# On the Role of Technical Cooperation in International Technology Transfers

Yasuyuki Sawada *U. Tokyo, JICA-RI, RIETI*

Ayako Matsuda *UC Berkeley*

Hidemi Kimura *MOF and RIETI*

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# MISSION: IMPOSSIBLE

- The effectiveness of technical co-operation aid has been largely unexplored:
  - Cassen et al. (1994): There is *no ready methodology for measuring the effectiveness of aggregate long-run effects of TC*. Difficulties to measure the impacts have hindered the academia from conducting quantitative evaluations of TC.

- **This paper aims to bridge this gap in the literature by analyzing the role of aggregate TC in facilitating tech. transfers from donors to recipients of aid.**
  - By doing so, we identify the key factors for institutional capacity development

# Outline

1. Introduction and Preview of Results
2. A Theoretical Framework of Int’l Tech. Transfers
3. An Econometric Model and Data
4. Benchmark Results
5. Robustness Tests
6. Concluding Remarks

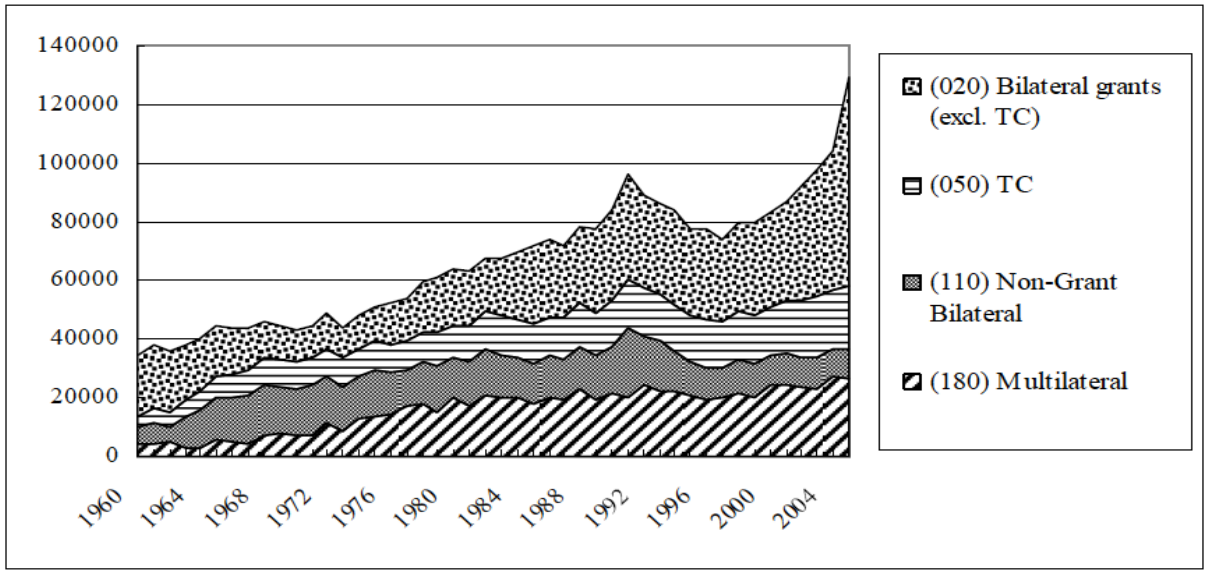
# 1. Introduction

# 1. Introduction

- Emerging dispute over the aid-growth nexus (Burnside and Dollar, 2000; Easterly, Levine, and Roodman, 2004; Dalgaard, Hansen, and Tarp, 2005).
- Three types of aid (DAC definitions):
  - Grants= "transfers made in cash, goods, or services"
  - Loans="transfers for which repayment is required"
  - TC= "activities to augment the level of knowledge and technical skills"

**ODA Decomposition**

**(All donors total, Gross Disbursements, 2005 USD million)**



# Research Strategy

- **TC ↑ → TFP ↑**

- Sources of tech. progress (int'l tech. transfers) in LDCs is multi-faceted:
  - Absorptive capacity (HC) (Lucas, 1993; Eaton and Kortum, 1996).
  - Channels of tech. diffusion
    - TC
    - FDI (Keller, 2004).
    - Int'l trade (Keller, 2004, Grossman and Helpman, 1991, Coe and Helpman, 1995)

- Augment the standard model of int'l tech. transfer of Benhabib and Spiegel (2005) by incorporating TC, FDI, and external openness.
  - Compare the relative importance of different channels (TC, FDI, and openness) in facilitating int'l tech. transfers quantitatively.

