A Tale of Two Gravities

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Goods flow, and so do territories

1. In peaceful times, countries redraw borders
2. In times of war, countries fight for targets differently
3. In interim periods, countries negotiate treaties to convert territories into equivalent interests.

Do they flow in the same way?

This paper

The gravity model for bilateral goods flows is useful for rationalizing bilateral territory flows

- A micro-founded tool for linking global demands and supplies
- Applied in a history-founded way to link goods and territory flows

Examples in history

1. US:
   - From Spain (Florida)
   - From France (Louisiana)
   - From Russia (Alaska)
   - From UK (part of Alakska)
2. Japan
   - From/to China
   - From/to Korea
   - From/to Russia
   - To US
3. China:
   - from/to UK
   - from/to Portugal
   - from/to Russia
4. Also, within the last century, Mexico, Mauritius, Nicaragua, Pakistan, Oman, Djibouti, Ethiopia, Kyrgyzstan, Afghanistan, Chile, Peru, etc. (see Table A1 in the paper for details)

Russia and Japan, 9/2016

Businessweek:

> *There seems to be the beginnings of a political deal, if you like, where you might give up one of the Kuril Islands in exchange for greater economic cooperation?*

Putin:

> *We don't trade territories... we're talking about finding a solution where neither party would feel defeated or a loser.*

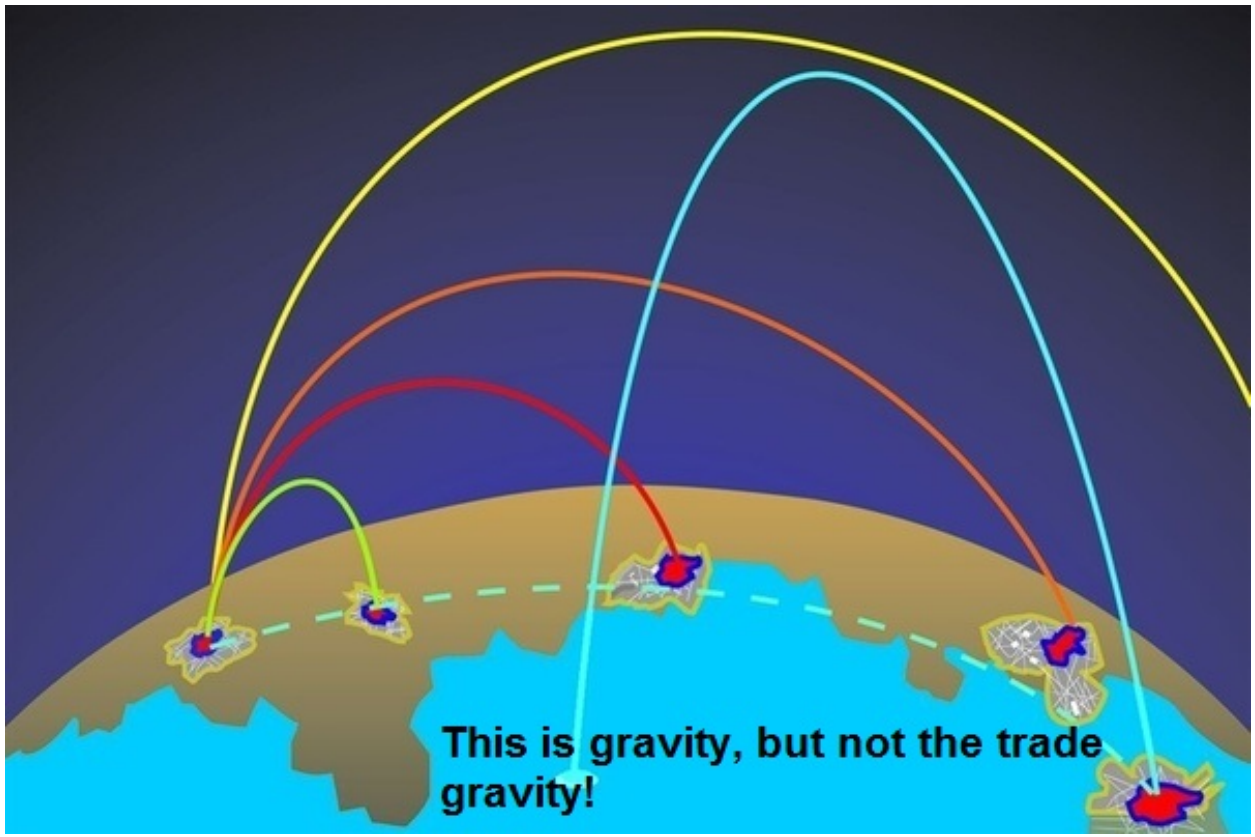
Preview - Finding 1

The bilateral territory flows across countries between 1870 and 2008 are more frequent between countries that are larger in size and closer to each other.

- Population size, not simply hegemonic expansion that accompanies rapid economic growth.
- Controlling for common borders, languages, and legal origins, not just historical, cultural, or ethnic conflicts between big powers
- Holds for three different subperiods (1870-1909, 1910-1949, and 1950-2008)

Plainly law of large numbers?

