The Sandwich Effect: Challenges for Middle-Income Countries

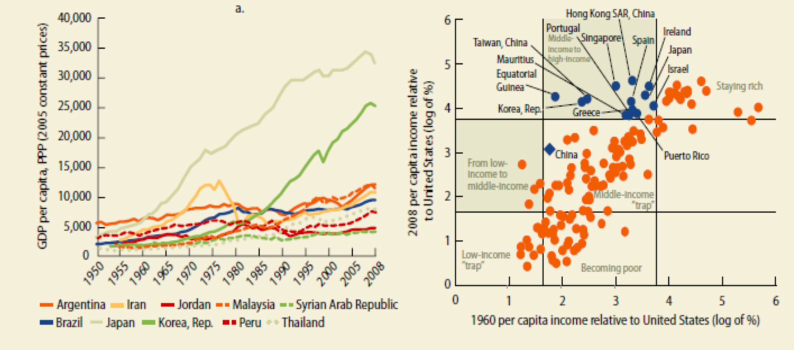
Yong Wang; Shang-Jin Wei

PKU; Columbia

June 2019

"Middle Income Trap"

Box 1 Figure Few countries escape the middle-income trap



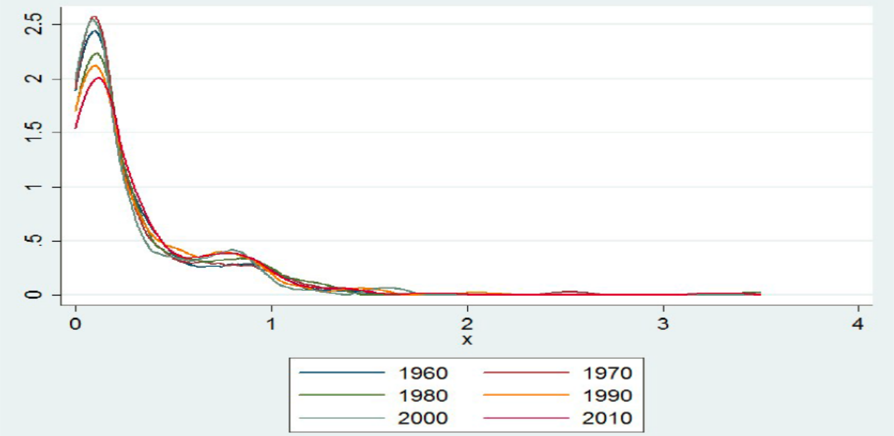
Source: Heston, Summers, and Aten 2011.

Source: Maddison database.

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 (Eeckhout and Jovanovic 2007).

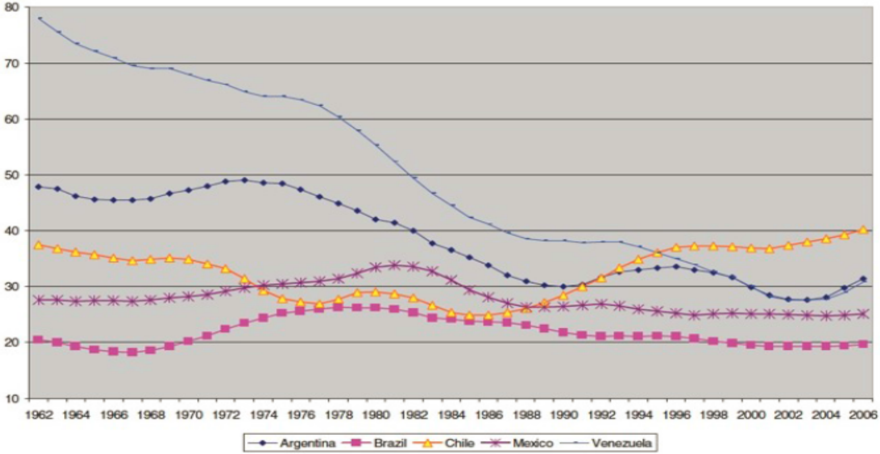
World Income Distribution



Graph (4): the world income distribution for the years 1960 to 2010

x is per capita real GDP relative to the US

GDP per capita (PPP) of Latin America as % of US Level



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.

Model Environment

- Extend Krugman (1979) to a world with three countries: N, M, S

Model Environment

- Extend Krugman (1979) to a world with three countries: N, M, S
- The populations are L_N, L_M, and L_S, respectively.