- Identify countries which diverge from the tech. leader.

# Preview of the Results

- TC, FDI and openness all contribute to facilitate int'l tech. transfers.
  - Openness seems to contribute the most which is followed by TC.
  - TC seems to compensate for the lack of sufficient human capital in developing countries.
- 6 to 17 countries out of 85 countries in our sample fail to catch up to the technological leader through over the 36 years.
  - These results suggest that TC can play an important role in facilitating technological catch up of developing countries.

# 2. A Theoretical Framework of Int'l Tech. Transfers

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- Exponential (*EXP*) int'l tech. transfer model (Nelson and Phelps, 1966; BS):

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = \underbrace{\alpha\Phi_i}_{\text{Innovation}} + \underbrace{\beta\Phi_i\left(\frac{A_{m0}}{A_{i0}} - 1\right)}_{\text{Imitation}}, \quad (1)$$

- Logistic (*LGS*) model:

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = \alpha\Phi_i + \beta\Phi_i \underbrace{\left(\frac{A_{i0}}{A_{m0}}\right)}_{\textit{difficulty}}\left(\frac{A_{m0}}{A_{i0}} - 1\right), \quad (2)$$

- The BS's nested model of int'l tech. transfers:

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = \left(g + \frac{c}{s}\right)\Phi(h_i, TC_i, FDI_i, OPEN_i) - \frac{c}{s}\Phi(h_i, TC_i, FDI_i, OPEN_i)\left(\frac{A_{iT}}{A_{mT}}\right)^s \quad (3)$$

  - EXP if $s$=-1; LGS if $s$=1
  - If $s \in (0,1]$, the tech. catch-up condition: $1 + \frac{c}{sg} > \frac{\Phi_m}{\Phi_i}$. (4)

# 3. An Econometric Model and Data

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- Estimation equation (5):

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = b_0 + b_1\left(h_i + b_4 TC_i + d_1 FDI_i + e_1 OPEN_i\right) - b_2\left(h_i + b_4 TC_i + d_1 FDI_i + e_1 OPEN_i\right)\left(\frac{A_{i0}}{A_{m0}}\right)^{b_3} + u_i,$$

  - *EXP* if $b_3 = -1$; *LGS* if $b_3 = 1$
  - $b_4 > 0$: TC facilitates int'l tech. diffusions
  - TC ($b_4$), FDI ($d_1$), and OPENNESS ($e_1$)

- Non-linear least squares (NLLS): Two step procedure to select initial parameters: First, use Benhabib and Spiegel (2005) to estimate four different sets of parameters (Model 1, Model 2, Model 3, and Model 4). Then the attained baseline parameters are used as the initial parameters for each model.

# Data

Cross-country data of 85 (110) countries for the period of 1960-1995.

- TFP: Replication of BS; C-D aggregate production function with $\alpha = 1/3$; $K$ compiled by the Klenow and Rodriguez-Clare (1997) method; and $\delta = 3\%$
- Human capital: Barro and Lee (1993)
- TC: OECD/DAC's DAC Int'l Development Statistics; disbursement data
  - ta12: Average amount of TC over all available years
  - tagdp12: Dividing the first measure (ta12) by the average GDP over 1960-95
  - ta111: Initially available value of TC for each country
  - ta80: Average value of TC over all available observations in and before 1980
  - ta90: Average amount of TC for all available observations in and before 1990.
- FDI: UNCTAD's World Investment Report (2006); OECD IDIS data
- Openness variables: (EX+IM)/GDP from PWT; Sachs Warner Index; Imports

