Accounting for the Business Cycle Relationship Between Japan and Asia

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Facts

- Korea and Taiwan grew much faster than Japan over the 1980-2009 period
  - average annual growth rates: 4.4%, 3.9%, 1.5%
- Business cycles in Japan and Asia (Korea + Taiwan) are highly correlated in the 1990s and 2000s
  - output correlation: -28% (1980s), 53% (1990s), 71% (2000s)
- Japan and Asia (Korea + Taiwan) are important trade partners
Figure 1a. Output-Detrended by 0.5% Growth Trend
Figure 1b. Output-HP Filtered

- JAPAN
- KOREA
- TAIWAN
- ASIA
### Direction of Trade

#### Japan

<table>
<thead>
<tr>
<th>Exports to</th>
<th>Imports from</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. USA</td>
<td>27.2%</td>
</tr>
<tr>
<td>2. China</td>
<td>8.2%</td>
</tr>
<tr>
<td>3. Korea</td>
<td>6.3%</td>
</tr>
<tr>
<td>4. Taiwan</td>
<td>5.9%</td>
</tr>
<tr>
<td>5. Hong Kong</td>
<td>5.3%</td>
</tr>
<tr>
<td>6. Germany</td>
<td>4.2%</td>
</tr>
<tr>
<td>7. Singapore</td>
<td>3.5%</td>
</tr>
<tr>
<td>8. UK</td>
<td>3.0%</td>
</tr>
<tr>
<td>9. Thailand</td>
<td>3.0%</td>
</tr>
<tr>
<td>10. Malaysia</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

#### Korea

<table>
<thead>
<tr>
<th>Exports to</th>
<th>Imports from</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. China</td>
<td>17.1%</td>
</tr>
<tr>
<td>2. USA</td>
<td>16.2%</td>
</tr>
<tr>
<td>3. Japan</td>
<td>9.5%</td>
</tr>
<tr>
<td>4. Hong Kong</td>
<td>6.3%</td>
</tr>
<tr>
<td>5. Taiwan</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

#### Taiwan

<table>
<thead>
<tr>
<th>Exports to</th>
<th>Imports from</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. USA</td>
<td>19.8%</td>
</tr>
<tr>
<td>2. Hong Kong</td>
<td>18.6%</td>
</tr>
<tr>
<td>3. China</td>
<td>12.3%</td>
</tr>
<tr>
<td>4. Japan</td>
<td>9.0%</td>
</tr>
<tr>
<td>5. Singapore</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

Note: Each data is the share of each trade partner in own country’s total exports or imports. Data are average over 1990-2009.

Korea: Bank of Korea Economic Statistic System.
Taiwan: Ministry of Finance R.O.C. Trade Statistics.
Introduction

Summary

Key Questions

- what are the major sources of growth and business cycles in Japan and Asia
- how did Asia and Japan affect each other over the 1980-2009 period?
Introduction

Literature 1

- Business cycle correlation between Asia and Japan
  - comovement: Chen and Shen (2007) etc.
  - trade integration: Kim, Lee and Park (2009)
  - financial integration: Fujiki and Hagiwara (2007)
International business cycle models

- Baxter and Crucini (1995): two-country one-good
- Stockman and Tesar (1995): two-country two-final-good
- Backus, Kehoe and Kydland (1994): two-country two-intermediate-good

- define competitive equilibrium in a DSGE model
- compute exogenous "wedges" as distortions in equilibrium conditions using data
- simulate the model taking the computed wedges as exogenous
Contribution of this paper

- Apply the business cycle accounting method to a two-country business cycle model à la Backus, Kehoe and Kydland (1994)
- Analyze the sources of business cycle relationships between Japan and Asian Tigers in a DSGE model
Introduction

Wedges

- **Business cycle accounting (closed economy)**
  - government wedges: \( g = y - c - x - tb \)
  - labor wedges: \( 1 - \tau_l = \frac{MRS(c, l)}{MPI} \)
  - capital wedges: \( 1 - \tau_k = \frac{MRS(c, c')}{Rx} \)
  - efficiency wedges: \( z = f / \theta l^{1-\theta} \)

- **International business cycle accounting**
  - international price wedges: \( \exp(p) = \frac{MU_{cJP}/P^{JP}}{MU_{cAS}/P^{AS}} \)
  - trade wedges: \( \tau = tb^{JP} + tb^{AS} / rer \)
Long-run

- Asian efficiency wedges had a positive long run effect on output in both countries
- Japanese efficiency wedges have negative long run effect on output in both countries

