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)
  - \( \text{corr}(\text{RER}, c_H/c_F) < 0 \); Agents consume more of domestic goods when they are more expensive

- The real exchange rate (RER) is negatively correlated with relative consumption (Backus-Smith puzzle)

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 $j$ produce $F^j = z^j f(n^j)$
- Current utility of households
  \[ u(c^{jj}, c^{jj*}, d^{ij}, d^{ij*}, n^j, \theta^j) \]
  - Consumption from home $c^{jj}$ and from foreign $c^{jj*}$
  - Search shopping effort for home good $d^{ij}$ and for foreign good $d^{ij*}$
  - $\theta^j$ 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 \(S = (\theta, B)\)

- \(\theta = \{(\theta_j^i, z_j^i)_{j=1,2}\}\) 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

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

- Then choose allocations

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

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

\[
c^{j\ell} = d^{j\ell} \Psi_d(Q^{j\ell}) F^{\ell} \quad \text{for } \ell = j, j^*
\]

\[
S' = G(S)
\]

- 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
  \[ \Pi^j(S) = \max \left\{ \Pi^{j\ell}(S) \right\}_{\ell=j} \]

- 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

\[ F \leq z^j f(n) \]

\[ \omega^\ell(S, B^\ell; p, Q, F, p^{\ell\ell*}(S), Q^{\ell\ell*}(S), F^{\ell\ell*}(S)) \geq V^\ell(S, B^\ell) \]

(households’ participation constraint)
Equilibrium

Market clearing conditions

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

\[ T^{jj} + T^{j*} = 1 \]

\[ B'_j + B'_{j*} = 2 \]
Example

- Endowment economy, symmetric equilibrium

- Utility

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

- \( \mu \): 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

$$
TFP_j = \gamma_{jj} + \gamma_{j^*j} = Az^j \left[ (D_{jj})^\alpha (T_{jj})^{1-\alpha} + \frac{\bar{p}_{j^*j}}{\bar{p}_{jj}} (D_{j^*j})^\alpha (1 - T_{jj})^{1-\alpha} \right]
$$

- Demand for goods has a productivity role

$$
\hat{TFP}_j = \hat{z}^j + \alpha \left[ \mu \hat{j} + (1 - \mu) \hat{j}^* \right]
$$
Real exchange rate and relative consumption

- Real exchange rate (RER)
  \[
  \hat{RER}_j = -(2\mu - 1)^2(1 - \alpha)(\hat{\theta}_j - \hat{\theta}_j^*) + (2\mu - 1)(\hat{\zeta}_j - \hat{\zeta}_j^*)
  \]

  RER appreciates under a positive demand shock \(\hat{\theta}_j\) but depreciates under a positive productivity shock \(\hat{\zeta}_j\)

- Relative consumption
  \[
  \hat{c}_j - \hat{c}_j^* = \left[1 - (2\mu - 1)^2(1 - \alpha)\right](\hat{\theta}_j - \hat{\theta}_j^*) + (2\mu - 1)(\hat{\zeta}_j - \hat{\zeta}_j^*)
  \]

  Domestic consumption increases with both demand shock \(\hat{\theta}_j\) and productivity shock \(\hat{\zeta}_j\)
Real exchange rate, relative consumption and TFP

- Under productivity shocks

\[ \hat{RER}_j = \hat{c}_j - \hat{c}_j^* \]

\[ \hat{TFP}_j - \hat{TFP}_j^* = \frac{1}{2\mu - 1}(\hat{c}_j - \hat{c}_j^*) \]

- 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

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

\[ \overline{TFP}^j - \overline{TFP}^j^* = \frac{\alpha(2\mu - 1)}{1 - (2\mu - 1)^2(1 - \alpha)} (\hat{c}^j - \hat{c}^j^*) \]

- 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**

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

- **Production function**

  \[
  F(n) = z (n)^{\gamma_n}
  \]

- **Shocks**

  \[
  \log(\theta_t) = \rho_{\theta} \log(\theta_{t-1}) + \nu_t, \quad \nu_t \sim N(0, \Sigma^2)
  \]
## Calibration

<table>
<thead>
<tr>
<th>Targets</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Group: Parameters Set Exogenously</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk aversion</td>
<td>2.</td>
<td>$\sigma$</td>
<td>2.</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>4%</td>
<td>$\beta$</td>
<td>0.99</td>
</tr>
<tr>
<td>Frisch elasticity</td>
<td>0.72</td>
<td>$\nu$</td>
<td>0.72</td>
</tr>
<tr>
<td>Armington elasticity</td>
<td>3</td>
<td>$\eta$</td>
<td>3</td>
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<tr>
<td>Shopping parameter</td>
<td>0.23</td>
<td>$\alpha$</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Second Group: Standard Targets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fraction of time spent working</td>
<td>30%</td>
<td>$\chi$</td>
<td>16.62</td>
</tr>
<tr>
<td>Labor share of income</td>
<td>0.67</td>
<td>$\gamma_n$</td>
<td>0.50</td>
</tr>
<tr>
<td>Steady-state output</td>
<td>1</td>
<td>$\bar{z}$</td>
<td>2.26</td>
</tr>
<tr>
<td>Import share</td>
<td>0.10</td>
<td>$\mu$</td>
<td>0.58</td>
</tr>
<tr>
<td><strong>Third Group: Targets Specific to This Economy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity utilization</td>
<td>0.81</td>
<td>$A$</td>
<td>0.98</td>
</tr>
</tbody>
</table>
## Quantitative results

Data: for US and EU15

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Standard IRBC</th>
<th>Shopping model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$z$</td>
<td>$\theta$</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>A. Puzzles of international economics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$corr(RER, C/C^*)$</td>
<td>-0.71</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>$corr(Y, Y^*)$</td>
<td>0.40</td>
<td>-0.86</td>
<td>-0.88</td>
</tr>
<tr>
<td>$corr(C, C^*)$</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>$corr(TFP, Output)$</td>
<td>0.45</td>
<td>0.99</td>
<td>0.99</td>
</tr>
</tbody>
</table>

|                      |              |               |                |
| **B. Co-movement within a country** |              |               |                |
| NX/output, Output    | -0.49        | 0.97          | 0.96           |

|                      |              |               |                |
| **C. Volatility relative to GDP** |              |               |                |
| TFP                  | 0.60         | 0.80          | 0.78           |
| Consumption          | 0.74         | 0.11          | 0.10           |
| Employment           | 0.81         | 0.05          | 0.06           |
| Net exports          | 0.29         | 0.48          | 0.50           |
Conclusion

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

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

