

On the Role of Technical Cooperation in International Technology Transfers

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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.**

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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

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1. Introduction

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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)

Year	Multilateral	Non-Grant Bilateral	TC	Bilateral grants (incl. TC)	Total
1980	10,000	10,000	5,000	5,000	30,000
1985	12,000	12,000	6,000	6,000	36,000
1990	15,000	15,000	8,000	8,000	46,000
1995	18,000	18,000	10,000	10,000	56,000
2000	20,000	20,000	12,000	12,000	64,000
2005	22,000	22,000	15,000	15,000	74,000

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Research Strategy

● **TC ↑ → IFP ↑**

- 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.

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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.

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

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

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

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

$\alpha\Phi$ and $\beta\Phi$ represent the follower county's capacity to innovate own tech. and to absorb foreign technologies, respectively.

- Logistic (*LGS*) model: $\frac{1}{T}(\log A_{iT} - \log A_{i0}) = \alpha\Phi_i + \beta\Phi_i \underbrace{\left(\frac{A_{i0}}{A_{m0}} \right)}_{\text{difficulty}} \left(\frac{A_{m0}}{A_{i0}} - 1 \right)$ (2)

- The BS's nested model of int'l tech. transfers (EXP if $s=-1$; LGS if $s=1$):

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

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

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3. An Econometric Model and Data

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3. An Econometric Model and Data

- Estimation equation (5):
$$\frac{1}{T}(\log A_T - \log A_0) = b_0 + b_1(h_i + b_4TC_i + d_1FDI_i + e_1OPEN_i) - b_2(h_i + b_4TC_i + d_1FDI_i + e_1OPEN_i) \left(\frac{A_{it}}{A_{i0}}\right)^{b_3} + u_{it}$$
 - 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.

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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
 - ta11: 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

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4. Benchmark Results

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4. Benchmark Results

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

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

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

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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)***
$b_3 (=c)$	0.023 (0.006)***	1.701 (1.008)**		0.014 (0.003)***	1.662 (1.591)	1 (0.862)***	2.802 (1.819)	1 (0.862)***	2.803 (4.105)	1 (0.862)***	2.195 (2.272)	1 (0.862)***	2.67 (3.039)	1 (0.862)***
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)**								
miTC							0.019 (0.008)**	0.018 (0.007)**						
miTC/mGDP									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 (2.4832)	8.063 (2.656)
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											

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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: $TC_i > \frac{1}{b_4} \left(\frac{h_m \cdot \hat{b}_3 \hat{g}}{\hat{b}_3 \hat{g} + \hat{c}} - h_i - \hat{d}_1 FDI_i - \hat{e}_1 Open_i \right)$, (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

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5. Robustness Tests

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5. Robustness Tests

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

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

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

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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 (0.004)**		0.009 (0.004)**											
h	-0.657 (0.474)	-0.401 (0.392)	-0.657 (0.47)	-0.374 (0.371)	-2.672 (1.476)*	-2.737 (1.475)*	-0.263 (0.390)	-0.203 (0.352)	-1.735 (1.243)	-1.792 (1.241)	0.055 (0.406)	0.071 (0.39)	0.625 (1.16)	0.782 (1.114)
b_1	0.013 (0.006)**	0.012 (0.004)**	0.013 (0.003)***	0.015 (0.003)***	0.013 (0.004)***	0.015 (0.003)***	0.011 (0.003)***	0.015 (0.003)***	0.013 (0.004)***	0.014 (0.004)***	0.012 (0.003)***	0.014 (0.004)***	0.014 (0.004)***	0.016 (0.004)***
b_2	0.012 (0.006)**	0.011 (0.003)***	0.012 (0.003)***	0.013 (0.003)***	0.01 (0.004)***	0.011 (0.004)***	0.009 (0.003)***	0.012 (0.003)***	0.007 (0.005)	0.007 (0.005)	0.008 (0.004)**	0.009 (0.004)**	0.01 (0.005)**	0.01 (0.005)**
$b_3 (=c)$	1.017 (0.775)	1.488 (0.718)**	1 (0.718)**	1 (0.718)**	1.503 (1.197)	1 (1.197)	2.261 (1.096)**	1 (1.096)**	1.973 (2.896)	1 (2.896)	2.183 (2.032)	1 (2.032)	2.419 (2.518)	1 (2.518)
$b_4 TC$	0.004 (0.002)*	0.007 (0.002)***	0.004 (0.002)**	0.006 (0.002)***										
TC/GDP					14.522 (7.079)**	13.444 (6.509)**								
$iniTC$							0.017 (0.006)***	0.013 (0.005)***						
$iniTCiniGDP$									10.608 (28.491)	9.709 (27.946)				
$TC\theta$											0.009 (0.003)***	0.009 (0.003)***		
$TC\theta/GDP\theta$													17.087 (19.225)	13.661 (18.437)
$d_1 FDIinflow$	0.0004 (0.0002)**	0.0003 (0.0001)**	0.0004 (0.0002)**	0.0003 (0.0001)**			0.0004 (0.0001)**	0.0003 (0.0001)**						
$FDIinflow/GDP$					5.842 (2.560)**	6.055 (2.555)**			3.762 (2.152)*	3.974 (2.141)*				
$FDIinflow\theta$											0.06 (0.036)*	0.063 (0.035)*		
$FDIinflow\theta/GDP\theta$													12.645 (23.75)	15.281 (23.648)
$e_1 Open$	0.011 (0.005)**	0.015 (0.005)**	0.011 (0.005)**	0.014 (0.004)***	0.011 (0.005)**	0.011 (0.004)**	0.018 (0.006)***	0.016 (0.004)***	0.014 (0.004)***	0.014 (0.004)***				
$Open\theta$											0.009 (0.004)**	0.008 (0.004)**	0.011 (0.004)***	0.011 (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 $\alpha=1$. 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

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6. Concluding Remarks

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6. Concluding Remarks

- 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.