# 4. Benchmark Results

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## 4.1 Benchmark results: Table 1, 2, and 3

- Largely, TC, FDI, Openness facilitate int'l tech. transfers
- Compare: "estimated coefficient" × "standard deviation of the variable":
  - Openness > TC > FDI

**Table 1 (Dependent variable: average growth rate of TFP)**

| | (1-1) Model 1 | (1-2) Model 2 | (1-3) Model 3 | (1-4) Model 4 | (1-5) Model 2 | (1-6) Model 4 | (1-7) Model 2 | (1-8) Model 4 | (1-9) Model 2 | (1-10) Model 4 | (1-11) Model 2 | (1-12) Model 4 | (1-13) Model 2 | (1-14) Model 4 | (1-15) Model 2 | (1-16) Model 4 | (1-17) Model 2 | (1-18) Model 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_0$ (=*C*) | 0.02 | | 0.02 | | | | | | | | | | | | | | | |
| | (0.004)*** | | (0.004)*** | | | | | | | | | | | | | | | |
| $b_1$ | 0.016 | 0.018 | 0.017 | 0.022 | 0.021 | 0.023 | 0.017 | 0.02 | 0.018 | 0.022 | 0.018 | 0.021 | 0.02 | 0.024 | 0.018 | 0.022 | 0.021 | 0.025 |
| | (0.011) | (0.006)*** | (0.004)*** | (0.004)*** | (0.007)*** | (0.004)*** | (0.005)*** | (0.004)*** | (0.005)*** | (0.005)*** | (0.005)*** | (0.004)*** | (0.006)*** | (0.004)*** | (0.005)*** | (0.004)*** | (0.007)*** | (0.004)*** |
| $b_2$ | 0.019 | 0.015 | 0.02 | 0.017 | 0.018 | 0.017 | 0.012 | 0.014 | 0.014 | 0.015 | 0.013 | 0.015 | 0.016 | 0.018 | 0.014 | 0.016 | 0.018 | 0.02 |
| | (0.009)* | (0.006)** | (0.006)*** | (0.006)*** | (0.007)*** | (0.009)* | (0.006)** | (0.007)* | (0.007)** | (0.008)* | (0.006)** | (0.007)** | (0.006)** | (0.007)** | (0.006)** | (0.007)** | (0.007)** | (0.008)** |
| $b_3$ (=*s*) | 1.149 | 1.649 | 1 | 1 | 1.426 | 1 | 2.219 | 1 | 2.387 | 1 | 2.11 | 1 | 1.872 | 1 | 2.03 | 1 | 1.703 | 1 |
| | (1.44) | (1.589) | | | (1.386) | | (2.789) | | (2.898) | | (2.19) | | (1.872) | | (2.244) | | (1.905) | |
| $b_4$ *TC* | 0.001 | 0.008 | 0.001 | 0.007 | | | | | | | | | | | | | | |
| | (0.002) | (0.002)*** | (0.002) | (0.002)*** | | | | | | | | | | | | | | |
| *TC/GDP* | | | | | 25.978 | 25.769 | | | | | | | | | | | | |
| | | | | | (7.733)*** | (7.614)*** | | | | | | | | | | | | |
| *iniTC* | | | | | | | 0.018 | 0.017 | | | | | | | | | | |
| | | | | | | | (0.006)*** | (0.005)*** | | | | | | | | | | |
| *iniTC/iniGDP* | | | | | | | | | 94.282 | 86.343 | | | | | | | | |
| | | | | | | | | | (37.917)** | (34.946)** | | | | | | | | |
| *TC80* | | | | | | | | | | | 0.01 | 0.009 | | | | | | |
| | | | | | | | | | | | (0.003)*** | (0.002)*** | | | | | | |
| *TC80/GDP80* | | | | | | | | | | | | | 60.315 | 58.915 | | | | |
| | | | | | | | | | | | | | (19.078)*** | (18.646)*** | | | | |
| *TC90* | | | | | | | | | | | | | | | 0.008 | 0.007 | | |
| | | | | | | | | | | | | | | | (0.002)*** | (0.002)*** | | |
| *TC90/GDP90* | | | | | | | | | | | | | | | | | 52.672 | 51.807 |
| | | | | | | | | | | | | | | | | | (17.197)*** | (16.858)** |
| Observation | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| R-squared | 0.25 | | 0.25 | | | | | | | | | | | | | | | |

