Do Trade Agreements Contribute to Technology Internationalization?

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Motivation

- Since the emergence of GVC →**innovation activities increasingly organized at an international level**
- Lower information and communication costs led to seek technological resources beyond national borders
- Through the process of technology internationalization→ firms gain access to more advanced technologies and larger pools of knowledge
- Deep and Comprehensive Free Trade Agreements (DCFTA) have been used to tackle issues related to innovation, technology transfer and IPR issues

Questions in this paper

- Do DCFTAs contribute to technology internationalization?
- What role do technology provisions play?
- How important are geographical and institutional distances?
- Role of the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)

What we precisely do is…

- Estimate a **gravity model of technology internationalization** using a panel of 6,480 country pairs of high- and middle-income countries for the period 1980-2015
- Proxy for technology internationalization: Patent statistics of **foreign inventions owned by domestic firms**
- Poisson Pseudo Maximum Likelihood (PPML) estimator to estimate the effect of FTAs (differentiating by their technology-related provisions), geographical and institutional distance on technology internationalization

Preview of the Results

- **First, trade agreements lead to a significant increase in the technology internationalization of firms:** After ratification, this effect increase when the implementation and enforcement are completed
- Second, FTAs in trade and services have a positive effect on technology internationalization
- Third, countries that are geographically and culturally closer, exchange more technology and knowledge
- Finally, the effects are heterogeneous: level of income/level of integration

Outline

- Literature Review
- Technology Provisions in Trade Agreements
- Data, Model and Estimations
- Main Results
- Conclusions
- Next Steps

Literature Review

- **Direct effect:** FTAs → technology internationalization
  - **Peri, 2005**: Cross-sectional gravity-like model to explain patents granted by the US patent office (and citations) between 1975 and 1996. 147 subnational regions in Europe and North America
  - **Picci, 2010**: Cross-border ownership, co-ownership and co-inventions flows between 1995 and 2005, for 42 countries, considers the EU membership
  - **Montobbio & Sterzi, 2013**: Focus only on the determinants of co-inventions –new technologies that have been created by inventors of different countries – between developed and emerging countries -- between 1990-2007, network analysis
  - **De Prato & Nepelski, 2014**: Also focus on co-inventions. Using patent data from the PATSTAT database, estimate a gravity model of co-inventions registered in 90 patent offices around the world over the period 1990-2007
  - **Jinji et al., 2019:** Patent citations as proxy for technology spillovers, find positive effects of FTAs on the number of patent citations. Sample: 1991-2007, 114 countries
  - **Santacreu, 2022**: Focus on the dynamics of international technology licensing in the context of FTAs with technological provisions Sample: 1995-2012, 41 countries

Technology Transfer Through Trade

- **Indirect Effects:** FTAs increase trade, trade increase knowledge flows
- **Campi and Dueñas, 2019: F**ocus on aggregate trade and FTAs with and without IPR provisions. No controls for multilateral resistance
- **Martínez-Zarzoso and Chelala, 2021:** Global sample of countries and broader set of technology-related provisions and sectoral trade. Heterogeneous effects
- **Maskus and Ridley, 2021**: Investigate whether FTAs with IPR chapters that exceed the requirements of the TRIPS agreement have an additional impact on sectoral exports→ IPR-related FTAs with USA, EU or EFTA, have a significantly positive effect on exports to third countries in high-technology goods
- **Erixon, Guinea et al., 2022**: Explore the link in EU FTAs between IP provisions and trade. (+) effect of FTAs with IP prov on exports IP-intensive goods. Marginal (-) effect of FTAs with IP prov on exports non-IP-intensive goods.

Technology Provisions in Trade Agreements: Types

1. **Intellectual Property Rights:** Implies ratification of international treaties or conventions not referenced in the TRIPS.
2. **Data Protection** Includes *exchange of information and experts*, and promotes joint projects between member states.
3. **Innovation Policies:** Fosters participation in *framework programs* and promotion of technology transfers.
4. **Information Society** Relates to *exchange of information, the dissemination of new technologies*, training as well as cooperation and exchange of information in the context of other policies.
5. **Research and Technology:** Promotes *joint research projects*, exchange of researchers, and the development of public-private-partnerships.

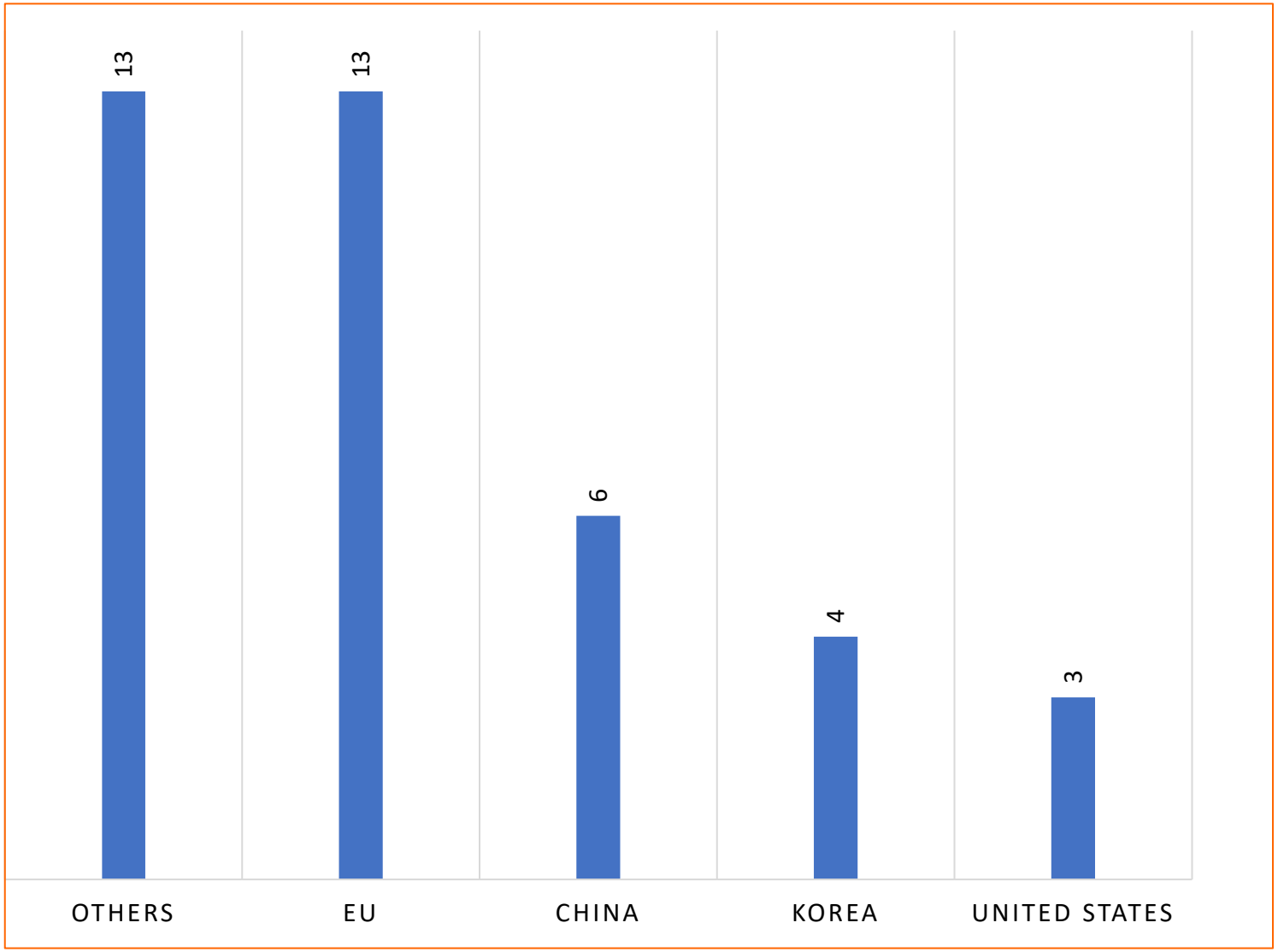
Free Trade Agreements and Tech-provisions

Total FTAs in the sample	**179**
FTAs with at least one technology related provision	141
FTAs with zero provisions	38
FTAs according to type of provisions:	
Intellectual property rights	111
Data protection	31
Information society	72
Innovation policies	27
Research and technology	61

Note: The total number of provisions exceed the total number of FTAs since an agreement can include more than one technology-related provision. Source: Hoffman et al. (2017) & WB.