Short-run

- Asian efficiency wedges are important in accounting for the short run Asian output fluctuation
- Japanese efficiency wedges are important in accounting for the short run Japanese output fluctuation
- Asian efficiency wedges led to a drop in Japanese output during the Asian crisis
Introduction

Outline

- Introduction
- Model
- Quantitative Analysis
- Conclusion
Intermediate goods firms combine labor and capital and produce specialized intermediate goods in each country $i = JP, AS$

$$f^i_t(s^t) = z^i_t(s^t)(k^i_t(s^t))^{\theta^i} (l^i_t(s^t))^{1-\theta^i}$$

where

$$f^{JP}_t(s^t) = a^{JP}_t(s^t) + a^{AS}_t(s^t)$$
$$f^{AS}_t(s^t) = b^{JP}_t(s^t) + b^{AS}_t(s^t)$$

Intermediate goods profits

$$\pi^i_t(s^t) = p^i_{j,t}(s^t)f^i_t(s^t) - w^i_t(s^t)l^i_t(s^t) - r^i_t(s^t)k^i_t(s^t)$$

where $j = a$ for $JP$ and $j = b$ for $AS$
Final goods firms combine intermediate goods and produce final goods

\[
G_t^{JP}(a_t^{JP}(s^t), b_t^{JP}(s^t)) = \left( \eta(a_t^{JP}(s^t))^\frac{\epsilon-1}{\epsilon} + (1 - \eta)(b_t^{JP}(s^t))^\frac{\epsilon-1}{\epsilon} \right)^\frac{\epsilon}{\epsilon-1}
\]

\[
G_t^{AS}(a_t^{AS}(s^t), b_t^{AS}(s^t)) = \left( (1 - \eta)(a_t^{AS}(s^t))^\frac{\epsilon-1}{\epsilon} + \eta(b_t^{AS}(s^t))^\frac{\epsilon-1}{\epsilon} \right)^\frac{\epsilon}{\epsilon-1}
\]

Final goods profits

\[
\hat{\pi}_t(s^t) = G_t(a_t(s^t), b_t(s^t)) - p_{a,t}(s^t)a_t(s^t) - p_{b,t}(s^t)b_t(s^t)
\]
Preferences

\[ U = \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) \left[ \Psi^i \ln c_t^i(s^t) + (1 - \Psi^i) \ln (1 - l_t^i(s^t)) \right] \]

- \( s^t \): state of the economy
- \( \pi(s^t) \): probability of the state to occur
Budget constraint:

\[
(1 - \tau_{lt}(s^t))w_t^i(s^t)l_t^i(s^t) + (1 - \tau_{kt}(s^t))r_t^i(s^t)k_t^i(s^{t-1}) + rer_t^i(s^t)d_t^i(s^t) + tr_t^i(s^t) = c_t^i(s^t) + x_t^i(s^t) + rer_t^i(s^t) \sum_{q_t(s^{t+1}|s^t)} q_t(s^{t+1}|s^t)d_{t+1}^i(s^{t+1}|s^t),
\]

- \(d_t^i\): state contingent real international claim denominated in yen
- \(q_t\): price of state contingent claim (for each possible state)
- \(rer_t^i\): real exchange rate (\(rer_t^{JP} = 1\), \(rer_t^{AS} = rer_t\))
- \(\tau_{lt}, \tau_{kt}\): distortionary labor and capital income tax
- \(tr_t^i\): lump sum transfer
Capital law of motion

\[ \Gamma^i k^i_{t+1}(s^t) = x^i_t(s^t) + (1 - \delta^i) k^i_t(s^{t-1}) + \Phi \left( \frac{x^i_t(s^t)}{k^i_t(s^{t-1})} \right) k^i_t(s^{t-1}) \]

where \( \Gamma^i \): growth trend of technology and population

Capital adjustment cost

\[ \Phi \left( \frac{x^i_t(s^t)}{k^i_t(s^{t-1})} \right) = \phi^i \left( \frac{x^i_t(s^t)}{k^i_t(s^{t-1})} - \Omega^i \right)^2 \]

where \( \Omega^i = \Gamma^i - (1 - \delta^i) \)
Government budget constraint

\[
\tau^i_{lt}(s^t) w^i_t(s^t) l^i_t(s^t) + \tau^i_{kt}(s^t) r^i_t(s^t) k^i_t(s^t) = tr^i_t(s^t) + g^i_t(s^t)
\]
International financial market equilibrium