## Table 3 (Dependent variable: average growth rate of TFP)

| | | (3-1) Model 1 | (3-2) Model 2 | (3-3) Model 3 | (3-4) Model 4 | (3-5) Model 2 | (3-6) Model 4 | (3-7) Model 2 | (3-8) Model 4 | (3-9) Model 2 | (3-10) Model 4 | (3-11) Model 2 | (3-12) Model 4 | (3-13) Model 2 | (3-14) Model 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_0$ (=$C$) | | 0.016 (0.003)*** | | 0.013 (0.004)*** | | | | | | | | | | | |
| $b_1$ | | 0.333 (0.001)*** | 0.012 (0.004)*** | 0.013 (0.003)*** | 0.015 (0.003)*** | 0.013 (0.005)*** | 0.015 (0.004)*** | 0.01 (0.003)*** | 0.012 (0.004)*** | 0.012 (0.003)*** | 0.013 (0.004)*** | 0.012 (0.004)*** | 0.014 (0.004)*** | 0.014 (0.004)*** | 0.016 (0.004)*** |
| $b_2$ | | 0.333 ♦ | 0.01 (0.004)*** | 0.013 (0.003)*** | | 0.01 (0.004)** | 0.011 (0.005)** | 0.008 (0.003)*** | 0.006 (0.005) | 0.006 (0.006) | 0.005 (0.005) | 0.009 (0.004)** | 0.01 (0.005)** | 0.01 (0.006)* | 0.009 -0.007 |
| $b_3$ (=$s$) | | 0.023 (0.006)*** | 1.701 (1.008)* | | 0.014 (0.003)*** | 1.662 (1.591) | 1 | 2.802 (1.819) | 1 | 2.803 (4.105) | 1 | 2.195 (2.272) | 1 | 2.67 (3.039) | 1 |
| $b_4$ | *TC* | 0.002 (0.002) | 0.008 (0.003)*** | 0.003 (0.003) | 0.007 (0.002)*** | | | | | | | | | | |
| | *TC/GDP* | | | | | 20.073 (9.990)** | 20.249 (9.862)** | | | | | | | | |
| | *iniTC* | | | | | | | 0.019 (0.008)** | 0.018 (0.007)** | | | | | | |
| | *iniTC/iniGDP* | | | | | | | | | 46.058 (42.457) | 44.681 (42.595) | | | | |
| | *TC80* | | | | | | | | | | | 0.009 (0.004)*** | 0.009 (0.003)*** | | |
| | *TC80/GDP80* | | | | | | | | | | | | | 27.548 (26.775) | 26.395 (26.424) |
| $d_1$ | *FDIinflow* | 0.001 (0.000)** | 0.0003 (0.0002) | 0.0004 (0.0002)* | 0.0004 (0.0002)* | | | 0.0003 (0.0002)* | 0.0004 (0.0002) | | | | | | |
| | *FDIinflow/GDP* | | | | | 5.423 (2.538)** | 5.708 (2.523)** | | | 4.031 (2.247)* | 4.309 (2.305)* | | | | |
| | *FDIinflow80* | | | | | | | | | | | 0.069 (0.041)* | 0.076 (0.042)* | | |
| | *FDIinflow80/GDP80* | | | | | | | | | | | | | 6.88 (24.832) | 8.063 (24.656) |
| $e_1$ | *Open* | 0.003 (0.004) | 0.014 (0.005)*** | 0.006 (0.005) | 0.012 (0.004)*** | 0.011 (0.005)** | 0.01 (0.005)** | 0.017 (0.006)*** | 0.017 (0.005)*** | 0.013 (0.005)** | 0.013 (0.005)** | | | | |
| | *Open80* | | | | | | | | | | | 0.007 (0.004)* | 0.006 (0.004)* | 0.011 (0.005)** | 0.01 (0.004)** |
| Observation | | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| R-squared | | 0.35 | | 0.4 | | | | | | | | | | | |