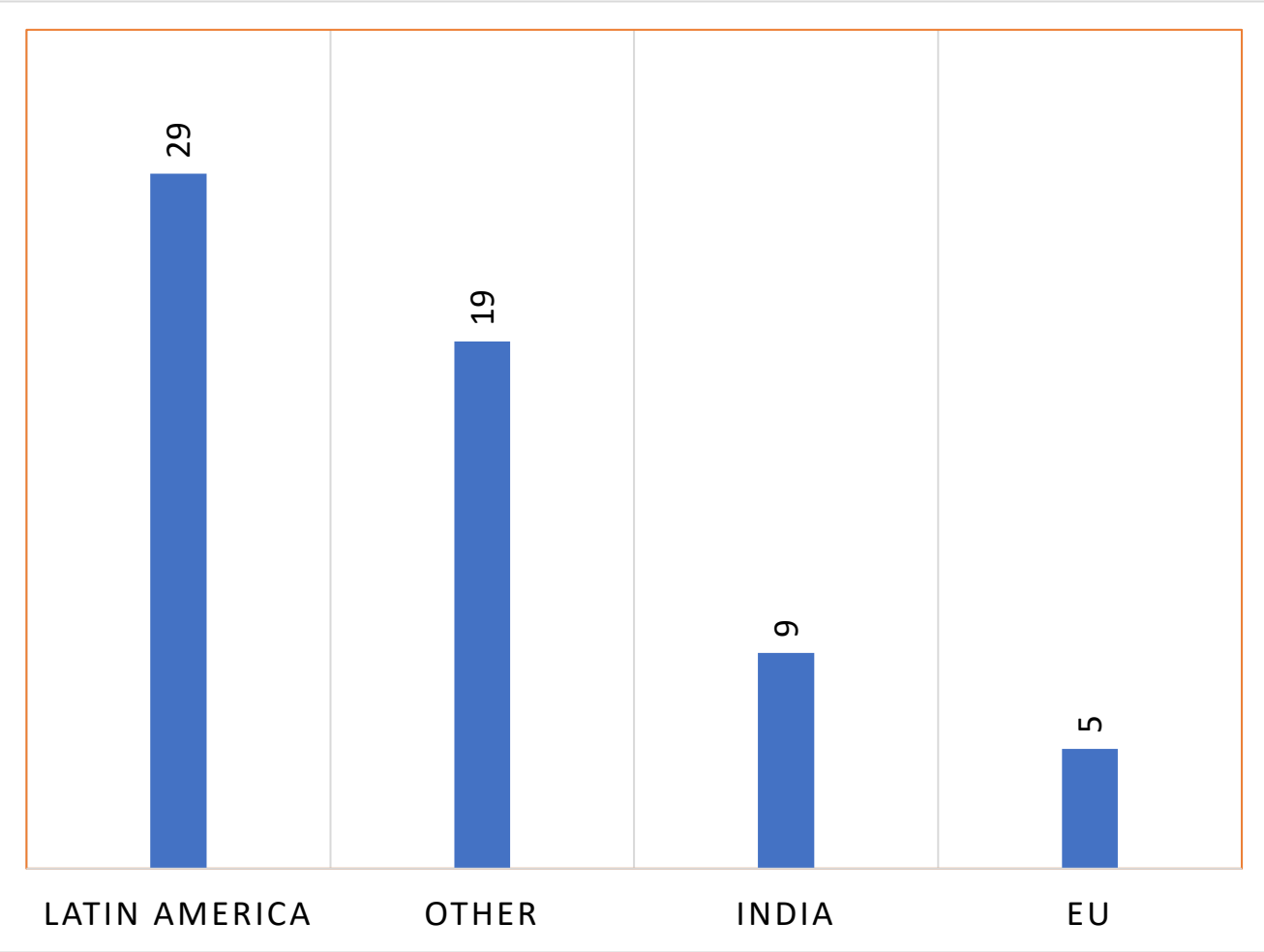
Agreements Containing All Types

- Most of the agreements that mention all types include European Union (13),
- followed by China(10),
- South Korea (4), and
- the United States (3)



Agreements with No Technology Provisions

- 29 are between Latin American countries
- 9 are between India and other developing countries
- 5 between the EU and others



Model Specification

Gravity model, widely used to predict bilateral flows between countries, is nowadays considered to be a *structural model* with solid theoretical underpinnings (Anderson, 1979; Bergstrand, 1985; Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Feenstra, 2016; Allen, Arkolakis, and Takahashi, 2014; Keith and Head 2014; among others). For technology internationalization (Peri, 2005; Santacreu, 2022)

$$c_{ijt} = exp[\rho_{it} + \vartheta_{jt} + \sum_k \delta_k \boldsymbol{FTA\_X_{ijt}^k} + \gamma_1 TRIPS_{ijt} + \beta_1 Border_{ij} + \beta_2 Language_{ij} + \beta_3 \ln Distance_{ij} + \beta_4 Colony_{ij}] * \varepsilon_{ijt} \quad (1)$$

$$c_{ijt} = exp[\rho_{it} + \vartheta_{jt} + \theta_{ij} + \sum_k \alpha_k \boldsymbol{FTA\_X_{ijt}^k} + \gamma_2 TRIPS_{ijt}] * \epsilon_{ijt} \quad (2)$$

$$c_{ijt} = exp[\rho_{it} + \vartheta_{jt} + \theta_{ij} * t + \sum_k \varphi_k \boldsymbol{FTA\_X_{ijt}^k} + \gamma_3 TRIPS_{ijt}] * \mu_{ijt} \quad (3)$$

c_{ijt} is the count of patents for *DOFI* calculated for the country pair i (owner) and j (inventor) with $i \neq j$. The bilateral number of patents depend on bilateral factors, θ_{ij}, as well as on country-time-specific fixed effects, ρ_{it} and ϑ_{jt} that act as multilateral resistance terms (MRT). (3) add bilateral-specific time trends, $\theta_{ij} * t$

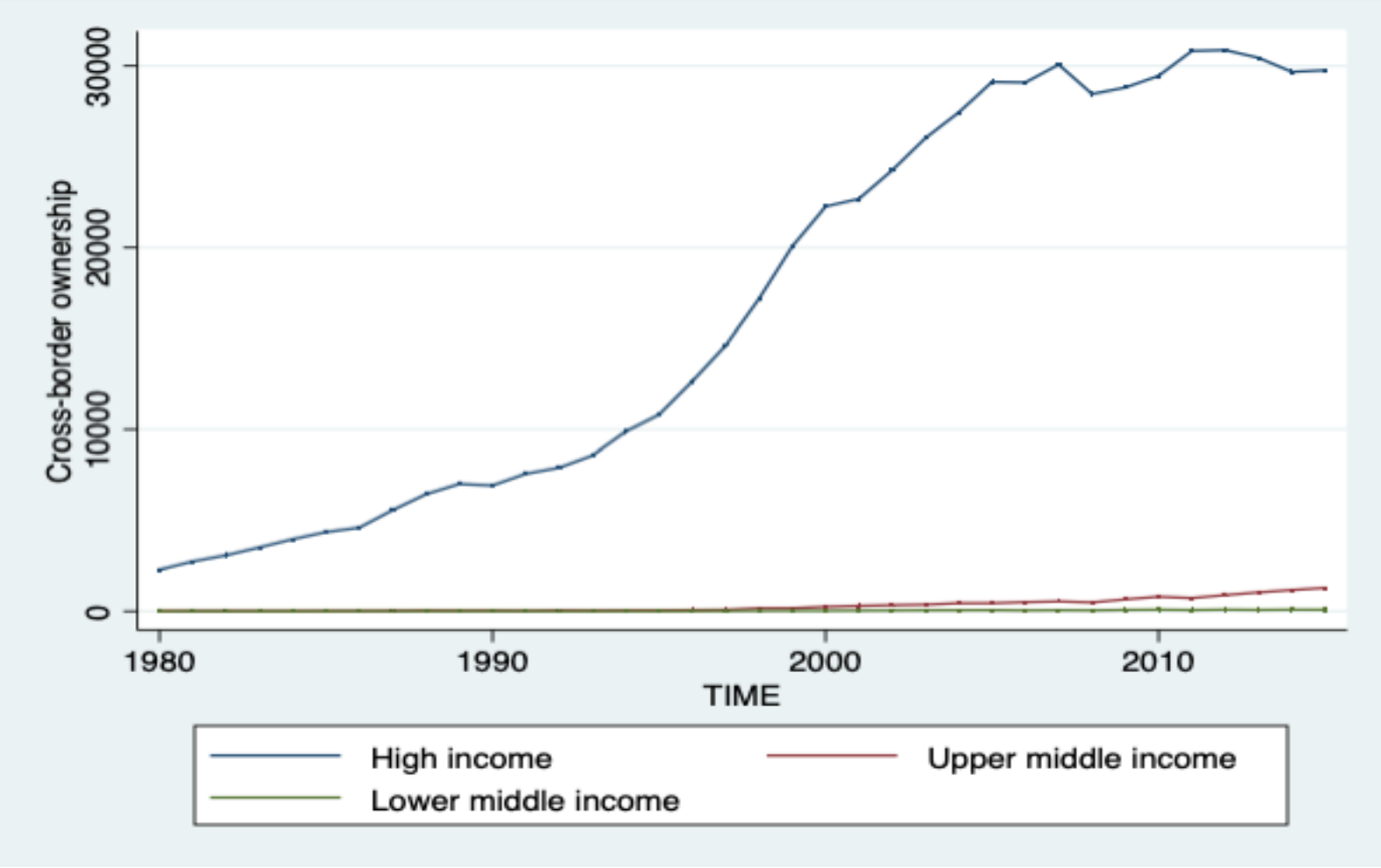
Summary Statistics

Depth indicates the degree of inclusiveness in terms of provisions
covered Dür et al. (2014)
Depth =0-7

- Full FTA 0,1
- Services prov. 0,1
- Investment 0,1
- General standards 0,1
- Public procurement 0,1
- Competition 0,1
- IPR 0,1

