Goods vs. Territories: A Tale of Two Gravities

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Abstract

The flows of traded goods across countries are known to follow a gravity pattern: their volumes are greater between countries that are larger in size and closer to each other. We find a similar pattern in the flows of territories across countries between 1870 and 2008. During this period, countries experienced inflows and outflows of territories, mirroring the international flows of goods. We find three other pieces of critical evidence supporting that the two flows interact through similar economic motives.

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1 Introduction

Throughout history, goods have flowed across countries to balance supply and demand. Territories have likewise flowed. Unlike goods, territories flow only in terms of sovereignty, but like goods, their flows are driven by the decisions of rational actors. In peaceful times, countries redraw borders in exchange for economic and political benefits. In times of war, countries fight each other for territories they covet. In interim periods, following war and before peace is established, countries negotiate treaties to convert territories they occupied in the war into equivalent interests.

This paper aims to rationalize the bilateral territory flows across countries. We find that the gravity model, originally built for modeling the goods flows across countries, also helps explain territory flows. As a namesake of Newton's third law, the gravity model predicts that the volumes of goods flows are greater between countries that are larger in size and closer to each other. This enlightens us in two ways. One, there is an extant micro-founded tool for linking demands and supplies across the globe. Two, applying a tool designed for studying goods flows to the study of territory flows is more than analogy. The trade of goods and the reshuffle of territories have evolved

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hand in hand since the time of Christopher Columbus.

The gravity of goods informs the gravity of territories. We apply the gravity model to the territory flows that occurred between 1870 and 2008, where a territory flow refers to a territory whose sovereignty transitions from one country to another. Territory flows turn out to be more frequent between countries that are larger in size and closer to each other. We use population rather than GDP to measure country size, such that the gravity pattern is not simply an outcome of hegemonic expansion that often accompanies rapid economic growth. The pattern is robust to controlling for common borders, languages, and legal origins, such that it cannot be attributed plainly to border disputes among world powers resulting from historical, cultural, or ethnic conflicts. In addition, the pattern holds for three different subperiods (1870-1909, 1910-1949, and 1950-2008), such that it endures across varying global political landscapes and climates.

Of course, having a gravity pattern does not necessarily mean that the pattern is related to international trade. A despotic king who randomly shoots missiles abroad to expand her domain would be most likely to land territories of nearby large countries. As in this dartboard metaphor, international incidents, including economic, political and military ones, obey the law of large numbers and attenuate in likelihood over space to a large extent. In addition to the gravity of territories itself, we find that

(i) The two flows remain positively associated, with gravity variables (i.e. country sizes and trade costs) held constant. This suggests that the unobserved pair-specific characteristics that drive bilateral goods flows also influence bilateral territory flows.

(ii) Bilateral goods flows decline after the occurrence of territory flows between two countries. In fact, the data also show that bilateral goods flows rise moderately before the occurrence of territory flows.

(iii) The duration of zero goods flows is shorter between countries with territory flows than those without. That is, territory flows do not necessarily happen between economically disconnected countries that have large trading potentials; but conditional on having territory flows, the economic disconnection ends sooner.

These three additional evidences uniquely indicate an interplay between the two types of flows, including cross-sectionally (evidence (i)), over time (evidence (ii)), and in terms of zero-flows (evidence (iii)).

This paper illustrates the usefulness of international trade models for understanding international politics. The evidence (i) above reflects the multilateral nature of bilateral economic and political relations. The recent gravity-model literature, led by Anderson and van Wincoop (2003), emphasizes the remoteness of a country with the rest of the world in determining its bilateral trade flows with every trade partner. Like their gravity equation for goods, our gravity equation for territories is also extended with a "gravitas" term. That is, the same distance may have very different geopolitical implications for country pairs with different locations within the world's economic geography. The evidence (ii) above makes use of the *tetrad* method developed by Head, Mayer, and Ries (2010). Since every country has time-varying fixed effects that influence their trade flows with every trade partner in every period, there are a huge number of fixed effects that need to be treated structurally. Their method matches our econometric needs. The evidence (iii) above connects to the fact that the potential trade volume between two countries has to be sufficiently large to be observed as positive (Helpman, Melitz, and Rubinstein, 2008). Our findings support the idea of the selection of destinations driven by observable gravity variables.

This paper is also related to the political/public economics studies that seek to understand modern countries (known as nation states), including their origins, capacities and efficient sizes.[1] Several studies in this literature also involve international trade, including Alesina, Spolaore, and Wacziarg (2000, 2005), Bonfatti (2014), Grossman and Iyigun (1995, 1997) and Gartzke and Rohner (2011). Their focuses are on *intra*national tradeoffs and compromises, rather than *inter*national interactions. Unlike this strand of the literature, our study focuses on international interactions.