Note:

## 4.2 Testing the Catching-Up Condition

- The test results of the catching-up condition (Tables 4 and 5):
  - If use spec. (3.2) in Table 3, 6 countries that do not comply with equation (4): Central African Republic, Mali, Mozambique, Niger, Nepal, and Togo.
  - If use spec. (3.5) in Table 3, 10 technologically trapped countries: Bangladesh, Central African Republic, Iran, Mali, Mozambique, Niger, Nepal, Pakistan, Togo, and Democratic Republic of Congo.

- Compute the minimum required amount of TC to catch-up with the leader technologically:

$$TC_i > \frac{1}{\hat{b}_4}\left(\frac{h_m \cdot \hat{b}_3 \hat{g}}{\hat{b}_3 \hat{g} + \hat{c}} - h_i - \hat{d}_1 FDI_i - \hat{e}_1 Open_i\right), \qquad (6)$$

- For Example:

| | **Central African Republic** | **Pakistan** |
|---|---|---|
| **Minimum required TC to catch-up (2004 price)** | 68.49 millions USD | 337.19 millions USD |
| **Average TC for 1960-95 (2004 price)** | 54.02 millions USD | 223.19 millions USD |
| **TC in 2004** | 34.72 millions USD | 124.4 millions USD |

# 5. Robustness Tests

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## 5.1 Regional Specificity: Tables 6 and 7

- Asian countries have systematically higher capacity to catch-up.

## 5.2 Robustness 1: Relaxing the Function Form of Capacity Function: Table 8

$$\frac{1}{T}\left(\log A_{it} - \log A_{i0}\right) = b_0 + b_1\left(X\beta\right) - b_2\left(X\beta\right)\left(\frac{A_{it}}{A_{mt}}\right)^{b_3} + u_i, \quad (6)$$

where $X$=[*h, TC, TC*h, FDI, FDI*h, Open, Open*h*].

- *TC*h* has negative coeff. Since, *TC* and *h* are negatively related, TC complement the lack of *h*.

