The Sandwich Effect: Challenges for Middle-Income Countries

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"Middle Income Trap"

Box 1 Figure  Few countries escape the middle-income trap

Source: Heston, Summers, and Aten 2011.

a. The term "middle-income trap" was first defined in Gill, Kharas, and others (2007). "Middle income economies" are defined in accordance with classifications by income group as given in: http://data.worldbank.org/about/country-classifications.

b. In today’s increasingly globalized world, escaping the middle-income trap may be even more difficult (Eckhout and Jovanovic 2007).

Source: Maddison database.
$x$ is per capita real GDP relative to the US
Graph (2): GDP per capita (PPP) of Latin America as % of US level
Main Question

- Why did most of middle-income countries fail to converge sufficiently fast to developed countries?
  - What mechanisms drive the diversified growth performance across middle-income countries?
  - To what extent are these mechanisms different from those for low-income countries and high-income countries?
  - What are the policy implications for middle-income countries?
Preview of Major Findings

A three-country dynamic GE model with trade is developed to illustrate how Sandwich Effects work.

We show that:

1. no chasing effect when the chasing country is sufficiently unproductive
2. The chasing effect works in different dimensions in different scenarios (intensive, extensive, speed, and size).
3. sandwich effects (endogenous intensification of the pressing and chasing effects)
4. Middle-income countries should boost productivity growth to offset chasing effects but enhance variety imitation (innovation) to dampen pressing effect.
Extend Krugman (1979) to a world with three countries: N, M, S
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Utility function:

$$\left[ \int_0^1 c(i)^\theta \, di \right]^{1/\theta}, \theta \in (0, 1).$$
S only knows how to produce $i \in [0, n_S]$,
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2. M only knows how to produce $[0, n_M], n_S < n_M$
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2. M only knows how to produce $[0, n_M]$, $n_S < n_M$
3. N knows how to produce all the good $[0, n]$, $n_M < n$
Technologies and Market Structure

1. S only knows how to produce $i \in [0, n_S]$.
2. M only knows how to produce $[0, n_M]$, $n_S < n_M$.
3. N knows how to produce all the good $[0, n]$, $n_M < n$.
4. One unit of labor in country $J$ produces $A_J$ units of good.
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3. N knows how to produce all the good $[0, n]$, $n_M < n$
4. One unit of labor in country $J$ produces $A_J$ units of good
5. All the markets in each country are perfectly competitive
<table>
<thead>
<tr>
<th>known by $S, M, N$</th>
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<tbody>
<tr>
<td>0</td>
<td>$n_S$</td>
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</table>
Free trade
Suppose $A_N = A_M = A_S = 1$.
When $w_N > w_M > w_S$, the specialization pattern is as follows:

\[
\begin{array}{ccc}
\text{produced by } S & \text{produced by } M & \text{produced by } N \\
0 & n_S & n_M & n \\
\end{array}
\]
Static Equilibrium

**Theorem**

*In the static free trade equilibrium with $A_N = A_M = A_S = 1$, we have*

\[
\frac{w_N}{w_M} = \left( \frac{n - n_M}{n_M - n_S} \frac{L_M}{L_N} \right)^{1-\theta}
\]

*when $w_N > w_M > w_S$, which holds iff*

\[
\frac{L_N}{n - n_M} < \frac{L_M}{n_M - n_S} < \frac{L_S}{n_S}.
\]

(1)

Country M is more "sandwiched" when $n_S$ increases or $n$ increases (or $n_M$ decreases).

\[
\frac{w_M}{w_S} = \left( \frac{n_M - n_S}{n_S} \frac{L_S}{L_M} \right)^{1-\theta} ; \quad \frac{w_N}{w_S} = \left( \frac{n - n_M}{n_S} \frac{L_S}{L_N} \right)^{1-\theta}
\]
1. $A_N$, $A_M$, and $A_S$ are not necessarily one
2. We focus on what determines $\frac{w_N}{w_M}$:
   - the chasing effect: $A_S$ and $n_S$ (and $L_S$)
1. \( A_N, A_M, \) and \( A_S \) are not necessarily one.