Dartboard metaphor: A despotic king who randomly shoots missiles abroad to expand her domain would be most likely to land territories of nearby large countries.



Preview - Findings 2-4

It is the trade gravity!

Evidence 1 The goods and territory flows remain positively associated, with gravity variables (i.e. country sizes and trade costs) held constant.

Evidence 2 Bilateral goods flows decline after the occurrence of territory flows between two countries (and rise before that).

Evidence 3 The duration of zero goods flows is shorter between countries with territory flows than those without.

This is *international* economics...

... actually, a trade paper!

Evidence 1 Cross-sectional evidence → "Gravity with gravitas" (Anderson van Wincoop, 2003)

Evidence 2 Panel-data evidence → the "tetrad" technique (Head, Mayer, and Ries, 2010)

Evidence 3 Zero-based evidence → the truncated goods flows (Helpman, Melitz, and Rubinstein, 2008)

Related to political/public economics

- Literature: nation-states
  - Focus: domestic affairs, including origins, capacities, and efficient sizes
  - Exceptions: Alesina, Spolaore, and Wacziarg (2000, 2005), Bonfatti (2014), Grossman and Iyigun (1995, 1997) and Gartzke and Rohner (2011) – intranational tradeoffs and compromises
- Our interest: international interactions

This is not economic imperialism

- Ricardo (1817) VS. Smith (1776): the welfare implications of pursuing foreign territories and trading with them
- Marx (1867-94) and Hobson (1902): how territorial expansions benefit and harm capitalist economies.
- Other social scientists followed, such as
  - Alaska Purchase and Fur trade (Haycox, 2002)
  - Hong Kong handover and entrepôt (Cheung, 1998).
- We are revisiting an area explored by early economists

Setup (1/2)

Consider a world with N symmetric territories, indexed by $v = 1, 2, ..., N$.

- Armington assumption: Every territory v is endowed with a unit of population and a unit of a distinct good.
- Country j has N_j territories: $L_j = \delta N_j$, δ normalized to 1.
- Domestic trade is free, foreign trade is costly (iceberg t_{ij})
- CES preferences everywhere ($\sigma \equiv 1/(1-\rho)$):

$$U_{v'} = \left(\sum_{v \in N} x_{vv'}^{\rho} \right)^{1/\rho}, \ 0 < \rho < 1, \tag{1}$$

- Thus,

$$P_{v'}^{1-\sigma} = P_j^{1-\sigma} \equiv \sum_{v \in N} (t_{i(v)j} p_v)^{1-\sigma}, \tag{2}$$

Setup (2/2)

On the origin side, territory v's income q_v and the local (domestic) price of its goods satisfies

$$p_v^{1-\sigma} = p_i^{1-\sigma} \equiv \frac{q_v}{q} \times \frac{1}{\Pi_v^{1-\sigma}}, \tag{3}$$

where $q \equiv \sum_{v' \in N} q_{v'}$ denotes the world's total income and

$$\Pi_v^{1-\sigma} = \Pi_i^{1-\sigma} \equiv \sum_{v' \in N} \left(\frac{t_{vv'}}{P_j} \right)^{1-\sigma} \frac{h_{v'}}{q} = \sum_{v' \in N} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \frac{h_{v'}}{q}. \tag{4}$$

Gravity equation for goods (a variant of AvW (2003))

$$X_{ij} = \sum_{v \in N_i} \sum_{v' \in N_j} p_{vv'} x_{vv'} = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{\text{"Gravity"}} \times \underbrace{\frac{q_i h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{\text{"Gravitas"}} \tag{5}$$

Timing

There are two phases (every period of time):

Day : Residents of different territories in the world trade goods, with their (preexisting) countries given.

Night : Politicians of different territories in the world choose each other to form new countries.

Politicians

At night, every territory is assigned two politicians, who have equal competences and chances to be in power.

- One represents local export interests, seeking to let her territory join the foreign territory with the **largest demand** for its local goods (henceforth, **out-politician**)
- The other represents local import interests, seeking to bring the foreign territory with the **largest supply** into her (territory's) country (henceforth, **in-politician**)

Out-politician at territory v

Her objective function be

$$W_{vv'}^{out} = \underbrace{\ln m_{vv'}^{out}}_{\text{econ consideration}} + \underbrace{\mu_{vv'}^{out}}_{\textit{non-econ consideration}}, \tag{6}$$

for any potential new fellow territory v', where

- $m_{vv'}^{out}$ is the share of sales to destination v' in the total sales of territory v:

$$m_{vv'}^{out} = \frac{\left(\frac{p_v t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}}{\sum_{v' \in N} \left(\frac{p_v t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}} = \frac{\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}}{\Pi_i^{1-\sigma}} \tag{7}$$

- $\mu_{vv'}^{out}$ represents the linkages between v and v' in history, culture and ethnicity, following (iid)

$$F(\mu) = \exp(\exp(-\mu)) \tag{8}$$

Outbound territory gravity

The probability for territory v to join territory v' (a territory flow denoted by $Z_{vv'} = 1$):

$$\text{Prob}^{out}(Z_{vv'} = 1) = t_{ij}^{1-\sigma} \times \frac{h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}} \tag{9}$$