It should be noted that, as in the two literatures above, the leading actors in this paper are countries rather than territories. Our data sources offer little information on the territories that "flowed." It is even harder to find data on territories that did not flow. We treat countries as collections of symmetric territories. Relatedly, this study does not examine independence of territories (i.e. territories of a given country become independent countries) because the size of a newly formed country and its distance from its previous country are ex ante undefined, even though the mechanism featured in our framework is applicable to the analysis of independence.

The connection between territories and trade has received continual attention from social scientists. Earlier economists prominently noted the interplay between territories and goods. Ricardo (1817) disagreed with Smith (1776) on the welfare implications of pursuing foreign territories and trading with them, and Marx (1867-94) and Hobson (1902) discussed extensively how territorial expansions benefit and harm capitalist economies. It was scholars in other social sciences who followed this line of exploration, such as the relation between fur trade and the Alaska Purchase (Haycox, 2002), and the role of Hong Kong as an entrepôt in its handover from the United Kingdom to China (Cheung, 1998). This being said, our study should not be interpreted as economic imperialism. We are revisiting an area explored by early economists, which is now a topic of interests within the social sciences.

The rest of the paper is organized as follows. In Section 2, we present a conceptual framework, where testable hypotheses are developed. The hypotheses are empirically tested in Section 3. We conclude in Section 4.

[1]See Ang (2015), Bates, Greif, and Singh (2002), Carneiro (1970), Hobbes (1651), Tilly (1985), and de la Sierra (2015) on the origins of states; Aghion, Persson, and Rouzet (2012), Alesina and Reich (2015), Besley and Persson (2009), and Iyigun, Nunn, and Qian (2015) on capacities; and Alesina and Spolaore (1997), Alesina and Spolaore (2005), Alesina and Spolaore (2006), Brennan and Buchanan (1980), Desmet, Le Breton, Ortuño-Ortín, and Weber (2011), and Friedman (1977) on efficient sizes.

2 Conceptual Framework

2.1 Environment

Consider a world with N symmetric territories, indexed by $v = 1, 2, ..., N$. Every territory v is endowed with a unit of population and a unit of a distinct good. We also use v to index the territory's good. The territories in the world are divided into J countries. Countries, indexed by $j = 1, 2, ..., J$, have asymmetric sizes. Country j has N_j territories, so that $\sum_{j=1}^{J} N_j = N$. N, when denoting a set, represents the collection of all territories in the world ("the world" for short). Similarly, N_j, when denoting a set, represents all territories in country j ("country j" for short). Since every territory has a unit of population, a country's population size L_j is in proportion to its number of territories: $L_j = \delta N_j$ for any j, with δ normalized to unity.

The goods are consumed by local residents. Local residents at every territory v' have the following utility function

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

where $x_{vv'}$ is the quantity of the good from territory v consumed at territory v'. For later use, we define $\sigma \equiv 1/(1-\rho)$, which is the elasticity of substitution.

Trade within a country is costless, whereas international trade is costly. Suppose that territory v is in country i, and territory v' in country j. If the price of a good at its origin v is p_v, the delivery price at destination v' is $t_{ij}p_v$, where $t_{ii} = t_{jj} = 1$ for any i or j, and $t_{ij} > 1$ for any $i \neq j$. By equation (1), the demand function at territory $v' \in N_j$ for territory $v \in N_i$'s good is

$$x_{vv'} = \frac{(t_{vv'}p_v)^{-\sigma} h_{v'}}{P_{v'}^{1-\sigma}} = \frac{(t_{ij}p_v)^{-\sigma} h_{v'}}{P_{v'}^{1-\sigma}}, \tag{2}$$

where $h_{v'}$ is the expenditure of territory v' and $P_{v'}$ is the price index of territory v'. Since domestic trade is costless, the trade cost between territory $v \in N_i$ and territory $v' \in N_j$ equals t_{ij}, which does not vary across territories within either country. Thus, $P_{v'}$ applies to every other territory in country j:

$$P_{v'}^{1-\sigma} = P_j^{1-\sigma} \equiv \sum_{v \in N} (t_{i(v)j}p_v)^{1-\sigma}, \tag{3}$$

where $i(v)$ represents the distance between country i (where territory v is located) and country j.

