

## Imitation as a Stepping Stone to Innovation

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## Shift from Imitation to Innovation

- Countries such as Korea, China, and Taiwan shifting from imitation to innovation.
- Product cycle literature examines effects of North-South trade on innovation.
- Existing work does not consider innovation in the South where only imitate.
- Goal to model both imitation and innovation in the developing South.



## Southern High-tech Exports

- High-tech exports in 2007
  - Many countries have higher percentage of exports that are high-tech than US:
    - Philippines 53.6%, Malaysia 51.7%, Singapore 46.5%, Taiwan 44.7%, Korea 33.5%, China 29.7%, US 28.4% ... Japan 19.8% (rank 17).
  - China's high-tech exports larger than US or Japan's (roughly equals those two combined)
    - China \$337b, US \$229b, Germany \$156b, Japan \$121b, Singapore \$105.5b, Taiwan 94.0 billion.
  - *World Competitiveness Yearbook* (2009)



## Southern R&D Increasing

- R&D expenditure growing
  - US \$368.8b, Japan \$148.4b, Germany \$83.8b, France \$53.9b, China \$48.8b (up from \$12.6 in 2001), UK \$42.7b, Korea \$28.6b (up from \$12.5 in 2001), Canada \$26.9b, ... Taiwan \$10.1 billion (rank 17) in 2007.
  - Israel 4.7% of GDP, Sweden 3.5%, Finland 3.6%, Japan 3.4%, Korea 3.0%, Switzerland 2.9%, US 2.7%, Taiwan 2.6% ... Singapore 2.3% (rank 12) ... China 1.5% (rank 23).



## Southern R&D Yields Patents

- Average number of patents granted to residents per year 2005-2007:
  - Japan 127,644, US 81,329, Korea 78,122 (up from 34,052 over 1998-2000), Taiwan 36,772 (up from 20,094), China 25,909 (up from 3,742).



## Questions About Southern Innovation

- Need a model in which Southern firms innovate (as well as imitate) to ask:
- What determines how much innovation occurs in the South?
  - How can the South increase its innovation?
  - Can general Southern R&D subsidy promote innovation?
- How do conditions affecting Southern R&D (such as resources and subsidies) influence how much innovation occurs in the North?
  - Does Southern innovation necessarily crowd out Northern innovation?
  - What happens to aggregate innovation?
  - How do results differ from case where no innovation in the South?



## Quality Ladders Model



- Continuum of products.
- Consumers buy highest quality level of each, evenly spread spending across time & products.
- Southern firms imitate.
  - Northern firms do not imitate because they lack the production cost advantage that supports imitation by Southern firms.
- Northern firms innovate.
  - Initially no Southern innovation so like standard model.

## Add Basic Southern Innovation



- As South develops, becomes able to innovate after imitation in some industries.
  - Imitation generates knowledge base that makes Southern innovation easier.
  - Fraction of industries where the South innovates after imitation increases with development.

## Then Advanced Southern Innovation



- Eventually South becomes able to innovate immediately after Northern innovation in some industries.
  - Fraction of industries where South can innovate immediately also increases with development.
  - When finally can innovate immediately in all industries, South is like the North.

## Southern Innovation Condition



- Following imitation, let the fraction  $\theta$  of industries have a low labor requirement in Southern innovation  $a_S$  and the rest  $A_S > a_S$ .
  - Industries with the low requirement will try to innovate, while the rest will not.
- Southern innovation condition equates the cost of innovation to the expected reward in terms of profit stream in industries where Southern innovation.

$$a_S = v_S = \frac{\pi_S}{\rho + I_N + I_S}$$

## Imitation Condition



- Southern imitation condition equates the cost of imitation to the expected reward.
- Reward is weighted average of reward when exposed to only Northern innovation and the reward when face both Northern and Southern innovation.

$$a_M = v_M = \frac{\theta \pi_M}{\rho + I_N + I_S} + \frac{(1 - \theta) \pi_M}{\rho + I_N}$$

- $\theta = 0$  is special case with no Southern innovation.

## Northern Innovation Condition



- Following Northern innovation, let the fraction  $\Theta$  of industries have a low labor requirement in Southern innovation  $a_S$  and the rest  $A_S > a_S$ .
- Northern innovation condition equates the cost of imitation to the expected reward, a weighted average of reward when exposed to only imitation & Northern innovation and the reward when also face Southern innovation.

$$w a_N = v_N = \frac{\Theta \pi_N}{\rho + \mu_M + I_N + I_S} + \frac{(1 - \Theta) \pi_N}{\rho + \mu_M + I_N}$$

- Special cases:  $\theta = 1, \Theta = 0$  all Southern innovation awaits imitation;  $\theta = \Theta = 1$  all Southern innovation immediate.

## Labor Constraints



- Northern labor split between innovation & production.
- Southern labor split between imitation, innovation, and production.

$$a_M \mu_M n_S + a_S l_S (\theta n_N + \theta n_M + n_S) + E \left( \frac{n_M}{w} + \frac{n_S}{\lambda} \right) = L_S$$

– Special case when no Southern innovation:

$$a_M \mu_M n_S + E \left( \frac{n_M}{w} \right) = L_S$$

## Results With Southern Innovation



	Northern innovation	Southern innovation	Imitation	Southern innovation /imitation	agg inn
$L_N$	+	-	+	-	+
$L_S$	0	+	+/0	+	+
$\sigma_N$	+	-	+	-	+/-
$\sigma_S$	0	+	-	+	+

## Notable Results and Contrast



- Rate of Northern innovation essentially **unaffected** by Southern labor or general Southern R&D subsidy but
  - rises when no Southern innovation
- Rate of imitation **falls** with general Southern R&D subsidy but
  - rises when no Southern innovation

## Notable Results and Contrast



- Rate of imitation **rises** with more Southern labor when Southern innovation follows imitation (and when no Southern innovation) but
  - unaffected when Southern innovation unrestricted
- Aggregate rate of innovation (Northern plus Southern) **rises** with Northern R&D subsidy when Southern innovation follows imitation (and when no Southern innovation) but
  - falls when Southern innovation unrestricted

## Answers



- Southern resources and R&D subsidies increase Southern innovation – in absolute terms and relative to imitation.
  - Both imitation\* and Southern innovation increase with more Southern labor; Southern innovation increases and imitation decreases with a general Southern R&D subsidy (to both innovation and imitation).
  - \*Whether innovation needs imitation as a stepping stone could matter for whether more Southern resources boost the rate of imitation.
  - Boost in Southern innovation has little impact on Northern innovation.
- Northern resources and R&D subsidies increase imitation and Northern innovation and decrease Southern innovation, with total innovation increased
  - Except that a Northern R&D subsidy can damage total innovation if all Southern innovation is unrestricted (all industries can innovate without needing imitation first).

## Conclusion



- Novel product cycle model
- South innovates and imitates
- Industries heterogeneous: in some
  - can innovate in the South easily,
  - need imitation to make innovation easy enough,
  - or too hard to innovate even after imitation
- Fractions exogenous but likely increase as South develops so that eventually can innovate in all industries like the North.