Model Environment

- Extend Krugman (1979) to a world with three countries: N, M, S
- The populations are L_N, L_M, and L_S, respectively.
- Each household is endowed with one unit of labor

Model Environment

- Extend Krugman (1979) to a world with three countries: N, M, S
- The populations are L_N, L_M, and L_S, respectively.
- Each household is endowed with one unit of labor
- Utility function:

$$\left[\int_0^n c(i)^\theta di\right]^{1/\theta}, \theta \in (0,1).$$

Technologies and Market Structure

1. S only knows how to produce $i \in [0, n_S]$,

Technologies and Market Structure

1. S only knows how to produce $i \in [0, n_S]$,
2. M only knows how to produce $[0, n_M]$, $n_S < n_M$

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 $[0, n]$, $n_M < n$

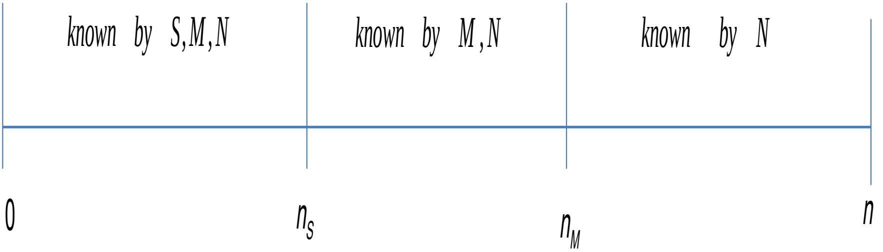
Technologies and Market Structure

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

Technologies and Market Structure

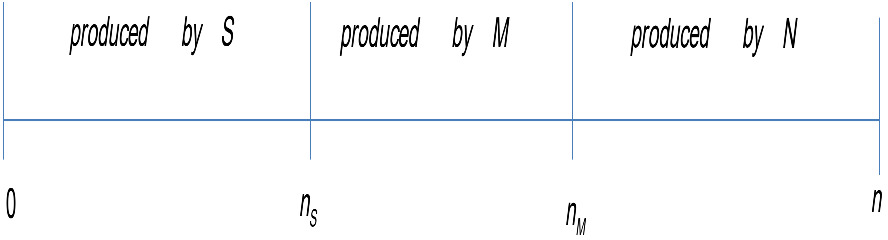
1. S only knows how to produce $i \in [0, n_S]$,
2. M only knows how to produce $[0, n_M]$, $n_S < n_M$
3. N knows how to produce all the good $[0, n]$, $n_M < n$
4. One unit of labor in country J produces A_J units of good
5. All the markets in each country are perfectly competitive

Technology



Trade and Specialization

- Free trade
- Suppose $A_N = A_M = A_S = 1$.
- When $w_N > w_M > w_S$, the specialization pattern is as follows:



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*

$$\frac{L_N}{n - n_M} < \frac{L_M}{n_M - n_S} < \frac{L_S}{n_S}. \tag{1}$$

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

$$\frac{w_M}{w_S} = \left(\frac{n_M - n_S}{n_S} \frac{L_S}{L_M} \right)^{1-\theta}; \frac{w_N}{w_S} = \left(\frac{n - n_M}{n_S} \frac{L_S}{L_N} \right)^{1-\theta}$$

Generalized Static Equilibrium

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)

Generalized Static Equilibrium

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)

Generalized Static Equilibrium

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*

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

where

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

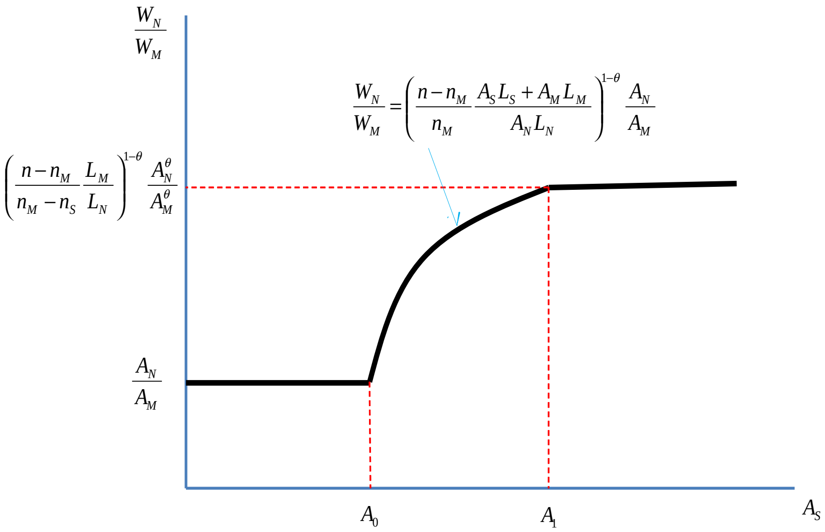
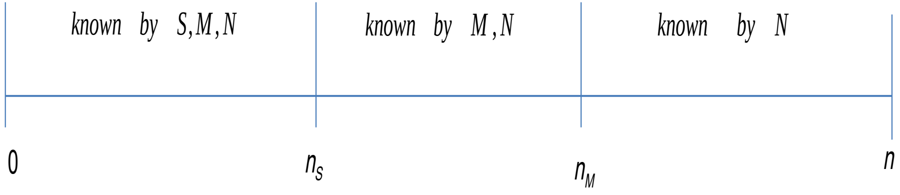