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

$$p_v^{1-\sigma} = p_i^{1-\sigma} \equiv \frac{q_v}{q} \times \frac{1}{\Pi_v^{1-\sigma}}, \tag{4}$$

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

$$\Pi_v^{1-\sigma} = \Pi_i^{1-\sigma} \equiv \sum_{v' \in N} \left(\frac{t_{vv'}}{P_j} \right)^{1-\sigma} \frac{h_{v'}}{q} = \sum_{v' \in N} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \frac{h_{v'}}{q}. \tag{5}$$

Notice that the p_v in equation (4) does not vary across territories within a country, though it varies across countries. As all territories have the same quantity of endowments, q_v does not vary within a country, and as a result neither does h_v. For convenience, we define

$$q_i \equiv q_v \text{ for any } v \in N_i,$$
$$h_i \equiv h_v \text{ for any } v \in N_i.$$

These variables represent every territory's affluence level in country i, measured by income and expenditure, respectively. Keep in mind that they are territory-level variables despite the fact that their subscripts are country indexes. They just do not vary across territories within a country.

Combining equations (2) and (4), we obtain the (value of) goods flows from territory $v \in N_i$ to territory $v' \in N_j$:

$$p_v x_{vv'} = \frac{q_i h_j}{q} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma}. \tag{6}$$

By aggregating equation (6) across all territories in the two countries, we obtain the gravity equation for goods:

$$X_{ij} = \sum_{v \in N_i} \sum_{v' \in N_j} p_v x_{vv'} = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_i h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas}. \tag{7}$$

This is a variant of the gravity equation derived by Anderson and van Wincoop (2003). The term "gravitas" is borrowed from their title. We assume symmetric territories worldwide since our focus is on territory flows between countries. Intuitively, larger countries have more territories, and therefore have stronger demands and supplies. Meanwhile, countries that have lower bilateral trade costs (including but not limited to a shorter geographic distance) trade more with each other. The gravitas term refers to the fact that the same bilateral trade cost penalizes bilateral trade differently, depending on the locations of the two countries within the world's economic geography.

2.2 Territories

There are two dates in every period of time. Goods flow across countries on date 1, while territories flow across countries on date 2. Territory flows are led by politicians. On date 2, every territory is assigned two politicians, who have equal competences and chances to be in power. One of them represents local export interests, seeking to let her territory join foreign territories where her territory's local goods have large market shares, while the other represents local import interests, seeking to bring foreign supplier territories into her (territory's) country. For convenience, we henceforth refer to the politician who represents local export interests as the *out-politician*, and the politician who represents local import interests as the *in-politician*.

First consider the out-politician. Suppose that the out-politician of territory $v \in N_i$ becomes in power. As a politician, she weighs both economic and non-economic considerations. Her economic consideration, in deciding whether to join with territory v', centers on the market share of territory v' within her territory's sales on date 1. By equation (2), (4) and (5), the market share equals

$$m_{vv'}^{out} = \frac{\left(\frac{p_v t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}}{\sum_{v' \in N} \left(\frac{p_v t_{vv'}}{P_{v'}}\right)^{1-\sigma} h_{v'}} = \frac{\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}}{\sum_{v' \in N} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}} = \frac{\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}}{\Pi_i^{1-\sigma}}, \tag{8}$$

representing the greater lobbying powers of the local exporters (at origin v) and their foreign customers (at destination v'), as well as other interests she has in the local exporting business. Her non-economic consideration, including bilateral linkages between territories v and v' in terms of history, culture and ethnicity, is represented by a stochastic term $\mu_{vv'}^{out}$, which is independently and identically distributed across territory pairs. It follows a type-1 extreme value distribution:[2]

$$F(\mu) = \exp(\exp(-\mu)). \tag{9}$$

To integrate the above economic and non-economic considerations, we let the objective function of the out-politician of territory v be

$$W_{vv'}^{out} = \ln m_{vv'}^{out} + \mu_{vv'}^{out}. \tag{10}$$

A logarithmic function is applied to $m_{vv'}^{out}$, because non-economic interests $\mu_{vv'}$, unlike the market share, do not have a cardinal real-world counterpart. It is thus more appropriate to integrate the two types of considerations in percentage terms. Note that transforming $W_{vv'}$ monotonically as $e^{W_{vv'}^{out}} = m_{vv'}^{out} e^{\mu_{vv'}^{out}}$ would not make any difference to the following discussion.

