probability that a firm is matched with a shopper

$$\Psi_T(Q^{ji}) \equiv \frac{A(D^{ji})^{\alpha} \ (T^{ji})^{1-\alpha}}{T^{ji}} = A\left(\frac{T^{ji}}{D^{ji}}\right)^{-\alpha} \equiv A(Q^{ji})^{-\alpha}$$

- Probability that a shopper is matched with a firm

$$\Psi_d(Q^{ji}) \equiv \frac{A(D^{ji})^{\alpha} \ (T^{ji})^{1-\alpha}}{D^{ji}} = A\left(\frac{T^{ji}}{D^{ji}}\right)^{1-\alpha} \equiv A(Q^{ji})^{1-\alpha}$$

Households in country j

- First choose which markets to shop for

$$V^j(S,b) = \max_{\{p^{j\ell},Q^{j\ell},F^\ell\}_{\ell=j,j^*}} w^j(S,b;\{p^{j\ell},Q^{j\ell},F^\ell\}_{\ell=j,j^*})$$

- Then choose allocations

$$w^j(S,b;\{p^{j\ell},Q^{j\ell},F^\ell\}_{\ell=j,j^*}) = \max\ u\left(c^{jj},c^{jj^*},d^{jj},d^{jj^*},n^j,\theta^j\right) + \beta E\left\{V^j(S',b')|\theta\right\}$$

$$\sum_{\ell=j}^{j^*} p^{j\ell}c^{j\ell} + b' = [1+R(S)]\,b + w^j n^j$$

$$c^{j\ell} = d^{j\ell}\ \ \Psi_d(Q^{j\ell})F^\ell \qquad \text{for } \ell = j, j^*$$

$$S' = G(S)$$

- Search friction: $\ell = \{1,2\}$

$$c^{j\ell} = \underbrace{d^{j\ell}}_{\text{shoppers sent}}\ \underbrace{\Psi_d(Q^{j\ell})}_{\text{prob. of finding a firm}}\ \underbrace{F^\ell}_{\text{fruits found when matched}}$$

Firm's problem

- First choose which markets to serve

$$\Pi^j(S) = \max\left\{\Pi^{j\ell}(S)\right\}_{\ell=j}^{j^*}$$

- Then choose (p, Q, F) to post

$$\Pi^{j\ell}(S) = \max_{p,Q,F,n} \; p\Psi_T(Q)F - w(S)n$$

subject to

$$F \leq z^j f(n)$$

$$w^\ell(S, B^\ell; p, Q, F, p^{\ell\ell^*}(S), Q^{\ell\ell^*}(S), F^{\ell\ell^*}(S)) \geq V^\ell(S, B^\ell)$$

(households' participation constraint)

Equilibrium

Market clearing conditions

$$C^{j\ell} = A(D^{j\ell})^{\alpha}(T^{j\ell})^{1-\alpha} z^{\ell} f(N^{\ell})$$

$$T^{jj} + T^{j^* j} = 1$$

$$B'_j + B'_{j^*} = 2$$

Example

- Endowment economy, symmetric equilibrium
- Utility

$$u(c^{jj}, c^{jj^*}, d^{jj}, d^{jj^*}, \theta) = \theta^j \log\left((c^{jj})^{\mu}(c^{jj^*})^{1-\mu}\right) - \left(d^{jj} + d^{jj^*}\right)$$

  - μ: home bias parameter, $\mu \geq \frac{1}{2}$
  - Elasticity of substitution between home and foreign goods is 1

Demand shocks as productivity shocks

- Let $\bar{x}$ denote steady state of variable x and $\hat{x} \equiv (x - \bar{x})/\bar{x}$
- Definition: TFP of country j is

$$TFP^j = \underbrace{Y^{jj}}_{\text{production for home}} + \underbrace{\frac{\bar{p}^{j^*j}}{\bar{p}^{jj}}}_{\text{relative price}} \underbrace{Y^{j^*j}}_{\text{production for foreign}}$$

$$= Az^j \left[\left(D^{jj} \right)^{\alpha} \left(T^{jj} \right)^{1-\alpha} + \frac{\bar{p}^{j^*j}}{\bar{p}^{jj}} \left(D^{j^*j} \right)^{\alpha} \left(1 - T^{jj} \right)^{1-\alpha} \right]$$

- Demand for goods has a productivity role

$$\widehat{TFP^j} = \hat{z}^j + \alpha \left[\mu \, \hat{\theta}^j + (1 - \mu) \, \hat{\theta}^{j^*} \right]$$