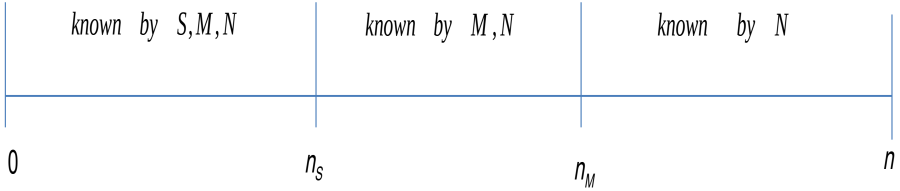
Figure 3. How w_N / w_M Changes with A_S

Intuition



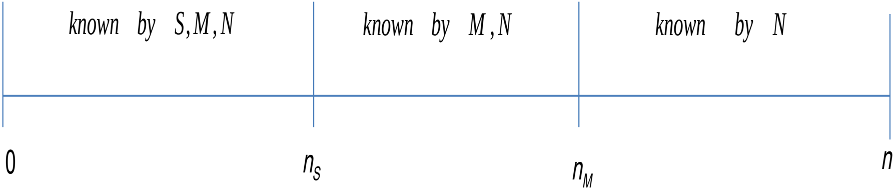
- $\frac{w_N}{A_N} = \frac{w_M}{A_M} = \frac{w_S}{A_S}$ when $A_S \in (0, A_0]$

Intuition



- $\frac{w_N}{A_N} = \frac{w_M}{A_M} = \frac{w_S}{A_S}$ 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



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

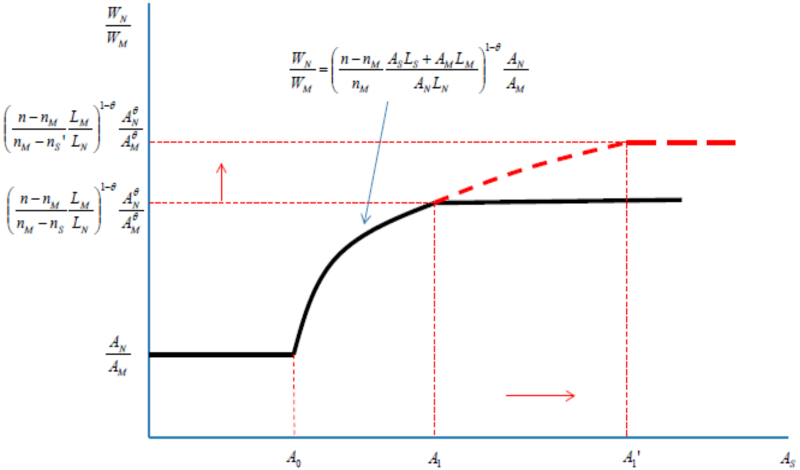


Figure 4. How w_N/w_M Changes with A_S when n_S Increases

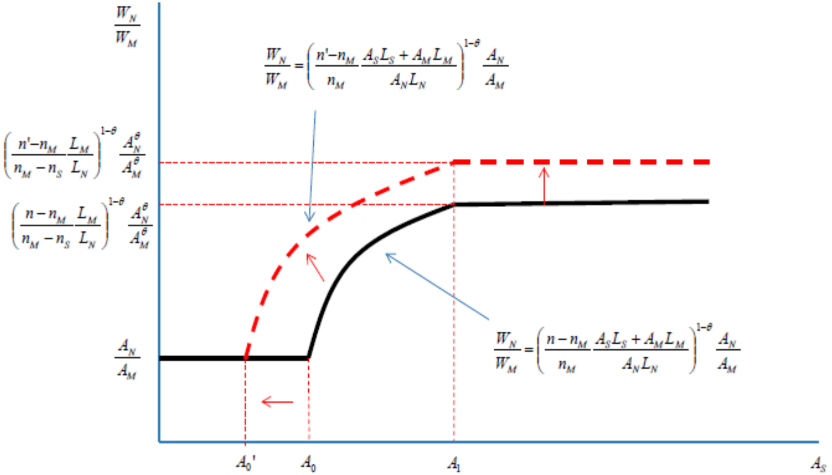


Figure 5. How w_N / w_M Changes with A_S when n increases under (??)