Thus, the expected territory flow from country i to country j equals

$$\begin{aligned} Z_{ij}^{out} &= \sum_{v \in N_i} \sum_{v' \in N_j} \text{Prob}^{out}(Z_{vv'} = 1) \\ &= \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas\ (outbound)}, \end{aligned} \tag{10}$$

Similarly, in-politician at territory v'

Objective function:

$$W_{vv'}^{in} = \ln m_{vv'}^{in} + \mu_{vv'}^{in}, \tag{11}$$

where

$$m_{vv'}^{in} = \frac{(p_v t_{vv'})^{1-\sigma}}{\sum_{v \in N}(p_v t_{vv'})^{1-\sigma}}. \tag{12}$$

and $\mu_{vv'}^{in}$ follows the same distribution as before.
Here, the expected territory flow from country i to country j equals

$$Z_{ij}^{in} = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_i}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas\ (inbound)}. \tag{13}$$

A tale of two gravities (Hypothesis 1)

Gravity equation for territories:

$$Z_{ij} = (Z_{ij}^{out} + Z_{ij}^{in})/2 = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_i + h_j}{2q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas}, \tag{14}$$

as opposed to the **gravity equation for goods**:

$$X_{ij} = \sum_{v \in N_i} \sum_{v' \in N_j} p_v x_{vv'} = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_i h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas}. \tag{15}$$

This is not surprising...

Take the goods-exporting side for example. In the gravity equation for goods,

$$X_{ij} = N_i \times N_j \times t_{ij}^{1-\sigma} \times \frac{q_i h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}$$

where

$$p_i^{1-\sigma} \equiv \frac{q_i}{q} \times \frac{1}{\Pi_i^{1-\sigma}}$$

and the market share of a destination territory $v' \in N_j$ within an origin territory $v \in N_i$'s sales equals

$$m^{out}_{v \in N_i, v' \in N_j} = \frac{\left(\frac{p_i t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}}{\sum_{v' \in N} \left(\frac{p_i t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}} = \frac{\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}}{\Pi_i^{1-\sigma}},$$

which corresponds to

$$Z_{ij} = N_i \times N_j \times t_{ij}^{1-\sigma} \times \frac{q_i + h_j}{2q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}},$$

Remark: a simple model...

- No collusion (between the two local politicians)
- No coordination (between domestic territories' politicians)
- No conspiracy (between domestic and foreign politicians)

