Do Regional Trade Agreements Enhance International Technology Spillovers?

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Economic Effects of RTAs

- Early studies on the economic effects of RTAs
  - Trade creation & trade diversion (Viner, 1950)
- Recent focus: Dynamic effects of RTAs
  - Technology adoption and technology diffusion
  - Bustos (2011 AER): The effects of Mercosur on Argentinean firms' technology adoption.
  - RTAs may also enhance tech. spillovers (Das and Andriamananjara, 2006)
    - Recent RTAs pursue a deeper integration (Baldwin, 2011)
    - e.g., Liberalization of investment & harmonization of IPR policy are included in RTAs.

Tech. Spillovers and Patent Citations

- Measuring tech. spillovers by patent citations
  - Pioneered by Jaffe et al. (1993 QJE).
    - Growing literature: e.g., Jaffe & Trajtenberg (1999), Maurseth & Verspagen (2002); MacGarvie (2006)
  - Advantage: Direct measure of knowledge flow (Hall et al., 2001)
  - Legal duty to list citations for applicants at USPTO.
- Localization of technology spillovers
  - Geographical distance hinders tech. spillovers both intra- and inter-nationally (e.g., Jaffe et al., 1993; Maurseth & Verspagen, 2002; Paci & Usai, 2009)
  - But, little analysis of the impact of "economic" distance on tech. spillovers

Related Literature

- Peri (2005 REStat): The effects of "borders"
  - Sample: 18 countries w/ 147 subnational regions in Western Europe & North America for 1975-96.
  - By estimating a gravity-type equation, he finds that borders (regional, national, & linguistic) have a significantly negative effect on tech. spillovers.
  - By contrast, the effect of trade-blocs is insignificant.
  - His study is partial b/c it includes only EU & NAFTA.
- Jinji et al. (2013)
  - Similar to this paper, but the sample is restricted to 103 countries for 1990-9 & only 9 RTAs are included.

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This Paper

- The effects of RTAs on tech. spillovers
  - Patent application and citation data at USPTO
  - A panel data of 142 countries during 1990-2006
  - An empirical model similar to the standard gravity model is derived.
  - Possible differential effects of FTAs and CUs
  - The effects of GATT/WTO and the Information Technology Agreement (ITA) are also estimated.
- The main contribution
  - The first comprehensive study of the effects of RTAs on int'l tech. spillovers

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Our Major Findings

- RTAs have a positive and significant effect on tech. spillovers measured by patent citations.
  - Consistent w/ Jinji et al. (2013) but disagree w/ Peri (2005)
  - No significant differences by types of RTAs (FTA/CU) in FXNB
  - Robust for different estimation techniques
  - Significant even with excluding US from the sample
- GATT/WTO and ITA also enhance tech. spillovers among members/signatories.
  - GATT/WTO dummy is significantly positive in FXNB.

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Data

- Data on RTAs and GATT/WTO
  - Extend the data by Andrew K. Rose to 2006 and expand the coverage of RTAs from 9 to 110 (FTA/CU/EIA).
  - Information is taken from the web site of the WTO
- Patent applications & citations
  - USPTO patents from PATSTAT April 2012 version
  - Sample period: 1990-2006
- Control variables in the gravity equation
  - The data provided by Rose (2004 AER; 2005 RIE).
- Sample countries/regions
  - At least one US patent application during the sample period.
  - 142 countries/regions → a panel of 17,120 pairs

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Empirical Framework

- A measure of technology spillovers
  - Extend the framework by Jaffee & Trajtenberg (1999) and Peri (2005)
  - Tech. spillovers from country j to country i at t:

$$\Phi_{ijt} = \left(Q_{it}\right)^{\alpha_1} \left(\tilde{\phi}_{ijt} K_{jt}\right)^{\alpha_2} \quad (1)$$

where Q_{it}: i's research ability, K_{jt}: j's knowledge stock, and $\tilde{\phi}_{ijt} \in [0,1]$ is i's accessibility to K_{jt}. Relabel: $\phi_{ijt} = \left(\tilde{\phi}_{ijt}\right)^{\alpha_2}$

  - The accessibility ϕ_{ijt} depends on "economic distance" b/w i and j that is affected by RTA and GATT/WTO:

$$\phi_{ijt} = \left(Dist_{ij}\right)^{\beta_1} e^{\beta_2 (Lang_{ij})} e^{\gamma_1 (RTA_{ijt})} e^{\gamma_2 (FTA_{ijt})} e^{\gamma_3 (CU_{ijt})} e^{\gamma_4 (WTO_{ijt})} e^{\gamma_5 (ITA_{ijt})} \quad (2)$$

Empirical Framework

- Derivation of a gravity-like model
  - Patent citation is a proxy for tech. spillovers:

$$C_{ijt} = \tilde{\lambda}_{ij}\Phi_{ijt}e^{\varepsilon_{ijt}} \quad (3)$$

where C_{ijt}: # of patent citations by country i to country j.