Sandwich Effect 2

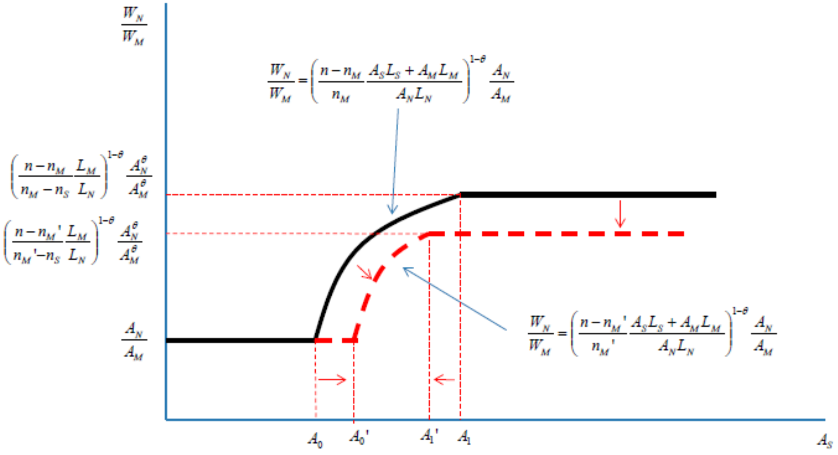


Figure 6. How w_N / w_M Changes with A_S when n_M increases.

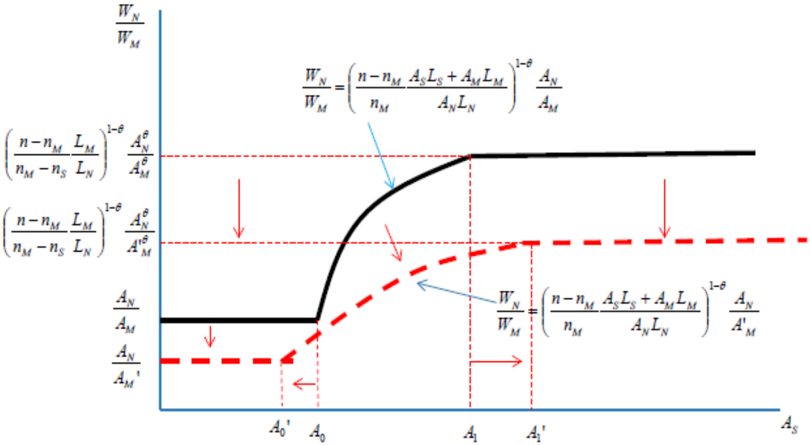


Figure 7. How w_N / w_M Changes with A_S when A_M increases under (**??**)

Dynamic Economy

Innovation and Imitation

- Country N keeps innovating at an exogenous and positive speed α:

$$\dot{n} = \alpha n. \tag{2}$$

- Country M adapts technologies from country N at an exogenous positive speed β :

$$\dot{n}_M = \beta(n - n_M), \tag{3}$$

- Country S imitates from country M at a positive imitation speed γ:

$$\dot{n}_S = \gamma(n_M - n_S). \tag{4}$$

Dynamic Sandwich Effect

Theorem

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

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

where

$$\widetilde{A_0} \equiv \frac{A_N L_N}{L_S}\frac{\beta}{\alpha} - \frac{A_M L_M}{L_S}; \widetilde{A_1} \equiv \frac{\gamma A_M L_M}{\alpha L_S}.$$

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

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

- g_N and g_S are exogenous

Optimal Policies of Country M

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

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

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

Optimal Policies of Country M

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

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

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

- 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:

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

Major implications for country M:

- should increase productivity growth (reduce μ^*) to offset chasing effect
- should increase variety imitation (raise μ^*) 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:

$$\frac{\partial\left(\frac{w_N}{w_M}\right)}{\partial\phi} < 0; \frac{\partial\left(\frac{w_N}{w_M}\right)}{\partial\xi} < 0; \frac{\partial\left(\frac{w_N}{w_M}\right)}{\partial\eta} < 0,$$

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

Major implications for country M:

- better institutions (ϕ, ξ, η) 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).

Preliminary Empirical Test

Combining both Theorems, we have

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

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

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

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

Regression specification:

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

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

	$\log \frac{W_N}{W_M}$
$\log \frac{A_N}{A_M}$	0.738
	(51.62)**
$D_1 \log(\frac{A_S L_S}{A_M L_N} + 1)$	0.739
	(10.54)**
$D_2 \log \frac{n_M}{n_M - n_S}$	0.145
	(18.22)**
$(D_1 + D_2) \log \left[\frac{L_M}{L_N} \frac{(n - n_M)}{n_M}\right]$	0.027
	(8.26)**
constant.	0.369
	(22.33)**
R^2	0.78
N	$1,012$

*p<0.05 **p<0.01