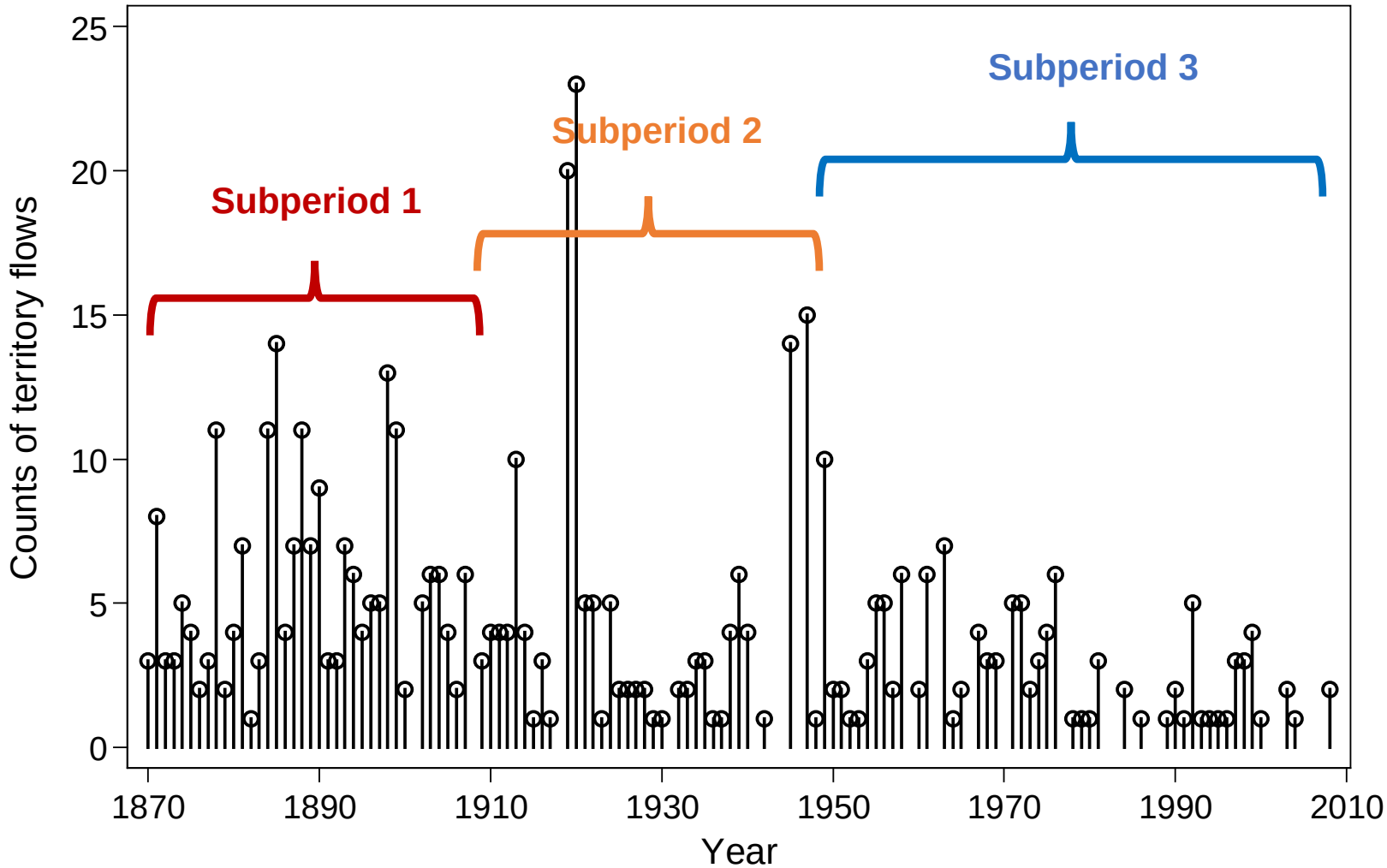
... but robust and flexible

1. Functional forms are important for the dual-flow equations; more hypotheses are on the way
2. The two politicians could be replaced by any de facto powers (warlords, dictators, monopolies, etc) so long as they have interests in exports and imports
   - Having only one politician does not change anything
3. A territory can join a domestic territory — a domestic "deal", no international territory flow in that case — that is actually quite likely
4. Territory is a territory-level (rather than national) issue.
5. Join others to form a new country? That is *independence*, excluded here

Data sources

- Bilateral territory flows: Jaroslav-Schafer-Diehl-Goertz (JSDG)
  - 1870-2008 (139 years) 243 pairs, 329 territory flows
  - Most pairs have only 1 territory flow
  - Recall: territory flows are probabilistic
- Bilateral goods flows: Barbieri-Keshk-Pollins (1870-2008, IMF and more)
- Gravity variables: CEPII gravity database (Head-Mayer-Ries)
- National material capabilities dataset (version 4) compiled by Singer (1870-2008): population, steel & iron production, priminary emerge

Figure 1: Territory Flows since 1870



Data structure

37,455 co-existing country pairs: IJ, among which

- 17,403 pairs have goods flows: IJ^{gd}
- 243 pairs have territory flow(s): IJ^{tr}
- Pairs without goods (territory) flows: IJ^{-tr} (IJ^{-gd})

Thus,

$$IJ = IJ^{tr} \cup IJ^{-tr} = IJ^{gd} \cup IJ^{-gd}.$$

Now, add the time dimension:

- IJT: all country pairs and their years
- $IJ^{tr}T^{+}$: the year(s) when the pairs in IJ^{tr} have ongoing territory flows. Their "idle" years are denoted by $IJ^{tr}T^{-}$
- $IJ^{-tr}T$ and $IJ^{-gd}T$, all the years of those without-flow pairs (for notational completeness)