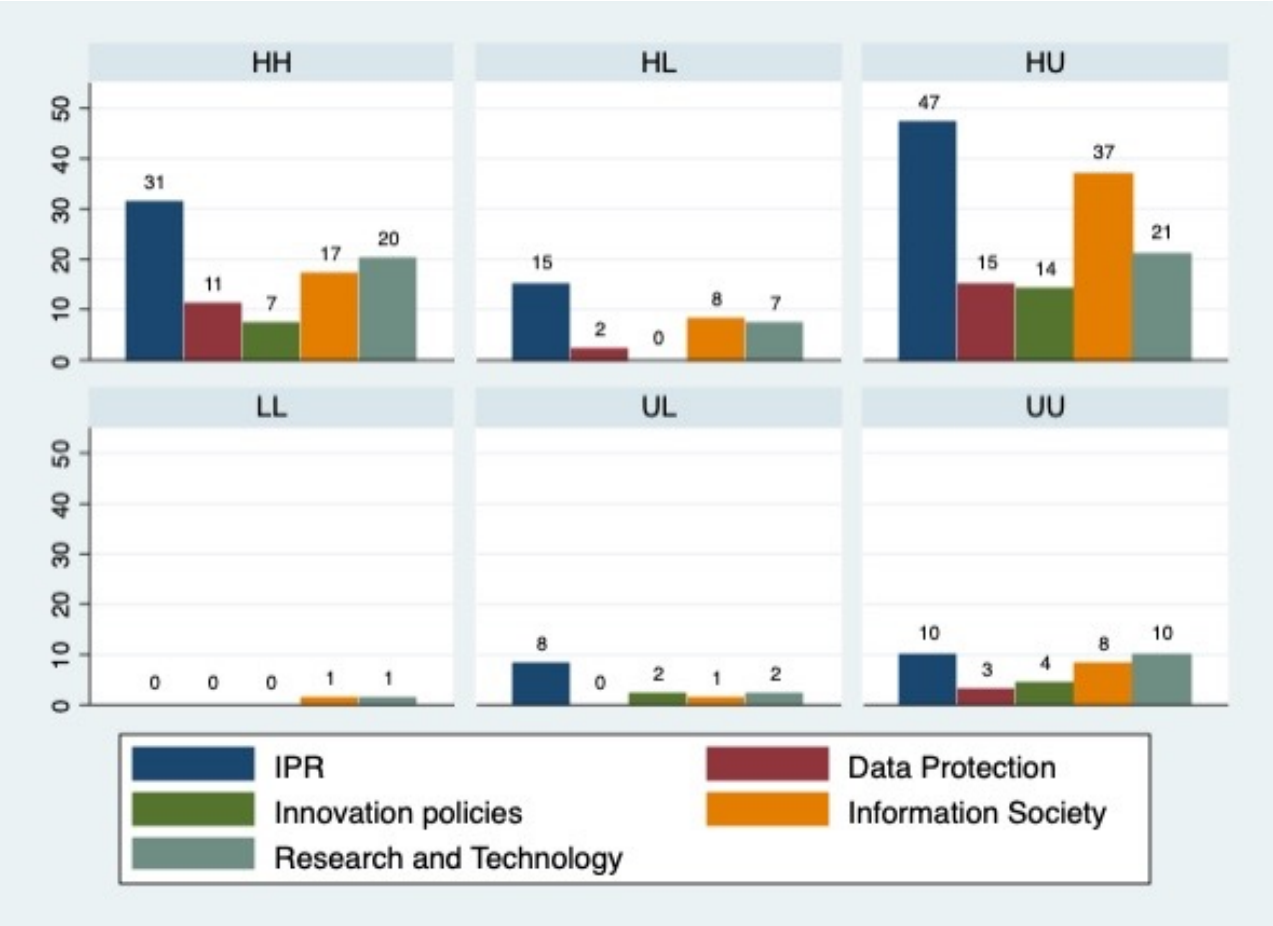
Variable	Description	No. Obs.	Mean	Std. Dev.	Min	Max
DOFI	Patent count of an invention of country j owned by a firm of country i	233,280	2.663	29.098	0	1450
FTA	1: country pair is member of the trade agreement at year t 0: otherwise	233,280	0.135	0.342	0	1
FTA_prov	1: country pair is member of the trade agreement with one or more technology-related provision at year t 0: otherwise	233,280	0.112	0.315	0	1
FTA_zprov	1: country pair is member of the trade agreement without technology-related provisions at year t 0: otherwise	233,280	0.024	0.152	0	1
Depth	Interaction variable between dummy variable FTA and depth index	233,280	0.305	1.163	0	7
Ln (distance)	Ln of geographical distance in km between country i and country j	227,520	8.480	0.970	4.088	9.892
Border	1: countries are neighbors 0: otherwise	227,520	0.031	0.173	0	1
Language	1: countries have the same official language 0: otherwise	227,520	0.087	0.282	0	1
Colony	1: countries share colonial past 0: otherwise	227,520	0.022	0.148	0	1
TRIPS	1: country pair complies with the TRIPS at time t 0: otherwise	233,280	0.106	0.308	0	1

Technology internationalization by income group



Note: Cross-border ownership measured as the domestic ownership of foreign inventions. Low-income countries not included because of lack of data. **Source:** International co-operation in patents (OECD, 2020)

FTAs provisions by income level of member countries



Bilateral and regional trade agreements in force since or after 1980, classified according the income level of the member states and technology content. HH: FTA among high income countries; HL: FTA among high income and low middle-income countries. HU: FTA among high income and upper middle-income countries; UU: FTA among upper middle-income countries; LL: FTA among low middle- countries; and UL: FTA among upper and low middle- countries.

Source: Hofmann et al. (2017).

Baseline Results

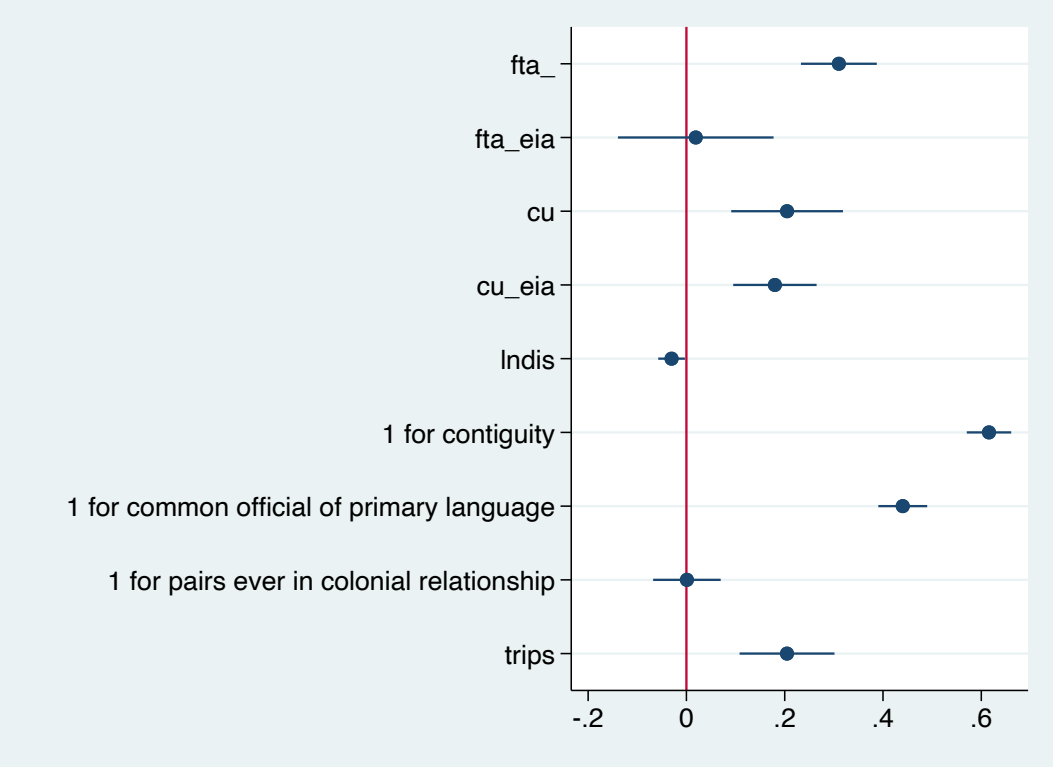
- FTAs increase Technology internationalization by about 24 % (1)

- FTA effect (+) for shallow agreements, but **(-) for deeper agreements>5 Prov**.(2)
- Does not seem to be endogenous (3)
- FTA effect vanishes when pair FE are included (4)
- Heterogeneous effects?

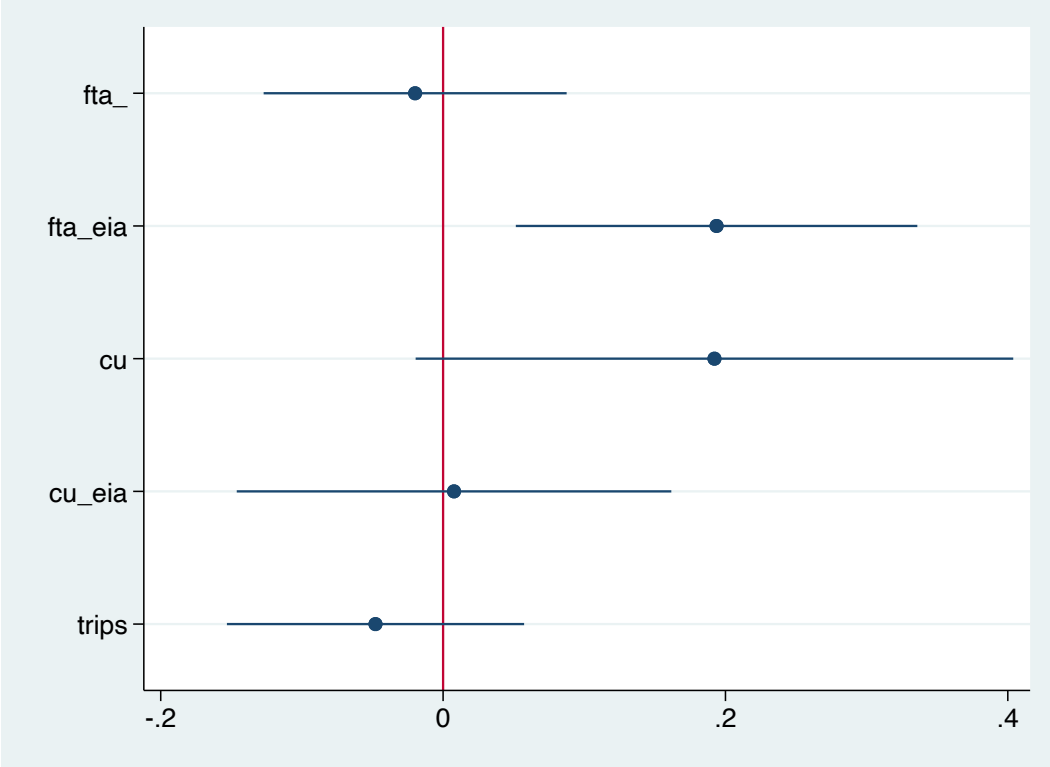
Fixed effects	Owner-year, creator-year FTA effect	Owner-year, creator-year FTA_depth	FTA_{t+1}	O-Y & C-Y & Pair
	(1)	(2)	(3)	(4)
FTA	**0.218*****	0.328***	0.192***	0.02
	(0.0253)	(0.0266)	(0.0298)	(0.043)
Ln (distance)	-0.0480***	-0.00580	-0.0361***	-
	(0.0119)	(0.0125)	(0.0121)	-
Border	0.599***	0.632***	0.602***	-
	(0.0233)	(0.0231)	(0.0238)	-
Language	0.451***	0.483***	0.454***	-
	(0.0232)	(0.0231)	(0.0240)	-
Colony	-0.00289	-0.0487	-0.00283	-
	(0.0345)	(0.0344)	(0.0355)	-
TRIPS	0.106***	0.213***	0.0773**	0.022
	(0.0228)	(0.0251)	(0.0305)	(0.037)
FTA_depth/FTA_{t+1}	-	-0.0833***	0.0725*	-
	-	(0.00690)	(0.0383)	-
Observations	124,203	124,203	119,523	72,613
R-squared	0.946	0.945	0.946	0.982
Park-type Test p-values	0.000	0.000	0.000	0.000
GNR p-values	0.184	0.176	0.089	0.005

Note: Standard errors in parentheses. Significance level * p<0.1, ** p<0.05, *** p<0.01. **Dependent variable DOFI.** Clustered standard errors at country pair. Estimation using the *ppml_panel_sg* command in Stata (Larch et al., 2019). Park-type Test: null hypothesis states homoscedastic errors. GNR denotes Gauss-Newton Regression: null hypothesis states CVMR assumption for the functional form of the variance. O-Y &C-Y refers to owner-year and creator-year FE as proxies for Multilateral Resistance. Pair refers to bilateral (owner-creator) fixed effects.