## 5.3 Robustness 2: Alternative Data

## 5.4 Robustness 3: Incorporating missing observations of HC

## Table 18 Robustness tests (Dependent variable: average growth rate of TFP)

| | (18-1) Model 1 | (18-2) Model 2 | (18-3) Model 3 | (18-4) Model 4 | (18-5) Model 2 | (18-6) Model 4 | (18-7) Model 2 | (18-8) Model 4 | (18-9) Model 2 | (18-10) Model 4 | (18-11) Model 2 | (18-12) Model 4 | (18-13) Model 2 | (18-14) Model 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_0$ (=*C*) | 0.009 | | 0.009 | | | | | | | | | | | |
| | (0.004)** | | (0.004)** | | | | | | | | | | | |
| h | -0.657 | -0.401 | -0.657 | -0.374 | -2.672 | -2.737 | -0.263 | -0.203 | -1.735 | -1.792 | 0.055 | 0.071 | 0.625 | 0.782 |
| | (0.474) | (0.392) | (0.47) | (0.371) | (1.476)* | (1.475)* | (0.396) | (0.352) | (1.243) | (1.241) | (0.406) | (0.39) | (1.16) | (1.114) |
| $b_1$ | 0.013 | 0.012 | 0.013 | 0.015 | 0.013 | 0.015 | 0.011 | 0.015 | 0.013 | 0.014 | 0.012 | 0.014 | 0.014 | 0.016 |
| | (0.006)** | (0.004)*** | (0.003)*** | (0.003)*** | (0.004)*** | (0.003)*** | (0.003)*** | (0.003)*** | (0.004)*** | (0.004)*** | (0.003)*** | (0.004)*** | (0.004)*** | (0.004)*** |
| $b_2$ | 0.012 | 0.011 | 0.012 | 0.013 | 0.01 | 0.011 | 0.009 | 0.012 | 0.007 | 0.007 | 0.008 | 0.009 | 0.01 | 0.01 |
| | (0.006)** | (0.003)*** | (0.003)*** | (0.003)*** | (0.004)*** | (0.004)*** | (0.003)*** | (0.003)*** | (0.005) | (0.005) | (0.004)** | (0.004)* | (0.005)** | (0.006)* |
| $b_3$ (=*s*) | 1.017 | 1.488 | 1 | 1 | 1.503 | 1 | 2.261 | 1 | 1.973 | 1 | 2.183 | 1 | 2.419 | 1 |
| | (0.775) | (0.718)** | | | (1.197) | | (1.096)** | | (2.896) | | (2.032) | | (2.518) | |
| $b_4$ *TC* | 0.004 | 0.007 | 0.004 | 0.006 | | | | | | | | | | |
| | (0.002)* | (0.002)*** | (0.002)** | (0.002)*** | | | | | | | | | | |
| *TC/GDP* | | | | | 14.522 | 13.444 | | | | | | | | |
| | | | | | (7.079)** | (6.509)** | | | | | | | | |
| *iniTC* | | | | | | | 0.017 | 0.013 | | | | | | |
| | | | | | | | (0.006)*** | (0.005)*** | | | | | | |
| *iniTC/iniGDP* | | | | | | | | | 10.608 | 9.709 | | | | |
| | | | | | | | | | (28.491) | (27.946) | | | | |
| *TC80* | | | | | | | | | | | 0.009 | 0.009 | | |
| | | | | | | | | | | | (0.003)*** | (0.003)*** | | |
| *TC80/GDP80* | | | | | | | | | | | | | 17.087 | 13.661 |
| | | | | | | | | | | | | | (19.225) | (18.437) |
| $d_1$ *FDIinflow* | 0.0004 | 0.0003 | 0.0004 | 0.0003 | | | 0.0004 | 0.0003 | | | | | | |
| | (0.0002)** | (0.0001)** | (0.0002)** | (0.0001)** | | | (0.0001)** | (0.0001)*** | | | | | | |
| *FDIinflow/GDP* | | | | | 5.842 | 6.055 | | | 3.762 | 3.974 | | | | |
| | | | | | (2.560)** | (2.555)** | | | (2.152)* | (2.141)* | | | | |
| *FDIinflow80* | | | | | | | | | | | 0.06 | 0.063 | | |
| | | | | | | | | | | | (0.036)* | (0.035)* | | |
| *FDIinflow80/GDP80* | | | | | | | | | | | | | 12.645 | 15.281 |
| | | | | | | | | | | | | | (23.75) | (23.648) |
| $e_1$ *Open* | 0.011 | 0.015 | 0.011 | 0.014 | 0.011 | 0.011 | 0.018 | 0.016 | 0.014 | 0.014 | | | | |
| | (0.005)** | (0.005)*** | (0.005)** | (0.004)*** | (0.005)** | (0.004)** | (0.006)*** | (0.004)*** | (0.004)*** | (0.004)*** | | | | |
| *Open80* | | | | | | | | | | | 0.009 | 0.008 | 0.011 | 0.011 |
| | | | | | | | | | | | (0.004)** | (0.004)** | (0.004)*** | (0.004)*** |
| Observation | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| R-squared | 0.39 | | 0.39 | | | | | | | | | | | |

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

# 6. Concluding Remarks

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- TC, FDI and openness all contribute to facilitate int'l tech. transfers.
  - Openness seems to contribute the most which is followed by TC.
  - TC seems to compensate for the lack of sufficient human capital in developing countries.

- 6 to 16 countries out of 85 countries in our sample fail to catch up to the technological leader through over the 36 years.

- Our contribution:
  - Use of TFP concept, which is a broad measure of a country's aggregate productivity, including institutional and intangible elements in order to evaluate the overall (unbiased) effectiveness of TC.
  - Above the "threshold," TC is likely to play an important role in facilitating institutional capacity development