2. We focus on what determines \( \frac{w_N}{w_M} \):
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   - the pressing effect: \( A_N \) and \( n_m, \) \( n \) (and \( L_N \))
1. $A_N$, $A_M$, and $A_S$ are not necessarily one

2. We focus on what determines $\frac{w_N}{w_M}$:
   - the chasing effect: $A_S$ and $n_s$ (and $L_S$)
   - the pressing effect: $A_N$ and $n_m, n$ (and $L_N$)
   - the sandwich effect: the interaction of chasing and pressing effects
Theorem

Suppose \( \frac{A_M L_M}{n_M - n_S} > \frac{A_N L_N}{n - n_M} \), we have

\[
\frac{w_N}{w_M} = \begin{cases} 
\frac{A_N}{A_M} & \text{if } A_S \in (0, A_0] \\
\left[ \frac{A_N L_N}{A_S L_S + A_M L_M} \frac{n_M}{n - n_M} \right]^{\theta-1} \frac{A_N}{A_M} \left( \frac{n - n_M}{n_M - n_S} \frac{L_M}{L_N} \right)^{1-\theta} \frac{A_N^\theta}{A_M^\theta} & \text{if } A_S \in (A_0, A_1] \\
\left( \frac{n - n_M}{n_M - n_S} \frac{L_M}{L_N} \right)^{1-\theta} \frac{A_N^\theta}{A_M^\theta} & \text{if } A_S \in (A_1, \infty) 
\end{cases}
\]

where

\[
A_0 \equiv \frac{n_M A_N L_N - (n - n_M) A_M L_M}{(n - n_M) L_S}; A_1 \equiv \frac{n_S A_M L_M}{(n_M - n_S) L_S}.
\]
Figure 3. How $w_N/w_M$ Changes with $A_S$
Intuition

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<tr>
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\[
\frac{w_N}{A_N} = \frac{w_M}{A_M} = \frac{w_S}{A_S} \text{ when } A_S \in (0, A_0]
\]
Intuition

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- $\frac{w_N}{A_N} = \frac{w_M}{A_M} = \frac{w_S}{A_S}$ when $A_S \in (0, A_0]$
- $\frac{w_N}{A_N} > \frac{w_M}{A_M} = \frac{w_S}{A_S}$ when $A_S \in (A_0, A_1]$
### Intuition

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- $\frac{w_N}{A_N} > \frac{w_M}{A_M} = \frac{w_S}{A_S}$ when $A_S \in (A_0, A_1]$
- $\frac{w_N}{A_N} > \frac{w_M}{A_M} > \frac{w_S}{A_S}$ when $A_S \in (A_1, \infty)$
Figure 4. How \( \frac{w_N}{w_M} \) Changes with \( A_s \) when \( A_s' \) Increases

\[
\frac{w_N}{w_M} = \left( \frac{n-n_M}{n_M} \left( \frac{A_N L_N + A_M L_M}{A_N L_N} \right) \right)^{1-\eta} \frac{A_N}{A_M}
\]
Figure 5. How $w_N/w_M$ Changes with $A_S$ when $n$ increases under (??)
Figure 6. How $w_N / w_M$ Changes with $A_S$ when $n_M$ increases.
Figure 7. How $w_N / w_M$ Changes with $A_S$ when $A_M$ increases under (?)
Dynamic Economy
Innovation and Imitation

- Country $N$ keeps innovating at an exogenous and positive speed $\alpha$:
  \[
  \dot{n} = \alpha n. 
  \] (2)

- Country $M$ adapts technologies from country $N$ at an exogenous positive speed $\beta$:
  \[
  \dot{n}_M = \beta(n - n_M). 
  \] (3)

- Country $S$ imitates from country $M$ at a positive imitation speed $\gamma$:
  \[
  \dot{n}_S = \gamma(n_M - n_S). 
  \] (4)
**Theorem**