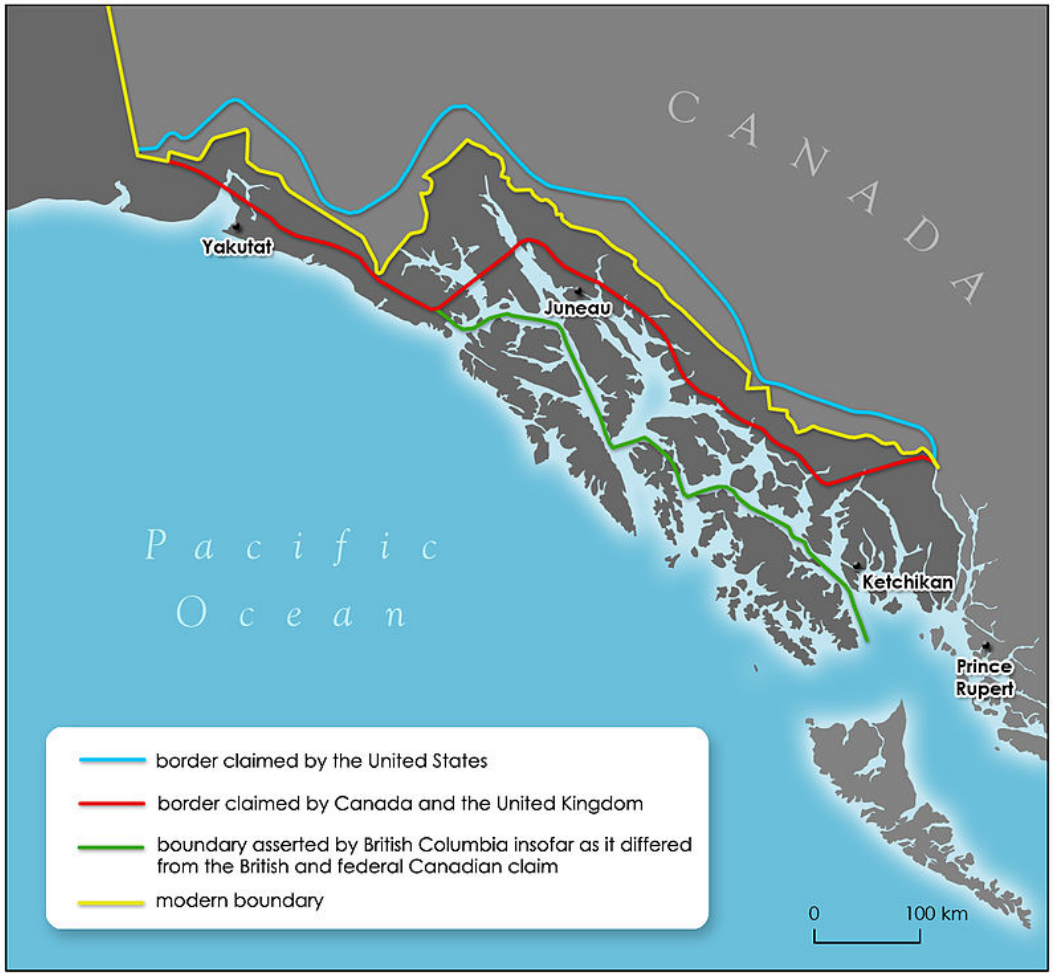
Thus,

$$IJT = \underbrace{IJ^{tr}T^{+} \cup IJ^{tr}T^{-}}_{IJ^{tr}T} \cup IJ^{-tr}T = \underbrace{IJ^{gd}T^{+} \cup IJ^{gd}T^{-}}_{IJ^{gd}T} \cup IJ^{-gd}T.$$

Data details

1. We use population to proxy for country size: recall $L_j = \delta N_j$
   - Real measure, and accurate
     - We will control for industrialization level
   - GDP? Fast growing economies might have hegemonic tendencies. And no such long panel data
   - Land area? Has no direct relevance. Our territories are political units.
2. There is little information on the flowed territories themselves
   - They might be nameless
   - We do not know their exports, imports, or population
   - Possible: a resource-exporting place controlled by a local warlord/monopoly
   - Possible: a territory that produces nearly nothing? (w/o economic value)

Example: the Hay-Herbert Treaty



This map is not part of the JSDG data

Hypotheses

1. Aforementioned: the gravity equation for territories
   - $L_i \uparrow$, $L_j \uparrow$, $t_{ij} \downarrow \rightarrow Z_{ij} \uparrow$
   - Using the cross-sectional (IJ) variations
2. The gravitas shared by the two gravities
   - Conditional on $L_i, L_j, t_{ij}, Z_{ij} \propto X_{ij}$
   - Also using the cross-sectional (IJ) variations
3. After the territory flow, bilateral goods flow decline over time
   - Tetrad-treated
   - Using the panel-variations within $IJ^{tr}T^{-}$
4. The duration of zero goods flows is shorter if having territory flows than otherwise
   - Duration analysis
   - Using the IJ^{tr} VS. IJ^{-tr} variation within

$$IJ^{gd}T^{-} \cup \underbrace{IJ^{-gd}T}_{\text{right-censored}} .$$

H1: Results

To test **Hypothesis 1**, we specify a gravity regression:

$$Z_{ij} = \exp[\alpha \ln L_i + \beta \ln L_j + \gamma \ln Distance_{ij} + \bar{\eta}' C_{ij}] \cdot \epsilon_{ij} \quad (16)$$

The Poisson Pseudo-Maximum Likelihood (PPML) Estimator is used:

- Here applied literally to count data
- Robust to heteroskedasticity
- Robust to zeros

H1: Results

Table 3: Gravity of Territories (excerpted for slides)

	(1)	(2)	(3)	(4)
Dependent variable:†	Territory flow			
ln(Population, country i)	0.665***	0.625***	0.356***	0.336***
	(0.0521)	(0.0525)	(0.0702)	(0.0932)
ln(Population, country j)	0.662***	0.597***	0.470***	0.445***
	(0.0517)	(0.0558)	(0.0753)	(0.0955)
ln(Distance)	-1.165***	-0.853***	-0.820***	-0.860***
	(0.0753)	(0.140)	(0.152)	(0.146)
▼ Time-invariant pair-level control variables (sharing borders, languages, legal origins)				
	NO	YES	YES	YES
▼ Control variables related to industrialization				
ln(Iron & steel prod., country i)			0.229***	
			(0.0374)	
ln(Iron & steel prod., country j)			0.120***	
			(0.0398)	
ln(Primary Energy consum., country i)				0.343***
				(0.0804)
ln(Primary Energy consum., country j)				0.202***
				(0.0777)