  - Use the stocks of patents, P_{it} and P_{jt}, as proxies for Q_{it} and K_{jt}, respectively, where P_{it} is constructed by

$$P_{it} = A_{it} + (1-\delta)P_{it-1} \quad (4)$$

  - Sub. Eqs. (1), (2), & (4) into (3) and rewrite to yield

$$C_{ijt} = \tilde{\lambda}_{ijt}\exp(\alpha_1 \ln(P_{it}) + \alpha_2 \ln(P_{jt}) + \beta_1 \ln(Dist_{ij}) + \beta_2 Lang_{ij} + \gamma_1 RTA_{ijt} + \gamma_2 FTA_{ijt} + \gamma_3 CU_{ijt} + \gamma_4 WTO_{ijt} + \gamma_5 ITA_{ijt} + \varepsilon_{ijt}) \quad (6)$$

which is quite similar to the standard gravity equation.

Estimation Strategy

- Since the dependent variable is the count data, we estimate (6) using a negative binomial (NB) model.
  - The data are assumed to be generated by a Poisson process
  - But, more flexible modeling of the variance is allowed to account for overdispersion.
- Fixed-effects negative binomial (FXNB) model is employed to capture time-invariant heterogeneity specific to pairs of citing & cited countries
  - Model is estimated by the maximum likelihood (ML) estimation technique.
  - Hausman test is implemented to check FXNB vs. random-effects NB model

Some Technical Issues

- Simultaneity bias and selection bias
  - ⇒ All decisions on RTAs & WTO are likely to be exogenous
  - ⇒ Include all relevant RTAs notified to WTO
- "Multilateral (price) resistance terms"
  - Pointed out by Anderson and van Wincoop (2003 AER).
  - We use patent citations & applications → Omitting price terms is less likely to be a problem
  - But, it still matters b/c tech characteristics across countries are important (Peri, 2005) → Capture them by utilizing the FXNB model.
- Estimation of log-linearized models by PPML
  - The issue raised by Santos Silva&Tenreyro(2006 REStat)
  - FXNB by ML is more general than their method.

Table 1: NB Model: The Effects of RTAs on Technology Spillovers

Dependent Variable: C_{ijt}	(1) Full Sample	(2) Full Sample	(3) Without US	(4) Without US
$\ln(P_i)$	0.91 ***	0.91 ***	0.87 ***	0.87 ***
	(149.79)	(149.92)	(190.66)	(191.78)
$\ln(P_j)$	0.96 ***	0.96 ***	0.95 ***	0.95 ***
	(223.23)	(233.40)	(255.34)	(256.58)
LDist	−0.04 ***	−0.05 ***	−0.11 ***	−0.12 ***
	(−4.47)	(−4.85)	(−11.91)	(−12.30)
Lang	0.39 ***	0.38 ***	0.31 ***	0.31 ***
	(19.23)	(18.90)	(15.63)	(15.30)
RTA	0.18 ***		0.22 ***	
	(7.62)		(9.51)	
FTA		0.22 ***		0.27 ***
		(7.27)		(8.94)
CU		0.13 ***		0.16 ***
		(4.61)		(6.28)
WTO	−0.17 ***	−0.17 ***	−0.08 ***	−0.08 ***
	(−5.50)	(−5.48)	(−2.92)	(−2.90)
ITA	0.12 ***	0.12 ***	0.20 ***	0.20 ***
	(5.32)	(5.47)	(9.64)	(9.84)
No. of Obs.	286128	286128	281378	281378
Log pseudolikelihood	−108659.8	−108653.9	−86414.3	−86404.7

Notes: (1) "***","**", and "*" denote 1%, 5%, and 10% significance level.
(2) Values in parentheses are t-statistics.
(3) Constant term and year dummies are included in the estimations.

Table 2: FXNB Model: The Effects of RTAs on Technology Spillovers

Dependent Variable: C_{ijt}	(1) Full Sample	(2) Full Sample	(3) Without US	(4) Without US
$\ln(P_i)$	0.51 ***	0.51 ***	0.54 ***	0.54 ***
	(102.57)	(102.59)	(86.86)	(86.86)
$\ln(P_j)$	0.43 ***	0.43 ***	0.49 ***	0.49 ***
	(81.92)	(81.88)	(75.83)	(75.78)
LDist	−0.19 ***	−0.20 ***	−0.13 ***	−0.13 ***
	(−12.73)	(−12.88)	(−8.05)	(−7.99)
Lang	−0.16 ***	−0.16 ***	0.20 ***	0.20 ***
	(−4.78)	(−4.82)	(4.56)	(4.55)
RTA	0.10 ***		0.14 ***	
	(6.71)		(8.70)	
FTA		0.12 ***		0.14 ***
		(6.61)		(6.99)
CU		0.07 ***		0.14 ***
		(3.06)		(6.13)
WTO	0.27 ***	0.27 ***	0.22 ***	0.22 ***
	(11.49)	(11.50)	(7.88)	(7.89)
ITA	0.07 ***	0.07 ***	0.03 *	0.03 *
	(4.63)	(4.82)	(1.84)	(1.84)
No. of Obs.	62816	62816	58238	58238
Log Likelihood	−76858.7	−76857.1	−62122.6	−62122.6
Hausman Test (chi^2)	2707.09 ***	2750.28 ***	2185.48 ***	2199.01 ***

Notes: (1) "***"', "**", and "*" denote 1%, 5%, and 10% significance level.
(2) Values in parentheses are t-statistics.
(3) Constant term and time dummies are included in the estimations.