Suppose $\frac{\alpha + \gamma}{\beta} > \frac{A_N L_N}{A_M L_M}$, the following is true on the Balanced Growth Path:

$$\frac{w_N}{w_M} = \begin{cases} 
\frac{A_N}{A_M} & \text{if } A_S \in (0, \bar{A}_0] \\
\left[\frac{A_S L_S + A_M L_M}{A_N L_N}\right]^{1-\theta} \frac{A_N}{A_M} & \text{if } A_S \in (\bar{A}_0, \bar{A}_1] \\
\left(\frac{\alpha + \gamma}{\beta} \frac{L_M}{L_N}\right)^{1-\theta} \frac{A_N}{A_M} & \text{if } A_S \in (\bar{A}_1, \infty) 
\end{cases}$$

where

$$\bar{A}_0 \equiv \frac{A_N L_N}{L_S} \frac{\beta}{\alpha} - \frac{A_M L_M}{L_S}; \quad \bar{A}_1 \equiv \frac{\gamma A_M L_M}{\alpha L_S}.$$

A special case ($A_N = A_M = A_s = 1$ and $A_S \in (A_1, \infty)$):

$$\frac{w_N}{w_M} = \left(\frac{\alpha + \gamma}{\beta} \frac{L_M}{L_N}\right)^{1-\theta}$$
Optimal Policies of Country M

Define $g_i \equiv \frac{\dot{A}_i}{A_i}$ for $i \in \{N, M, S\}$.

- $g_N$ and $g_S$ are exogenous
Define $g_i \equiv \frac{\dot{A}_i}{A_i}$ for $i \in \{N, M, S\}$.

- $g_N$ and $g_S$ are exogenous
- $g_M$ is endogenous: $\mu$ (endogenous employment share in the R&D sector in $M$).

\[
\begin{align*}
\dot{n}_M & = \beta(n - n_M) [\mu L_M + 1]^{\xi} \\
\dot{A}_M & = \phi(A_N - A_M) [(1 - \mu)L_M + 1]^{\eta}
\end{align*}
\]
Define $g_i \equiv \frac{A_i}{\hat{A}_i}$ for $i \in \{N, M, S\}$.

- $g_N$ and $g_S$ are exogenous
- $g_M$ is endogenous: $\mu$ (endogenous employment share in the R&D sector in $M$).

\[
\begin{align*}
\dot{n}_M &= \beta(n - n_M) [\mu L_M + 1]^\xi \\
\dot{A}_M &= \phi(A_N - A_M) [(1 - \mu)L_M + 1]^\eta
\end{align*}
\]

- Trade off: $\dot{n}_M$ vs $\dot{A}_M$
Theorem

When $g_N = g_S = g > 0$ and $A_S \in (A_0, A_1]$ hold on the BGP, the following is true:

\[
\begin{align*}
g_M^* &= g; \\
\frac{\partial \mu^*}{\partial A_S} &< 0; \quad \frac{\partial \mu^*}{\partial L_S} < 0; \quad \frac{\partial \mu^*}{\partial A_N} > 0; \quad \frac{\partial \mu^*}{\partial g} < 0, \\
\frac{\partial \mu^*}{\partial \alpha} &= \frac{\partial \mu^*}{\partial \beta} = \frac{\partial \mu^*}{\partial L_N} = 0;
\end{align*}
\]

Major implications for country $M$:

- should increase productivity growth (reduce $\mu^*$) to offset chasing effect
- should increase variety imitation (raise $\mu^*$) to offset pressing effect
Theorem

When \( g_N = g_S = g > 0 \) and \( A_S \in (A_0, A_1] \) hold on the BGP, the following is true:

\[
\frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial \phi} < 0; \quad \frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial \zeta} < 0; \quad \frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial \eta} < 0,
\]

\[
\frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial L_S} > 0; \quad \frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial L_N} < 0; \quad \frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial L_M} < 0; \quad \frac{\partial \left( \frac{w_N}{w_M} \right)}{\partial g} > 0.
\]

Major implications for country M:

- better institutions \((\phi, \zeta, \eta)\) help convergence
- larger chaser \((L_S)\) and smaller presser \((L_N)\) impose stronger sandwich effects
- a larger size \((L_M)\) helps convergence
- faster world productivity growth \((g)\) hampers convergence
Conclusion

We develop a three-country model of trade and growth to illustrate how middle-income countries can be sandwiched by poorer countries that chase from behind and richer countries that press from front.