Real exchange rate and relative consumption

- Real exchange rate (RER)

$$\widehat{RER}^j = -(2\mu-1)^2(1-\alpha)(\hat{\theta}^j - \hat{\theta}^{j^*}) + (2\mu-1)(\hat{z}^j - \hat{z}^{j^*})$$

  - RER appreciates under a positive demand shock $\hat{\theta}^j$ but depreciates under a positive productivity shock $\hat{z}^j$

- Relative consumption

$$\hat{c}^j - \hat{c}^{j^*} = \left[1 - (2\mu-1)^2(1-\alpha)\right](\hat{\theta}^j - \hat{\theta}^{j^*}) + (2\mu-1)(\hat{z}^j - \hat{z}^{j^*})$$

  - Domestic consumption increases with both demand shock $\hat{\theta}^j$ and productivity shock $\hat{z}^j$

Real exchange rate, relative consumption and TFP

- Under productivity shocks

$$\widehat{RER}^j = \hat{c}^j - \hat{c}^{j^*}$$

$$\widehat{TFP}^j - \widehat{TFP}^{j^*} = \frac{1}{2\mu - 1}(\hat{c}^j - \hat{c}^{j^*})$$

  - Backus-Smith puzzle: the observed correlation between RER and relative consumption is small and mostly negative; the model, however, generates perfectly correlated relationship.

Real exchange rate, relative consumption and TFP

- Under demand shocks

$$\widehat{RER}^j = -\left[\frac{(2\mu-1)^2(1-\alpha)}{1-(2\mu-1)^2(1-\alpha)}\right](\hat{c}^j - \hat{c}^{j^*})$$

$$\widehat{TFP}^j - \widehat{TFP}^{j^*} = \frac{\alpha(2\mu-1)}{1-(2\mu-1)^2(1-\alpha)}(\hat{c}^j - \hat{c}^{j^*})$$

  - When $\alpha = 0$, we have the standard IRBC model which accounts for Backus-Smith puzzle but TFP and consumption are uncorrelated
  - Our shopping model with demand shock can account for both correlations: negatively correlated RER and relative consumption, and positively correlated TFP and consumption.

Putting the model to work

- Preferences

$$u(c, c^*, d, d^*, n, \theta) = \theta \frac{\left(\left[\mu\ c^{\frac{\eta-1}{\eta}} + (1-\mu)(c^*)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}\right)^{1-\sigma}}{1-\sigma} - \chi \frac{n^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} - (d+d^*)$$

- Production function

$$F(n) = z\ (n)^{\gamma_n}$$

- Shocks

$$\log(\theta_t) = \rho_\theta\ \log(\theta_{t-1}) + v_t, \quad v_t \sim N(0, \Sigma^2)$$

Calibration

Targets	Value	Parameter	Value
First Group: Parameters Set Exogenously			
Risk aversion	2.	σ	2.
Real interest rate	4%	β	0.99
Frisch elasticity	0.72	ν	0.72
Armington elasticity	3	η	3
Shopping parameter	0.23	α	0.23
Second Group: Standard Targets			
Fraction of time spent working	30%	χ	16.62
Labor share of income	0.67	γ_n	0.50
Steady-state output	1	$\bar{z}$	2.26
Import share	0.10	μ	0.58
Third Group: Targets Specific to This Economy			
Capacity utilization	0.81	A	0.98

Quantitative results

Data: for US and EU15

	Data	Standard IRBC		Shopping model	
		z	θ	z	θ
A. Puzzles of international economics					
$corr(RER, C/C^*)$	-0.71	1.00	-1.00	0.99	-0.98
$corr(Y, Y^*)$	0.40	-0.86	0.97	-0.88	0.92
$corr(C, C^*)$	0.25	0.25	0.25	0.25	0.25
$corr(TFP, Output)$	0.45	0.99	0.00	0.99	1.00
B. Co-movement within a country					
NX/output, Output	-0.49	0.97	-0.22	0.96	-0.13
C. Volatility relative to GDP					
TFP	0.60	0.80	0.00	0.78	0.14
Consumption	0.74	0.11	1.67	0.10	1.55
Employment	0.81	0.05	2.23	0.06	0.83
Net exports	0.29	0.48	0.41	0.50	0.26

Conclusion

With demand shocks only, our shopping model can account for puzzles in the international economics:

- Backus-Smith puzzle: $corr(RER, cH/cF) < 0$
- Quantity anomaly: international consumption correlation smaller than output correlation
- Comovement of output and TFP
- Volatile and countercyclical net exports

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