Results for different levels of integration

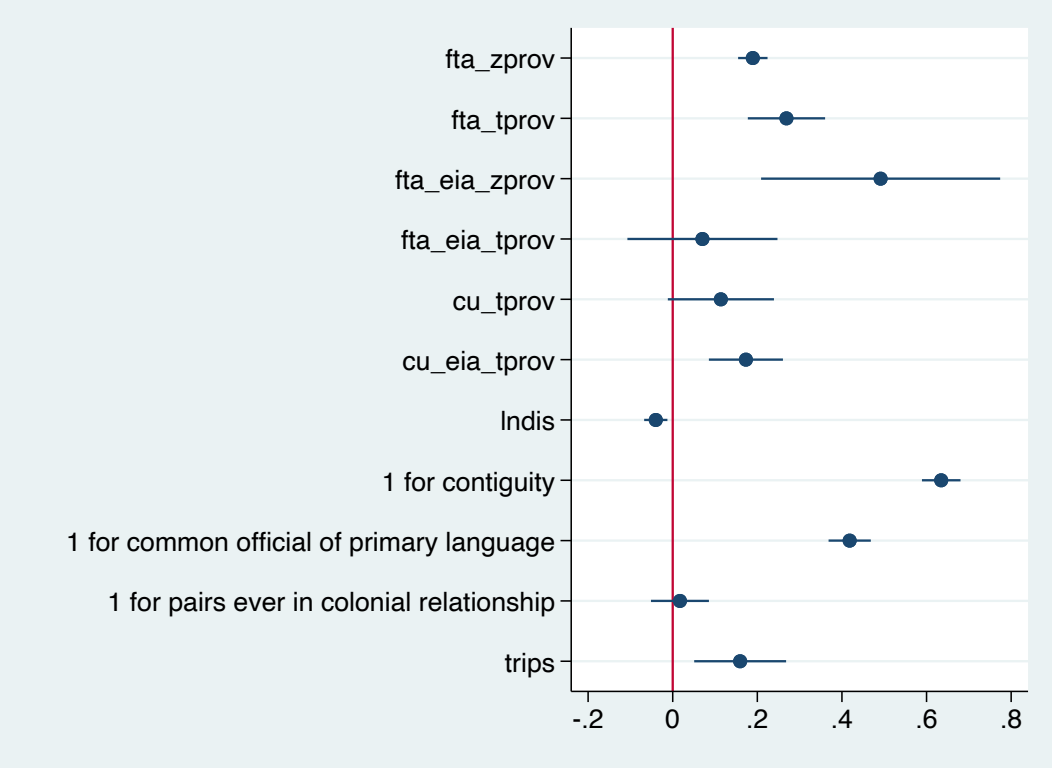


Model with gravity variables and MRT (Eq.1)

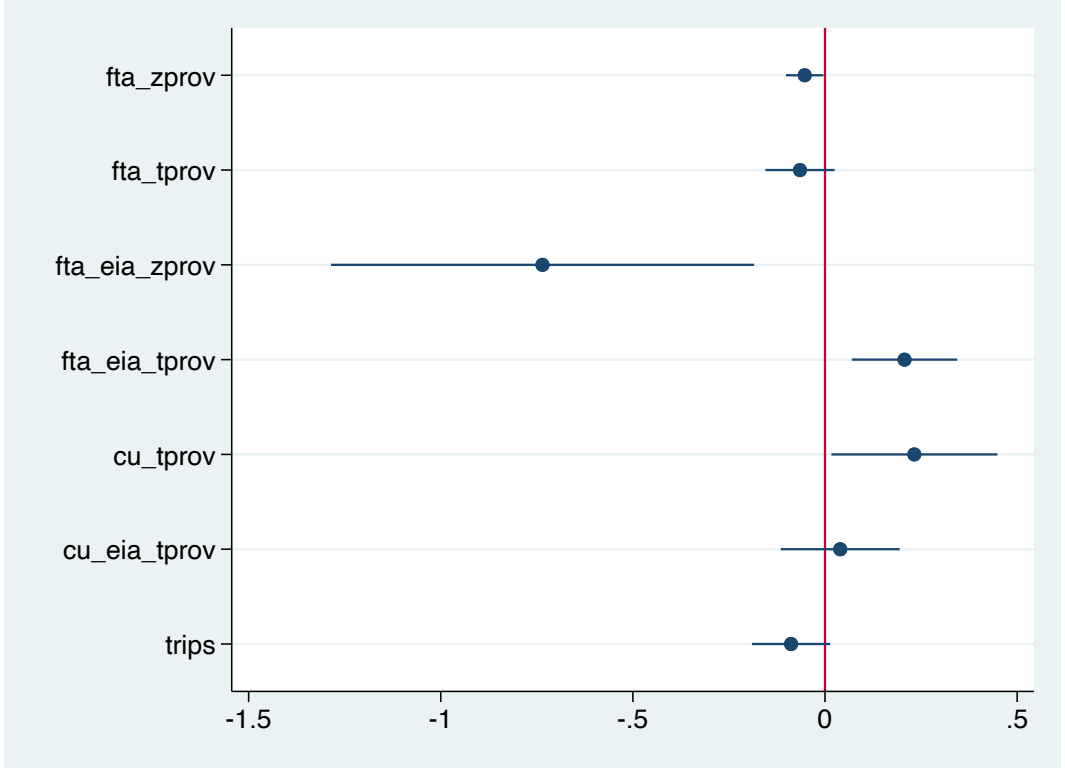


Model with pair FE and MRT (Eq.2)

Results by level of integration with tech-prov



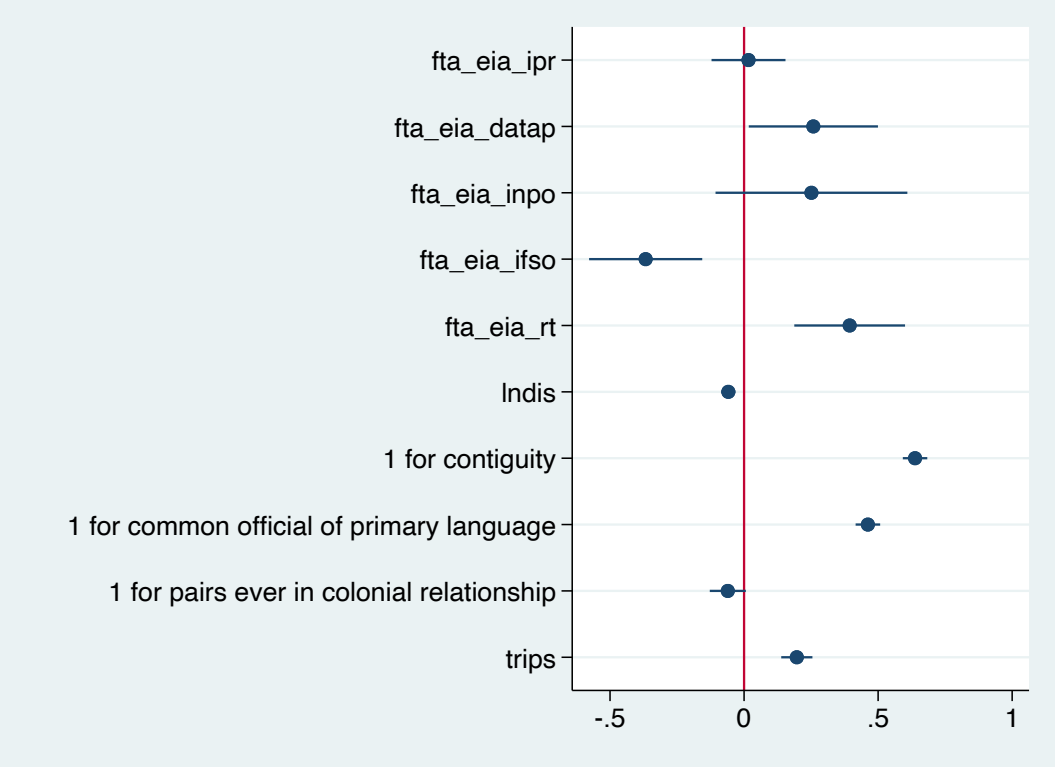
Model with Gravity variables and MRT (Eq.1)



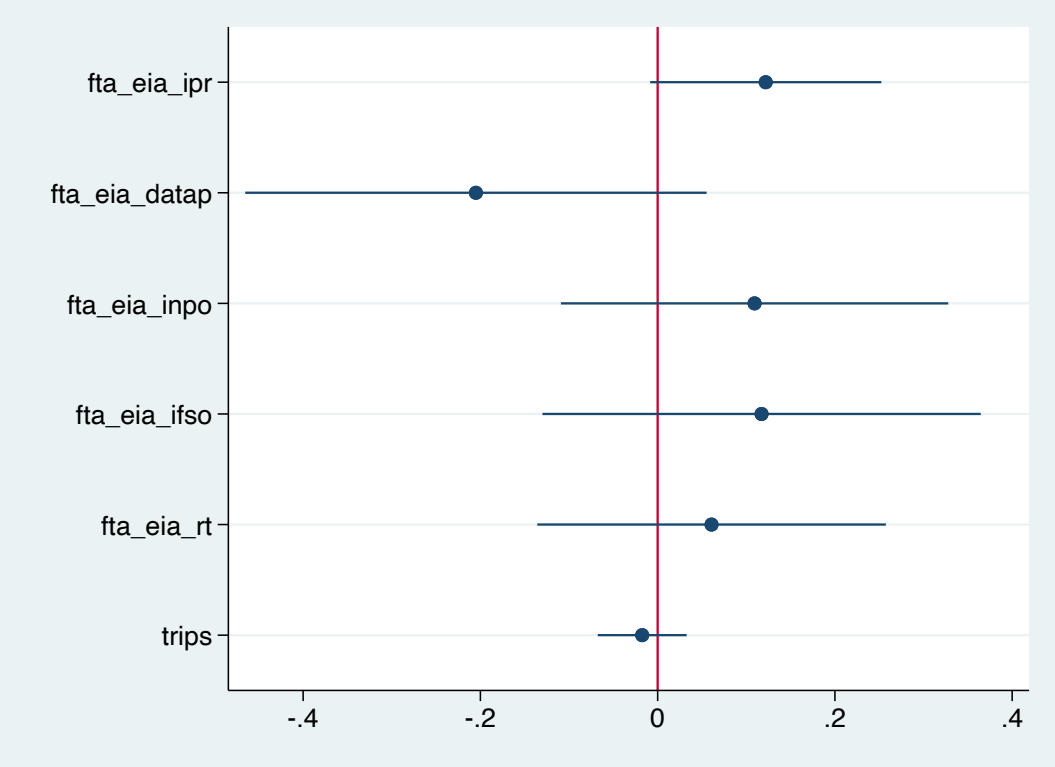
Model with pair FE and MRT (Eq.2)