We show that:

1. no chasing effect when the chasing country is sufficiently unproductive
2. The chasing effect works in different dimensions in different scenarios (intensive, extensive, speed, and size).
3. sandwich effects (endogenous intensification of the pressing and chasing effects)
4. Middle-income countries should boost productivity growth to offset chasing effects but enhance variety imitation (innovation) to dampen pressing effect.

Preliminary empirical evidence supports the model mechanism (in progress).
Combining both Theorems, we have

$$\frac{w_N}{w_M} = \begin{cases} 
\left( \frac{A_S L_S}{A_M L_N} + 1 \right)^{1-\theta} \left( \frac{n-n_M}{n_M} \frac{L_M}{L_N} \right)^{1-\theta} \frac{A_N}{A_M} & \text{if } A_S \in (0, A_0] \text{ or (4) violate} \\
\left( \frac{n_M}{n_M-n_S} \right)^{1-\theta} \left( \frac{n-n_M}{n_M} \frac{L_M}{L_N} \right)^{1-\theta} \frac{A_N}{A_M} & \text{if } A_S \in (A_0, A_1] \& (4) \\
\left( \frac{n_M}{n_M-n_S} \right)^{1-\theta} \left( \frac{n-n_M}{n_M} \frac{L_M}{L_N} \right)^{1-\theta} \frac{A_N}{A_M} & \text{if } A_S \in (A_1, \infty) \& (4) 
\end{cases}$$

where

$$A_0 \equiv \frac{n_M A_N L_N - (n - n_M) A_M L_M}{(n - n_M) L_S}; A_1 \equiv \frac{n_S A_M L_M}{(n_M - n_S) L_S}.$$
Preliminary Empirical Test

\[ D_1 = \begin{cases} 
1, & \text{if } A_S \in (A_0, A_1] \text{ and (4) holds}, \\
0, & o/w 
\end{cases} \]

\[ D_2 = \begin{cases} 
1, & \text{if } A_S > A_1 \text{ and (4) holds} \\
0, & o/w 
\end{cases} \]

Regression specification:

\[
\log \frac{w_N}{w_M} = \beta_0 + \beta_1 \log \frac{A_N}{A_M} + \beta_2 D_1 \log \left( \frac{A_S L_S}{A_M L_N} + 1 \right) + \beta_3 D_2 \log \frac{n_M}{n_M - n_S} + \beta_4 (D_1 + D_2) \log \left[ \frac{L_M}{L_N} \frac{(n - n_M)}{n_M} \right] + B'X + \varepsilon
\]
Data and Measurement

- \( n, n_M, n_S \) are computed by using revealed comparative advantage (RCA) by Balassa (1965):

\[
RCA_j^A = \frac{x_j^A / x^A}{x_j^W / x^W}
\]

- NBER-UN world trade flow data (Feenstra et al 2005), \( j \) is SITC Rev.2 at 4-digit level from 1962 to 2000.

- \( w_i \) and \( A_i \) for \( i \in \{N, M, S\} \), from Penn World Table
<table>
<thead>
<tr>
<th>Expression</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$\log \frac{A_N}{A_M}$</td>
<td>0.738</td>
</tr>
<tr>
<td>$D_1 \log \left( \frac{A_S L_S}{A_M L_N} + 1 \right)$</td>
<td>(51.62)**</td>
</tr>
<tr>
<td>$D_2 \log \frac{n_M}{n_M - n_S}$</td>
<td>0.145</td>
</tr>
<tr>
<td>$(D_1 + D_2) \log \left[ \frac{L_M (n - n_M)}{L_N n_M} \right]$</td>
<td>(18.22)**</td>
</tr>
<tr>
<td>constant.</td>
<td>0.027</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.78</td>
</tr>
<tr>
<td>$N$</td>
<td>1,012</td>
</tr>
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</table>

*p<0.05  **p<0.01