Table 3: FXNB Model: RTA & WTO Dummies with Lags

Dependent Variable: C_{ijt}	(1) Full Sample	(2) Full Sample	(3) Full Sample	(4) Full Sample
$\ln(P_i)$	0.51 ***	0.51 ***	0.51 ***	0.51 ***
	(98.54)	(98.57)	(94.77)	(94.77)
$\ln(P_j)$	0.43 ***	0.43 ***	0.42 ***	0.43 ***
	(78.32)	(78.31)	(74.79)	(74.80)
LDist	−0.20 ***	−0.20 ***	−0.20 ***	−0.21 ***
	(−12.96)	(−13.15)	(−12.66)	(−12.70)
Lang	−0.15 ***	−0.15 ***	−0.13 ***	−0.13 ***
	(−4.37)	(−4.41)	(−3.72)	(−3.73)
RTA $(t-1)$	0.07 ***			
	(4.78)			
RTA $(t-2)$			0.06 ***	
			(3.82)	
FTA $(t-1)$		0.10 ***		
		(5.05)		
FTA $(t-2)$				0.07 ***
				(3.71)
CU $(t-1)$		0.04 *		
		(1.80)		
CU $(t-2)$				0.04 *
				(1.87)
WTO $(t-1)$	0.29 ***	0.29 ***		
	(12.61)	(12.61)		
WTO $(t-2)$			0.28 ***	0.28 ***
			(12.02)	(12.02)
ITA $(t-1)$	0.06 ***	0.06 ***		
	(3.95)	(4.14)		
ITA $(t-2)$			0.05 ***	0.05 ***
			(3.38)	(3.46)
No. of Obs.	58804	58804	54877	54877
Log Likelihood	−73350.8	−73348.9	−69866.3	−69865.8
Hausman Test (chi^2)	2638.70 ***	2675.39 ***	2587.52 ***	2608.49 ***

Table 3: FXNB Model: RTA & WTO Dummies with Lags (cont'd)

Dependent Variable: C_{ijt}	(5) Without US	(6) Without US	(7) Without US	(8) Without US
$\ln(P_i)$	0.53 ***	0.53 ***	0.53 ***	0.53 ***
	(82.41)	(82.41)	(78.70)	(78.69)
$\ln(P_j)$	0.49 ***	0.49 ***	0.48 ***	0.48 ***
	(72.15)	(72.12)	(68.31)	(68.31)
LDist	−0.14 ***	−0.14 ***	−0.15 ***	−0.15 ***
	(−8.68)	(−8.68)	(−8.70)	(−8.61)
Lang	0.19 ***	0.19 ***	0.19 ***	0.19 ***
	(4.12)	(4.10)	(4.04)	(4.05)
RTA $(t-1)$	0.10 ***			
	(6.07)			
RTA $(t-2)$			0.08 ***	
			(4.88)	
FTA $(t-1)$		0.11 ***		
		(5.05)		
FTA $(t-2)$				0.08 ***
				(3.64)
CU $(t-1)$		0.09 ***		
		(4.11)		
CU $(t-2)$				0.09 ***
				(3.74)
WTO $(t-1)$	0.25 ***	0.25 ***		
	(9.23)	(9.23)		
WTO $(t-2)$			0.23 ***	0.23 ***
			(8.71)	(8.71)
ITA $(t-1)$	0.02	0.03		
	(1.41)	(1.45)		
ITA $(t-2)$			0.02	0.02
			(1.40)	(1.37)
No. of Obs.	54496	54496	50854	50854
Log Likelihood	−59383.9	−59383.8	−56678.2	−56678.1
Hausman Test (chi^2)	2154.61 ***	2165.28 ***	2126.48 ***	2133.88 ***

Summary

- RTAs significantly enhance technology spillovers
  - RTA, FTA, and CU dummies are all significant
  - Robust for NB & FXNB
  - No significant differences b/w FTA and CU
  - Robust even with excluding US from the sample
  - Also robust for lagged dummies
- GATT/WTO also enhances technology spillovers
  - Both GATT/WTO membership and ITA
- Implications
  - RTAs increase knowledge flows among members
  - Economic distance affects tech spillovers. → Active role for governments