_zprov=zero technology provisions; _tprov= at least 1 technology provision

What provisions are relevant for EIAs



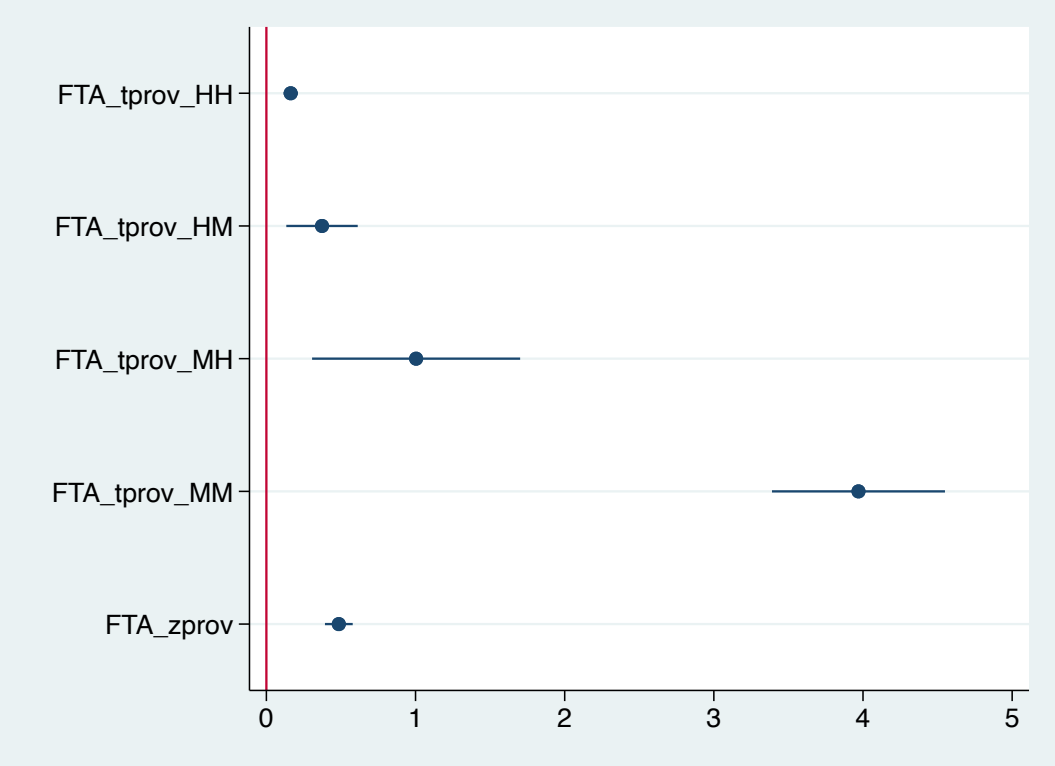
With gravity variables and MRT



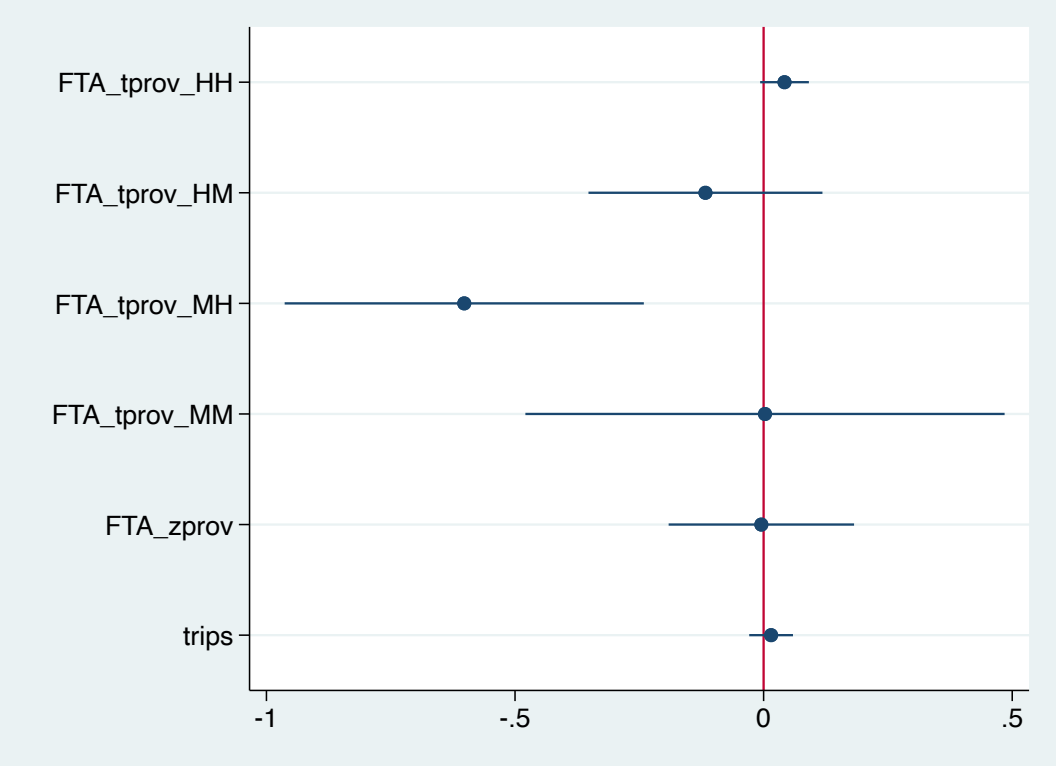
With pair FE and MRT

ipr=Intellectual Property Rights; datap=Data Protection; inpo=innovation policies; ifso=Information Society; rt=research and technology

Heterogeneity: Results by income group, FTA effect



With gravity variables and MRT

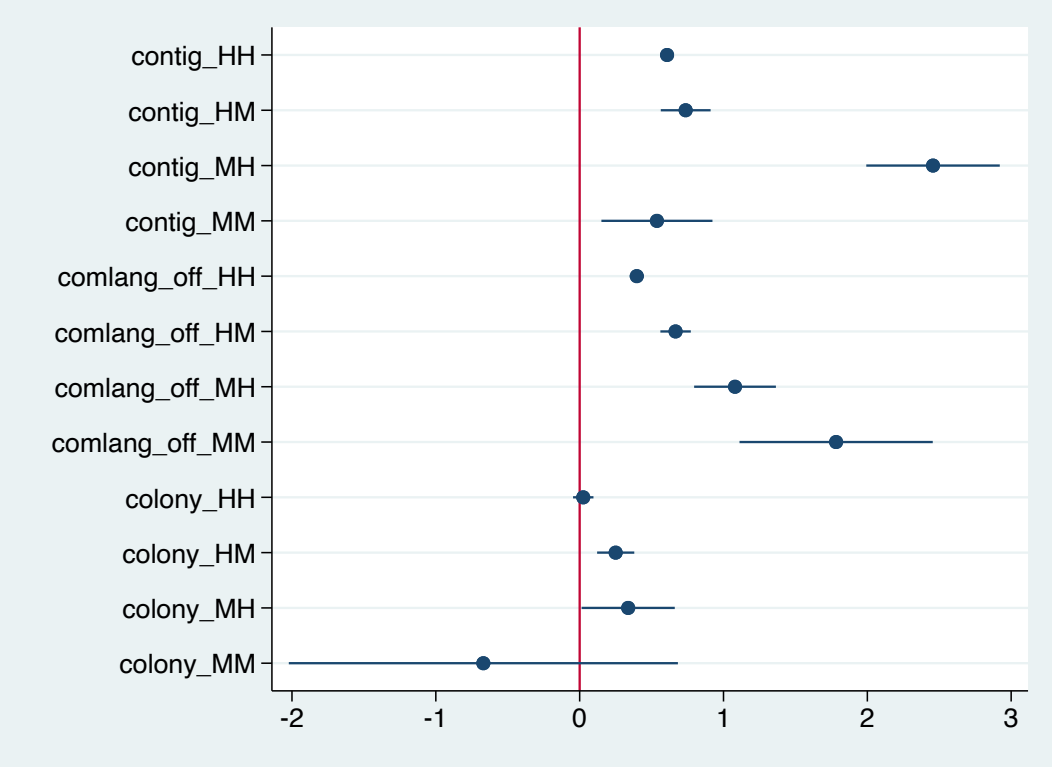


With pair FE and MRT

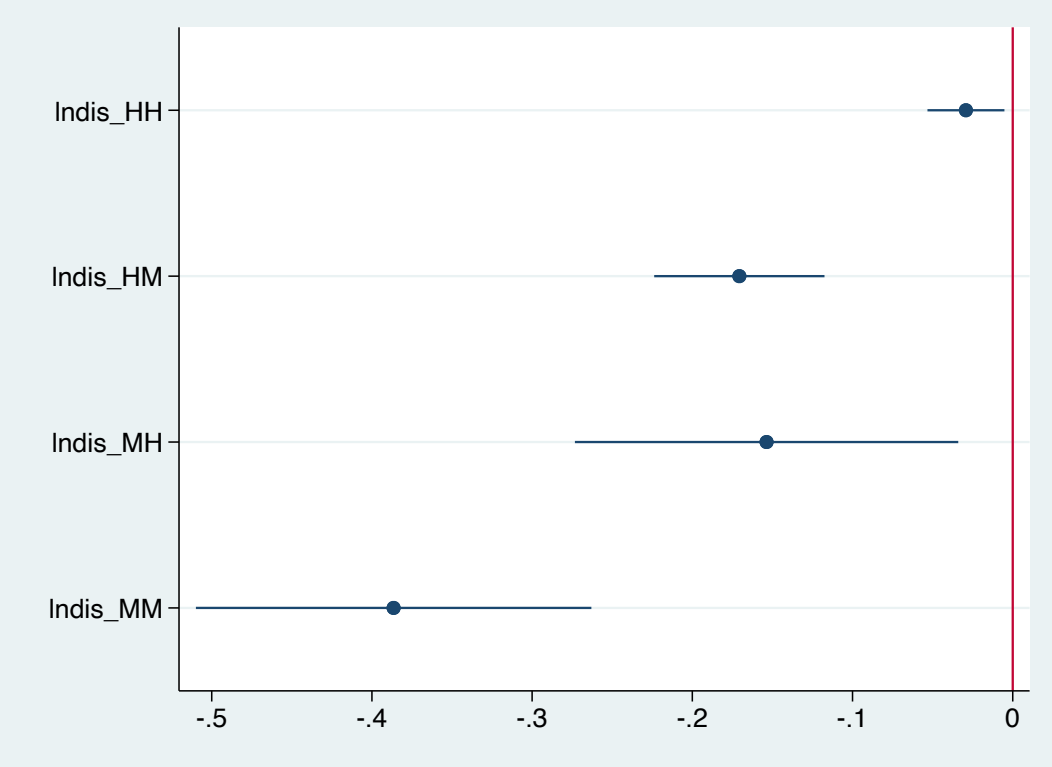
HH= owner high income, inventor high income
HM= owner high income, inventor upper- or lower-middle income
MH= owner upper- or lower-middle income, inventor high income
MM= owner and inventor upper- or lower-middle income