\[
\begin{align*}
&\left[ q_t (s^{t+1} | s^t) d_{t+1}^{JP} (s^{t+1} | s^t) - d_t^{JP} (s^t) \right] \\
&+ \left[ q_t (s^{t+1} | s^t) d_{t+1}^{AS} (s^{t+1} | s^t) - d_t^{AS} (s^t) \right] \\
= &\quad t b_t^{JP} (s^t) + t b_t^{AS} (s^t) / r e r_t (s^t) = \tau_t (s^t)
\end{align*}
\]

where

\[
\begin{align*}
t b_t^{JP} (s^t) &= p_{at}^{JP} a_t^{AS} (s^t) - p_{bt}^{JP} b_t^{JP} (s^t) + \tau_t (s^t) \\
t b_t^{AS} (s^t) &= p_{bt}^{AS} b_t^{JP} (s^t) - p_{at}^{AS} a_t^{AS} (s^t).
\end{align*}
\]

- \( p_t \) causes disturbances in the conversion rate of resources in one country shifted to another
- \( \tau_t \) causes disturbances in the total resource in the world
Model
International Relative Prices

- Terms of trade
  \[ \text{tot}_t = \frac{p_{a,t}^{JP}}{p_{b,t}^{JP}} = \frac{p_{a,t}^{AS}}{p_{b,t}^{AS}} \]

- The real exchange rate: the price of Japanese final goods relative to that of Asian final goods
  \[ \text{rer}_t = \frac{MU_{c,t}^{JP}}{MU_{c,t}^{AS}} = \exp(p_t) \frac{p_{a,t}^{AS}}{p_{a,t}^{JP}} = \exp(p_t) \frac{p_{b,t}^{AS}}{p_{b,t}^{JP}} \]
Model

Domestic Absorption and National Accounts

- **Domestic absorption**

\[ G_t^i(a_t^i(s^t), b_t^i(s^t)) = c_t^i(s^t) + x_t^i(s^t) + g_t^i(s^t) \]

- **Gross domestic product**

\[ y_t^i = p_{jt}^i f_t^i = c_t^i(s^t) + x_t^i(s^t) + g_t^i(s^t) + tb_t^i(s^t) \]

where total factor productivity is \( p_{jt}^i z_t^i \)
Model
International Prices

- Terms of trade

\[ \text{tot}_t = \frac{p_{a,t}^{JP}}{p_{b,t}^{JP}} = \frac{p_{a,t}^{AS}}{p_{b,t}^{AS}} \]

- The real exchange rate: the price of Japanese final goods relative to that of Asian final goods

\[ \text{rer}_t = \exp(p_t) \frac{p_{a,t}^{AS}}{p_{a,t}^{JP}} = \exp(p_t) \frac{p_{b,t}^{AS}}{p_{b,t}^{JP}} \]
10 exogenous variables $s = \{g^i, \tau^i_I, \tau^i_X, z^i, p, \tau\}$

$$s_t = P_0 + P \ast s_{t-1} + \varepsilon_t$$

where $\varepsilon = \{\varepsilon^i_g, \varepsilon^i_I, \varepsilon^i_X, \varepsilon^i_z, \varepsilon_p, \varepsilon_{ts}\} \sim N(0, V)$
Model

Equilibrium

- Capital Euler equation

\[ \Gamma^i (1 + \Phi'_t) MUC^i_t = \beta^i E_t \left[ MUC^i_{t+1} \left( (1 - \tau^i_{kt+1}) p^i_{j,t+1} MPk^i_{t+1} + (1 + \Phi'_{t+1}) \left( 1 - \delta^i - \Phi'_{t+1} \frac{x_{t+1}}{k_{t+1}} + \Phi_{t+1} \right) \right) \right] \]

- Labor First order condition

\[ - \frac{MUI^i_t}{MUC^i_t} = (1 - \tau^i_{lt}) p^i_{j,t} MPL^i_t \]

- International financial condition (complete markets)

\[ rer_t = \frac{MUC^JP_t}{MUC^AS_t} = \exp(p_t) \frac{p^AS_{a,t}}{p^JP_{a,t}} \]
Model
Equilibrium

- Domestic resource constraint
  \[ y^i_t = c^i_t + x^i_t + g^i_t + t b^i_t \]

- Production function
  \[ f^i_t = \exp(z^i_t)(k^i_t)^{\theta^i_t}(l^i_t)^{1-\theta^i_t} \]

- Capital law of motion
  \[ \Gamma^i k^i_{t+1} = x^i_t + (1 - \delta^i_t) k^i_t + \Phi \left( \frac{x^i_t}{k^i_t} \right) k^i_t \]

- International resource constraint
  \[ t b^J_{t} + t b^A_{t} / rer_t = \tau_t \]
Domestic absorption

\[ G^i_t(a^i_t, b^i_t) = c^i_t + x^i_t + g^i_t \]