H1: Remarks

1. It also holds for a territory-flow indicator logit regression
   - A slightly different micro-foundation

$$\begin{aligned}&\Pr(\mathbb{I}(Z_{ij} > 0) = 1)\\ &= 1 - [1 - \text{Prob}^{out}(Z_{vv'} = 1)]^{N_i}[1 - \text{Prob}^{in}(Z_{vv'} = 1)]^{N_j}\end{aligned}$$

2. It holds every subperiod
   - The gravity pattern endures across varying global political landscapes and climates.
3. This gravity regression is old-fashioned
   - Gravity with sizes variables but without country fixed effects
4. We will address the gravitas term, but in the form of
   - Hypothesis 2 (i.e. Conditional on L_i, L_j, t_{ij}, $Z_{ij} \propto X_{ij}$)
   - Hypothesis 3: tetrad for goods flows X_{ij}

H2: Results

Table 5: Hypo. 2 (excerpted for slides)

	Dependent variable: territory-flow indicator (from country i to country j)			Dependent variable: territory-flow indicator (from country j to country i)		
ln(Population, country i)	0.441***	0.419***	0.346***	0.451***	0.409***	0.510***
	(0.0772)	(0.0730)	(0.0856)	(0.0834)	(0.0775)	(0.0912)
ln(Population, country j)	0.447***	0.405***	0.447***	0.436***	0.425***	0.307***
	(0.0764)	(0.0710)	(0.0865)	(0.0740)	(0.0687)	(0.0843)
ln(Distance)	-0.898***	-0.619***	-0.628***	-0.920***	-0.667***	-0.680***
	(0.114)	(0.157)	(0.158)	(0.116)	(0.153)	(0.152)
ln(Goods flows)	*0.378****	*0.400****	*0.363****	*0.385****	*0.396****	*0.378****
	(0.0572)	*(0.0557)*	*(0.0743)*	*(0.0586)*	*(0.0577)*	*(0.0741)*
Pair-level controls§	No	Yes	Yes	No	Yes	Yes
Industrialization controls△	No	No	Yes	No	No	Yes

Prepare for testing H3: tetrad

The "tetrad" technique (Head, Mayer, and Ries, 2010):

- Recall

$$X_{ijt} = \underbrace{N_{it} \times N_{jt} \times t_{ijt}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_{it} h_{jt}}{q_t} \times \frac{1}{\Pi_{it}^{1-\sigma}} \times \frac{1}{P_{jt}^{1-\sigma}}}_{Gravitas}. \quad (17)$$

- A gravitas-free dependent variable:

$$r_{ijt|k,l,t} \equiv \frac{X_{ijt}/X_{ikt}}{X_{ljt}/X_{lkt}}, \quad (18)$$

where country k is a reference importer, and country l is a reference exporter.

- Applying it to our context, the trade ratio $r_{ijt|k,l,t}$ equals

$$r_{ijt|k,l,t} = \left(\frac{t_{ijt}/t_{ikt}}{t_{ljt}/t_{lkt}} \right)^{1-\sigma} \quad (19)$$

H3: Details

- We construct a dummy variable $DUMa_{ijt}$ that represents the a-th year, $a = 1, 2, ...,$ after countries i and j have a territory flow.
- A related question is whether the territory-gaining country should have an increase in bilateral imports from the territory-losing country before the territory flow occurs.
  - Our model in Section 2 does not predict such an increase but does not preclude it.
- So, construct a dummy variable $DUMb_{ijt}$ that represents the b-th year, $b = 1, 2, ...,$ before the territory flow.
- We report $\widehat{DUMb_{ijt}}$ and $\widehat{DUMa_{ijt}}$