Heterogeneity: Results by income group, other factors

- Institutional distance

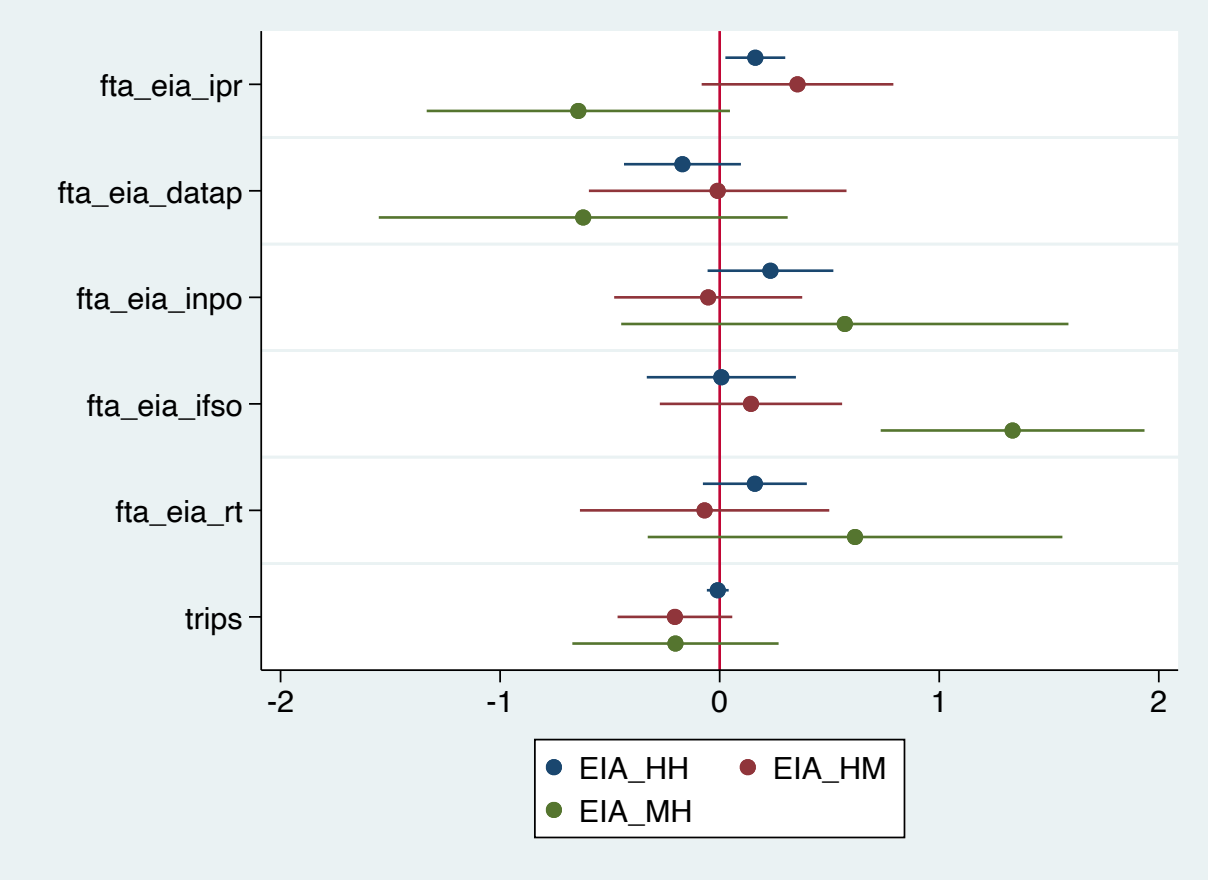


- Geographical distance



With gravity variables and MRT

Heterogeneity: Results for EIAs by provision type



ipr=Intellectual Property Rights;
datap=Data Protection;
inpo=innovation policies;
ifso=Information Society;
rt=research and technology

With pair FE and MRT HH= owner high income, inventor high income

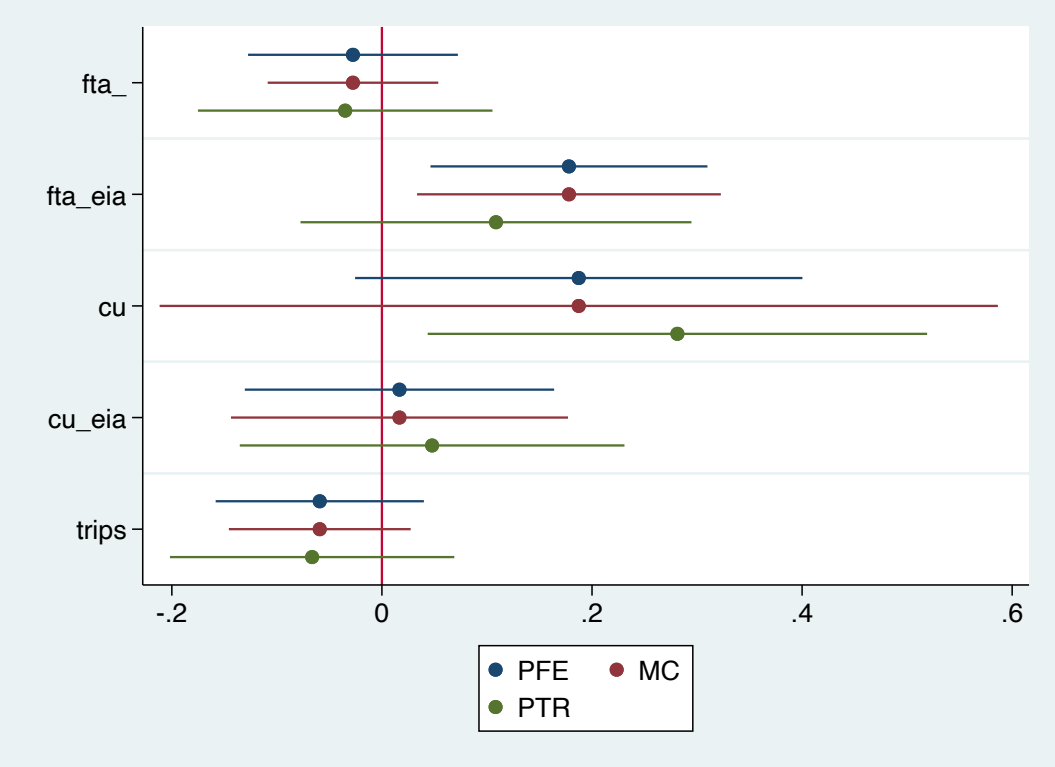
HM= owner high income, inventor upper- or lower-middle income

MH= owner upper- or lower-middle income, inventor high income

Robustness & further research

- Estimations with multi-clustering and pair-trends (Eq. 3)
- Phasing-in effects (higher effects after 5, 10 and 15 years of ratification)
- Co-inventions as dependent variable, controlling for trade, results hold
- Next steps: Provisions effect changes over time
- **Enforcement:** Treaties must take these provisions into account but enforcement is also important
- **Innovation gap:** Estimate what are the direct effects (due to technology transfer) and indirect effects (through trade) of the FTAs with provisions on the innovative and technological capacity of the countries that ratify these agreements

Robustness I: Different clustering options, bilateral-trends



PFE=pair clustering; MC=multiclustering; PTR=Pair trend

Results for phasing in effects

Estimates of the gravity model for cross-border ownership flows
sample of 81 countries and for the period 1980 to 2015

Fixed effects	Time-Country	Time-Country
	(1)	(2)
FTA	0.137***	0.252***
	(0.0286)	(0.0305)
FTA (t - 5)	0.159***	0.159***
	(0.0361)	(0.0357)
FTA (t - 10)	0.0531	0.0452
	(0.0346)	(0.0341)
FTA (t - 15)	0.0384	0.0181
	(0.0381)	(0.0373)
Ln (distance)	-0.0345**	0.00294
	(0.0142)	(0.0145)
Border	0.558***	0.601***
	(0.0268)	(0.0270)
Language	0.451***	0.477***
	(0.0255)	(0.0253)
Colonial	0.0413	-0.00561
	(0.0385)	(0.0386)
TRIPS	0.0134	0.132***
	(0.0288)	(0.0319)
FTA_depth		-0.0794***
		(0.00749)
Observations	142,902	142,902
R-squared	0.964	0.966

Note: Standard errors in parentheses. Significance level * p<0.1, ** p<0.05, *** p<0.01. Dependent variable DOFI. FTA (t - 5), FTA (t - 10), FTA (t - 15) denote lags of the variable FTA of five, ten and fifteen years. Clustered standard errors, clustered at country pair. Estimation using the ppml_panel_sg command in Stata (Larch et al., 2019). Time-country fixed effect refers to time-varying country specific fixed effects.