International prices

\[ \frac{MUc^{JP}_t}{MUc^{AS}_t} = \exp(p_t) \frac{G^{AS}_{a,t}}{G^{JP}_{a,t}} \]

\[ \frac{G^{JP}_{a,t}}{G^{JP}_{b,t}} = \frac{G^{AS}_{a,t}}{G^{AS}_{b,t}} = tot_t \]
Calibration

Table 2. Parameter Values

<table>
<thead>
<tr>
<th></th>
<th>Japan</th>
<th>Korea</th>
<th>Taiwan</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>0.390</td>
<td>0.322</td>
<td>0.507</td>
<td>0.407</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.023</td>
<td>0.010</td>
<td>0.009</td>
<td>0.014</td>
</tr>
<tr>
<td>$\Gamma$</td>
<td>1.005</td>
<td>1.014</td>
<td>1.011</td>
<td>1.010</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.993</td>
<td>0.991</td>
<td>0.960</td>
<td>0.982</td>
</tr>
<tr>
<td>$\Psi$</td>
<td>0.227</td>
<td>0.243</td>
<td>0.293</td>
<td>0.254</td>
</tr>
</tbody>
</table>
Stochastic process

\[ s_t = P_0 + P \times s_{t-1} + \epsilon_t \]

where \( P = 0.8 \times I_{10 \times 10} \)

- also estimated by maximum likelihood estimation
- simulation results are not sensitive to the stochastic process parameters
solve the model for linear decision rules

\[
\{ k_{t+1}^i, y_t^i, c_t^i, l_t^i, x_t^i, g_t^i \} = DR(k_t^i, g_t^i, \tau_{lt}^i, \tau_{kt}^i, z_t^i, p_t, \tau_t)
\]

assuming \( k_1^i = k_{ss}^i \), compute \( \{ g_1^i, \tau_{l1}^i, \tau_{k1}^i, z_1^i, p_1, \tau_1 \} \) from

\[
\{ y_1^i, c_1^i, l_1^i, x_1^i, g_1^i \} = DR(k_1^i, g_1^i, \tau_{l1}^i, \tau_{k1}^i, z_1^i, p_1, \tau_1)
\]

compute \( k_1^i \) from

\[
k_2^i = DR(k_1^i, g_1^i, \tau_{l1}^i, \tau_{k1}^i, z_1^i, \nu_1, \tau_1)
\]

solve for \( \{ g_2^i, \tau_{l2}^i, \tau_{k2}^i, z_2^i, p_2, \tau_2 \} \) from

\[
\{ y_1^i, c_1^i, l_1^i, x_1^i, g_1^i \} = DR(k_1^i, g_1^i, \tau_{l1}^i, \tau_{k1}^i, z_1^i, p_1, \tau_1)
\]

repeat 4 and 5 for the whole period
Figure 3. Wedges
Quantitative Analysis

Simulation

- Simulation with each wedge (linearly detrended)
  - growth in Asian efficiency benefitted both Asia (112%) and Japan (62%) substantially
  - drop in Japanese efficiency hurt Asia (-35%) and Japan (-66%)
  - other wedges do not seem important
Figure 4a. Results-Japanese Output
Figure 4b. Results-Asian Output

- g(JP)
- tl(JP)
- tk(JP)
- z(JP)
- g(AS)
- tl(AS)
- tk(AS)
- z(AS)
- p
- t
- DATA
The effect of a rise in efficiency wedges

- a rise in $z_{AS}$ leads to an improvement in the Japanese terms of trade
- this works as a positive total factor productivity shock to Japanese aggregate output
- both Asia and Japan booms
Impulse Response to Efficiency Wedge

- Efficiency (AS)
- Output (JP)
- Output (AS)
- Terms of Trade
Simulation with each wedge (HP filtered)

- efficiency wedges are important in accounting for fluctuation in output in each region
- the drop in efficiency wedge in Asia in 1997 caused a large drop in output in Japan! (-2.6%)
- the main reason of the recent recession is the drop in efficiency wedges in each country
Figure 5a. Results-Japanese Output (HP Filtered)
Figure 5b. Results-Asian Output (HP Filtered)
Conclusion

- Efficiency wedges are important in accounting for both short run fluctuations and long run trends in each country
  - the contributions of other wedges were relatively small

Extensions

- what are efficiency wedges?
  - long run trend in efficiency wedges: productivity
  - short run fluctuation in efficiency wedges: financial frictions & efficiency?

- the effects of US and China?