H3: Results

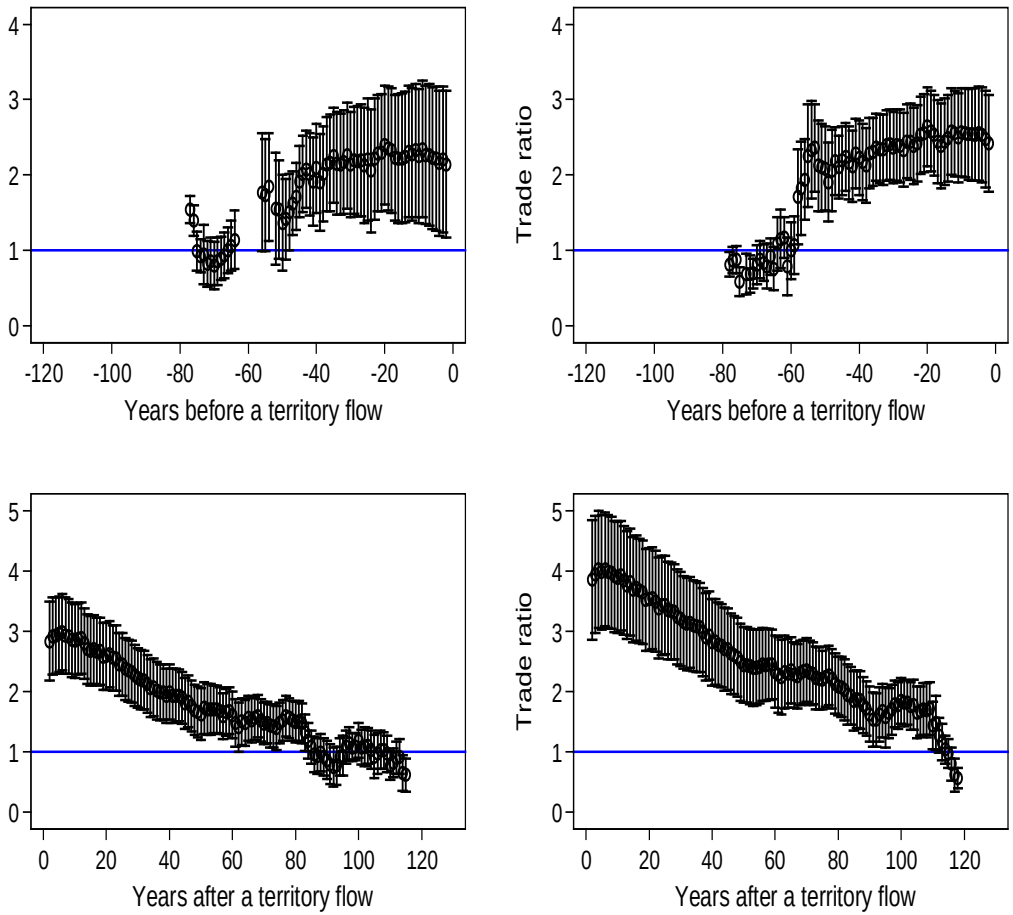


Figure 2: Trade in Goods before/after having a territory Flow (excerpted)

Point and interval (5% to 95%) estimates

(Reported only if statistically significant)

Prepare for testing H4: Gravity of Goods Zeros

- Dep. variable is zero-goods-flow indicator
- Findings:
  - Zero goods flows and zero territory flows are positively associated
  - Positive signs of gravity-variable coefficients
  - Zeros are treated as independent from each other

Table 6: Gravity of Zeros in Goods and Territory Flows (excerpted for slides)

	(1)	(2)	(3)	(4)
Direction of territory flows:¥	Outbound	Inbound	Outbound	Inbound
Indicator of zero in a territory flow	0.429***	0.432***	0.0327***	0.0250***
	(0.00126)	(0.00120)	(0.00179)	(0.00184)
ln(Population, country i)			-0.0854***	-0.0854***
			(0.000179)	(0.000179)
ln(Population, country j)			-0.0706***	-0.0707***
			(0.000189)	(0.000188)
ln(Distance)			0.134***	0.134***
			(0.000471)	(0.000471)
Pairwise control variables§	No	No	Yes	Yes

H4: Results (part 1)

- Dep. variable is the hazard of starting goods flows (i.e., probability of having positive goods flows conditional on currently having zero goods flows)
- Finding: a gravity pattern in terms of trading hazard rather than trade volume

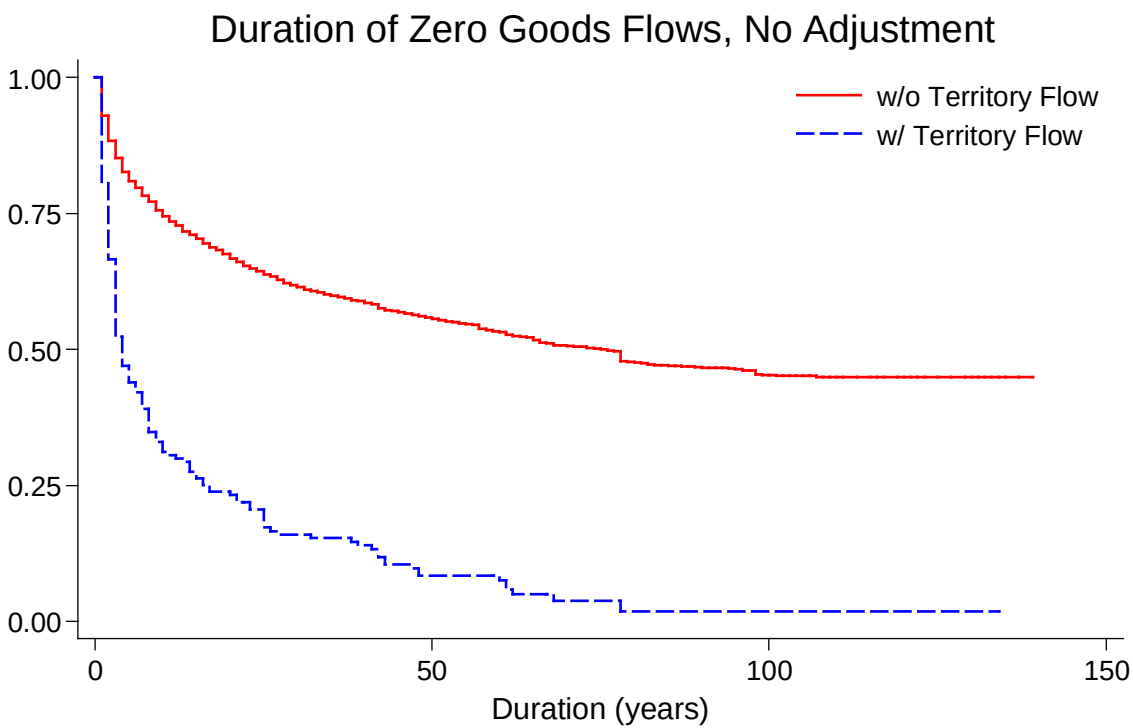
	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Full		Pairs with outbound territory flows§		Pairs with inbound territory flows§	
ln(Population, country i)	0.317***	0.326***	0.181***	0.201***	0.189***	0.209***
	(0.00539)	(0.00565)	(0.0572)	(0.0625)	(0.0545)	(0.0622)
ln(Population, country j)	0.285***	0.292***	0.197***	0.217***	0.137**	0.174***
	(0.00521)	(0.00546)	(0.0552)	(0.0622)	(0.0559)	(0.0637)
ln(Distance)	-0.456***	-0.497***	-0.213**	-0.302**	-0.195**	-0.273**
	(0.0105)	(0.0130)	(0.0853)	(0.127)	(0.0855)	(0.127)
Control variables	NO	YES	NO	YES	NO	YES