Results for phasing in effects

Estimates of the gravity model for co-invention flows sample of 81 countries and for the period 1980 to 2015

Fixed effects	Time-Country	Time-Country
	(1)	(2)
FTA	**0.143*** **	**0.101*** **
	(0.028)	(0.039)
FTA (t - 5)	**0.240*** **	**0.255*** **
	(0.038)	(0.039)
FTA (t - 10)	**0.163*** **	**0.164*** **
	(0.04)	(0.04)
FTA (t - 15)	-0.004	0.007
	(0.032)	(0.0326)
Ln (distance)	-0.093***	-0.093***
	(0.009)	(0.009)
Border	0.698***	0.701***
	(0.019)	(0.019)
Language	0.469***	0.471***
	(0.021)	(0.021)
Colonial	0.133***	0.130***
	(0.023)	(0.023)
TRIPS	0.004	-0.025
	(0.024)	(0.03)
FTA_depth	-	0.03**
	-	(0.015)
Observations	142,902	142,902
R-squared	0.964	0.964

Note: Standard errors in parentheses. Significance level * p<0.1, ** p<0.05, *** p<0.01. Dependent variable DOFI. FTA (t - 5), FTA (t - 10), FTA (t - 15) denote lags of the variable FTA of five, ten and fifteen years. Clustered standard errors, clustered at country pair. Estimation using the ppml_panel_sg command in Stata (Larch et al., 2019). Time-country fixed effect refers to time-varying country specific fixed effects.

Conclusions

- Agreements with and without technology & innovation provisions increase technology internationalization
- For agreements with more than 5 non-trade provisions FTAs have lower effect
- The effects are heterogeneous: by depth and income group
- The effect differ by type of provision→ IPR provisions are important
- Countries that are geographically and culturally closer, exchange more technology and knowledge, these effects are also heterogeneous by income group

Many Thanks ☺

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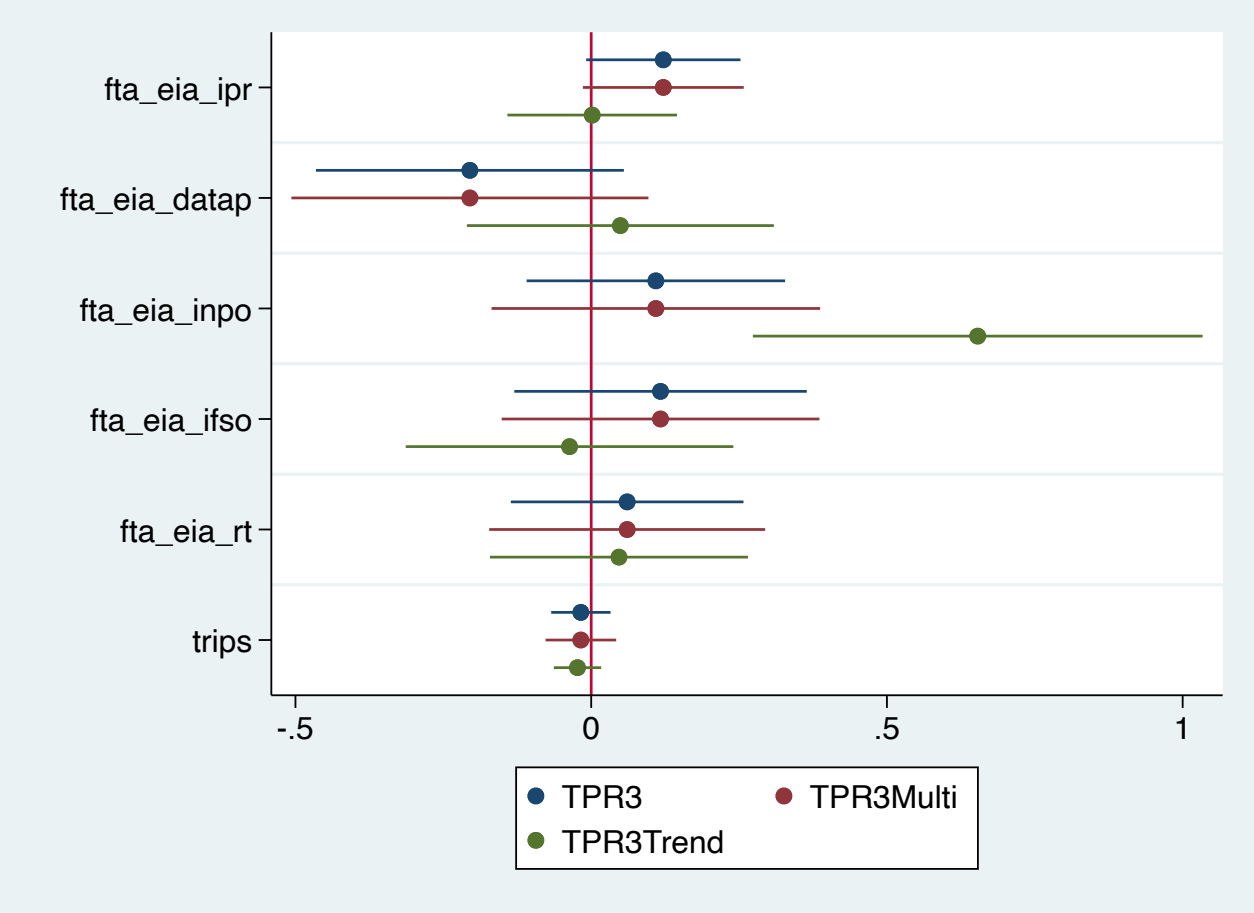
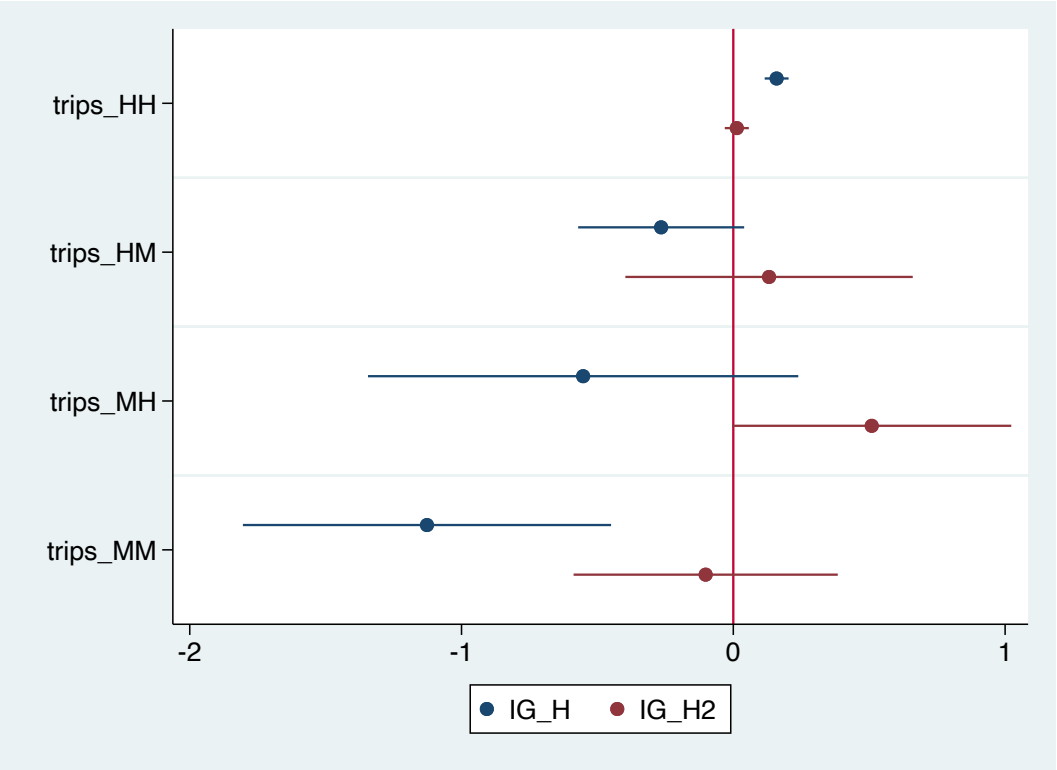
Robustness: Different clustering options, pair-trends EIAs with tech prov



TPR3=pair-clustering; TPR3Multi=multi-clustering; TPR3Trend=Pair-trends

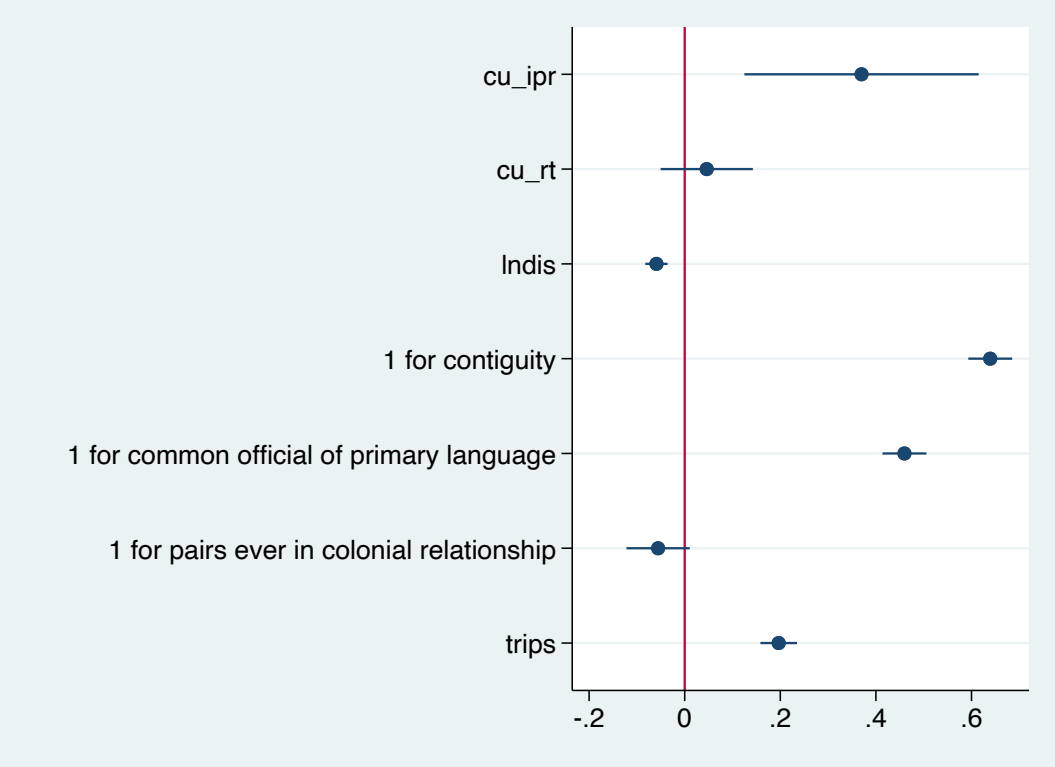
Heterogeneity: Results by income group, TRIPS



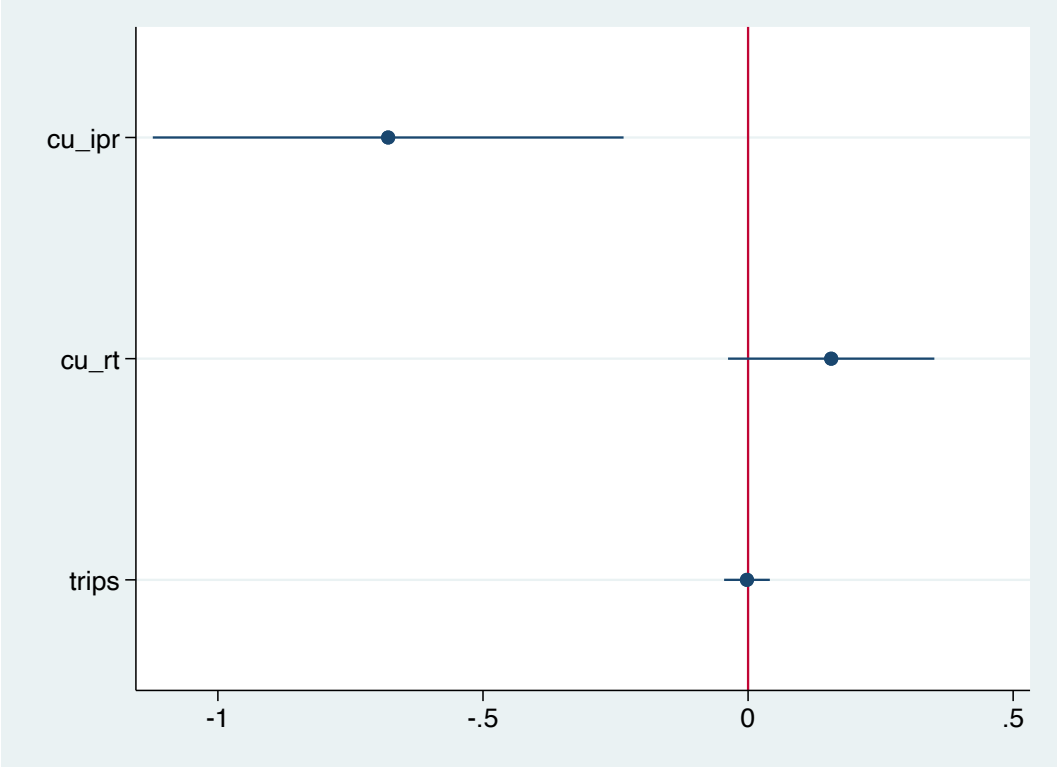
- IG_H: TRIPS with gravity variables
- IG_H2: TRIPS with pair FE

MH= owner upper- or lower-middle income, inventor high income

What provisions are more relevant for CUs



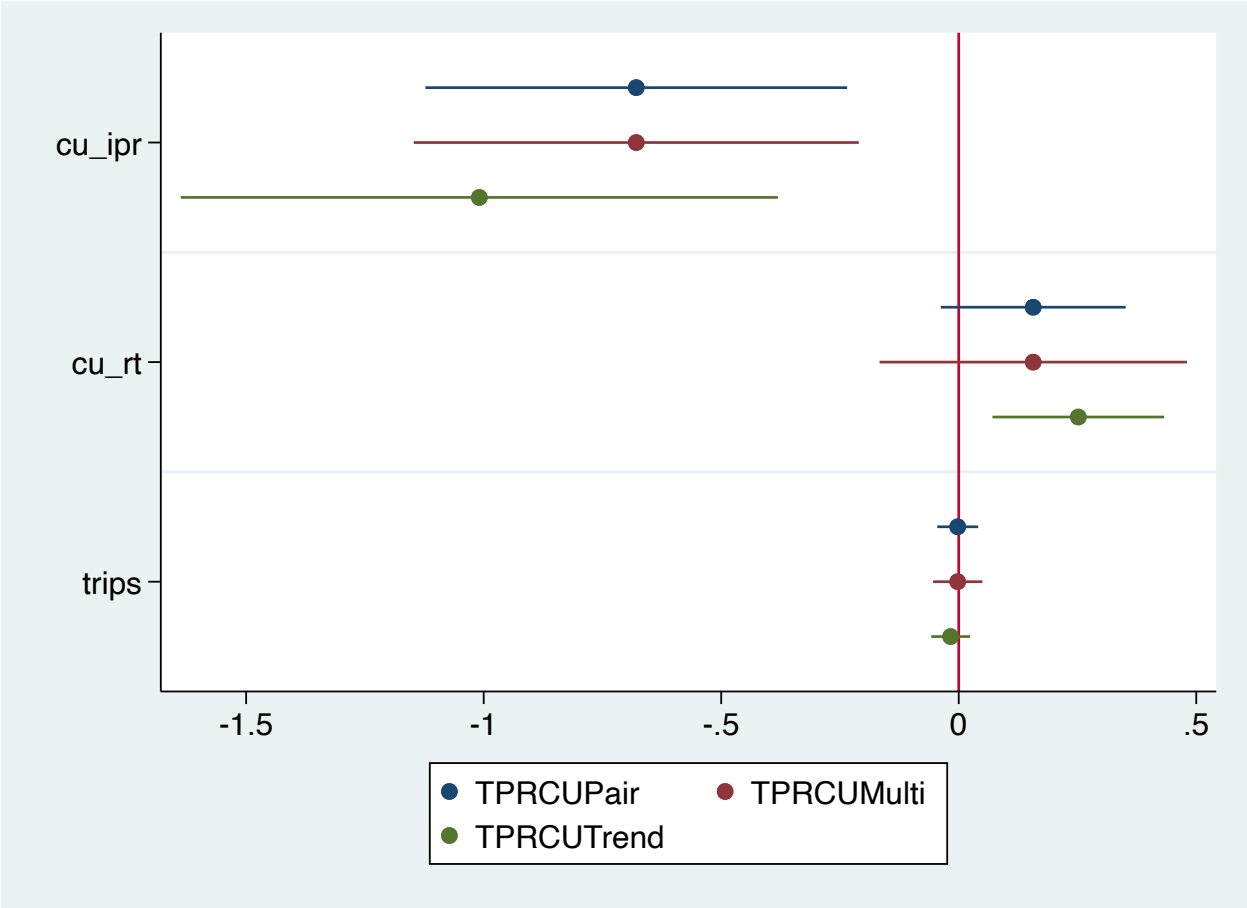
With gravity variables and MRT



With pair FE and MRT

ipr=Intellectual Property Rights; rt=research and technology

Robustness: Different clustering options, trends Cus with Tech prov



TPRCU=pair clustering; TPRCUMulti=multiclustering; TPRCUTrend=Pair trend

Estimations by Depth

FTAS with D5-D7 provisions have a lower effect on technology internationalization

D1: basic trade agreement
D2: substantive provisions on services
D3: includes provisions on investment
D4: general standards
D5: public procurement
D6: competition
D7: IPRs

Fixed effects	Time-Country
	(1)
FTA	0.284***
	(0.04)
Depth 1	1.993***
	(0.464)
Depth 2	0.679***
	(0.087)
Depth 3	0.007
	(0.032)
Depth 4	0.099***
	(0.016)
Depth 5	-0.029***
	(0.008)
Depth 6	-0.072***
	(0.018)
Depth 7	-0.052***
	(0.008)
Ln (distance)	-0.023*
	(0.013)
Border	0.648***
	(0.023)
Language	0.419***
	(0.025)
Colony	-0.002
	(0.036)
TRIPS	0.401***
	(0.031)
Observations	124,203
R-squared	0.947

Estimation by type of provision

IPR (+)
Innovation policies (+)
and research and technlology (+)

Fixed effects	Time-Country	Time-Country
	(1)	(2)
FTA_zprov	0.531***	0.555***
	(0.0493)	(0.0480)
IPR	**0.125*** **	**0.299*** **
	(0.0399)	(0.0507)
Data protection	-0.0379	-0.0847*
	(0.0499)	(0.0494)
Innovation policies	**0.267***	**0.309** **
	(0.144)	(0.130)
Information societies	-0.125	0.00539
	(0.0829)	(0.0848)
Research & Technology	**0.353*** **	**0.218*** **
	(0.0405)	(0.0478)
TRIPS	-0.0170	-0.00592
	(0.0132)	(0.0132)
FTA_depth	0.633***	0.658***
	(0.0229)	(0.0235)
No. observations	124,203	124,203
R-squared	0.946	0.946
Park-type Test p-values	0.000	0.000
GNR p-values	0.190	0.179

Note: Standard errors in parentheses. Significance level * p<0.1, ** p<0.05, *** p<0.01. Dependent variable DOFI. form of the variance. Time-country fixed effect refers to time-varying country specific fixed effects.

Heterogeneous effects by income group

	(1)	(2)	(3)	(4)
VARIABLES	HH	HH	HH	HH
FTA_tprov_HH	0.167***	0.285***	0.165***	**0.0420***
	(0.0242)	(0.0262)	(0.0242)	(0.0250)
FTA_tprov_HM	0.0997	0.416***	0.103	-0.117
	(0.117)	(0.102)	(0.117)	(0.120)
FTA_tprov_MH	2.450***	2.700***	2.455***	**-0.602*** **
	(0.207)	(0.188)	(0.208)	(0.184)
FTA_tprov_MM	2.697***	2.840***	2.704***	0.00279
	(0.171)	(0.165)	(0.171)	(0.246)
FTA_zprov	0.447***	0.516***	0.617***	-0.00455
	(0.0465)	(0.0443)	(0.195)	(0.0951)
FTA_zprov_HH			-0.188	
			(0.200)	
FTA_zprov_HM			0.0729	
			(0.281)	
FTA_zprov_MH			0.0500	
			(0.232)	
lndis	-0.0457***	-0.00198	-0.0471***	
	(0.0119)	(0.0123)	(0.0119)	
contig	0.609***	0.643***	0.607***	
	(0.0231)	(0.0231)	(0.0231)	
comlang_off	0.427***	0.468***	0.428***	
	(0.0237)	(0.0237)	(0.0237)	
colony	0.00728	-0.0500	0.00672	
	(0.0347)	(0.0348)	(0.0347)	
trips	0.128***	0.241***	0.129***	0.0151
	(0.0223)	(0.0237)	(0.0223)	(0.0224)
FTA_depth		-0.0914***		
		(0.00708)		
Observations	124,203	124,203	124,203	72,613
R-squared	0.947	0.948	0.947	0.982
Country-time FE	YES	YES	YES	YES
& pair				YES