H4: Results (part 2)

- Kaplan-Meier estimator of duration function (non-parametric): the probability for zeros to lasting longer than d years, where $d = 1, 2, ...$:

$$S(d) = \Pr(D > d)$$

- Finding: pairs that have territory flows have shorter zero-goods-flow duration than otherwise



H4: Results (part 3)

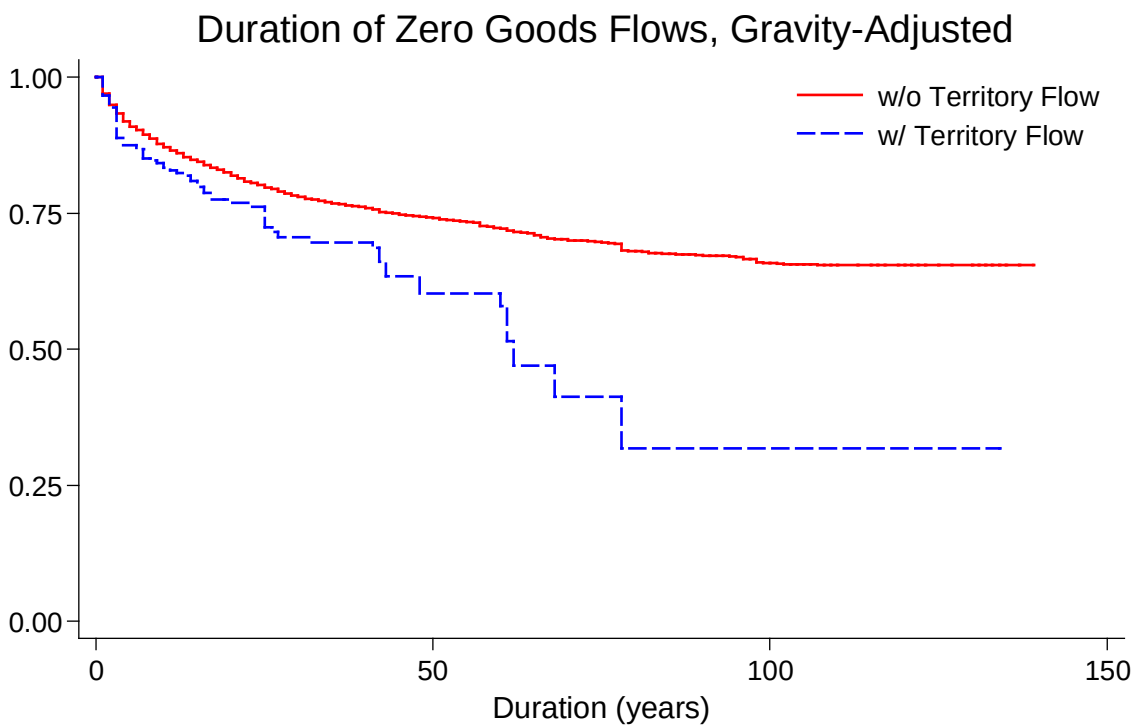
- Adjust for gravity variables:

$$-\frac{S'(d)}{S(d)} = \mathbb{h}(d|G_{ij}) \rightarrow S^{adjusted}(d)$$

where

$$\mathbb{h}(d|G_{ij}) = \mathbb{h}_0(d)\exp(\bar{\phi}'G_{ij}) \quad (20)$$

- Finding: as before,



Conclusions

- Altering the sovereignty status of territories is probably the most consequential aspect of international relations.
  - Territory flows follow a gravity pattern
  - Not just superficially, but integrated with the gravity of goods that stem from a CES-Armington system
- The gravity model in the international trade literature is more versatile than one might expect.
  - May lead to a unified framework of a more broadly defined *international economics*
- Limitations and future research: symmetric territories
  - Territory-level data are yet available (will be in the future, thanks to geo-referencing technologies)
  - With more data, the theory could be made richer and more quantitative