When the out-politician of territory v is in power, she chooses to join the territory v' that brings the highest $W_{vv'}^{out}$. Thus, the probability for territory v to join territory v' (a territory flow denoted by $Z_{vv'} = 1$) follows from equations (9) and (10):[3]

$$\text{Prob}^{out}(Z_{vv'} = 1) = t_{ij}^{1-\sigma} \times \frac{h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}. \tag{11}$$

[2]The type-1 extreme value distribution is extensively used in statistics to model extreme events, such as maximum rainfall and droughts. It is also widely used in econometrics (e.g. McFadden (1974) and Train (2003)). The use of extreme-value distributions is common in economics, such as Eaton and Kortum (2002) on trade and Alvarez and Lucas (2007) on economic growth.

[3]We provide a detailed derivation of equation (11) in Appendix A1.

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

$$Z_{ij}^{out} = \sum_{v \in N_i} \sum_{v' \in N_j} \text{Prob}^{out}(Z_{vv'} = 1) = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{h_j}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{Gravitas\ (outbound)}, \tag{12}$$

which has a similar form as the previous gravity equation (7) for goods. The p_v (or p_i) of the out-politician's territory $v \in N_i$ is absent here, as equation (12) is from territory $v \in N_i$'s perspective.

The intuition behind equation (12) is as follows. A larger country tends to lose more territories because all else held equal, it has more territories to lose. So does it gain more territories because all else held equal, it also has a higher probability of attracting foreign territories. Given the sizes of the two countries, the lower their bilateral trade costs are, the more likely it is for them to have territory flows, because they are more connected economically through the aforementioned market share. Just as in the gravity equation for goods, there is also a gravitas term here, representing the fact that trade costs matter not only absolutely but also relatively. That is, the same t that discourages territory flows within one pair may encourage territory flows within another pair, depending on the locations of the two sides within the world's economic geography. This is a geopolitical implication of the gravitas term in the gravity equation (7) for goods.

Now turn to the in-politician. She also has economic and non-economic considerations. To avoid repeating some of the equations above, let us consider the in-politician of territory $v' \in N_j$ rather than the in-politician of territory $v \in N_i$.[4] Her objective function is

$$W_{vv'}^{in} = \ln m_{vv'}^{in} + \mu_{vv'}^{in}, \tag{13}$$

where

$$m_{vv'}^{in} = \frac{(p_v t_{vv'})^{1-\sigma}}{\sum_{v \in N} (p_v t_{vv'})^{1-\sigma}}. \tag{14}$$

and $\mu_{vv'}^{in}$ follows the same distribution in equation (9). Thus,[5]

$$\text{Prob}^{in}(Z_{vv'} = 1) = p_v^{1-\sigma} \times \frac{t_{ij}^{1-\sigma}}{P_j^{1-\sigma}}, \tag{15}$$

which, with equation (4) inserted, becomes

$$\text{Prob}^{in}(Z_{vv'} = 1) = t_{ij}^{1-\sigma} \times \frac{q_i}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}. \tag{16}$$

[4]Note that this in-politician's competitor is the out-politician of territory $v' \in N_j$ rather than the out-territory politician of territory $v \in N_i$.

[5]We provide a detailed derivation of equations (15)-(16) in Appendix A1.

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

$$Z_{ij}^{in} = \sum_{v \in N_i} \sum_{v' \in N_j} \text{Prob}^{in}(Z_{vv'} = 1) = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{\textit{Gravity}} \times \underbrace{\frac{q_i}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{\textit{Gravitas (inbound)}}. \tag{17}$$

The intuition behind equation (17) is similar to that behind equation (12).

Recall that the out-politician and the in-politician have equal chances of being in power. So, for any country pair ij, the total expected territory flow from country i to country j equals

$$Z_{ij} = (Z_{ij}^{out} + Z_{ij}^{in})/2 = \underbrace{N_i \times N_j \times t_{ij}^{1-\sigma}}_{\textit{Gravity}} \times \underbrace{\frac{q_i + h_j}{2q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}}_{\textit{Gravitas}}, \tag{18}$$

This is the first hypothesis that we will test empirically:

Hypothesis 1 *Bilateral territory flows follow a gravity pattern.*

In summary, in every period of time, goods are endowed and flow across countries following equation (7), then territories flow across countries following equation (18). There are no intertemporal concerns in the model, but the time periods do not simply repeat themselves because non-economic shocks $\mu_{vv'}$ trigger territory changes to countries in every period.

2.3 Remarks

This framework is a deliberately simple one, built to inform our later empirical study. It abstracts away from within-territory collusion between the two local politicians, within-country coordination across domestic territories' politicians, and cross-border conspiracy through which domestic and foreign politicians plot to merge their territories. Although stylized, the framework is robust and flexible in several ways that are noteworthy.

First, the two competing politicians of every territory are metaphoric, representing two opposing economic interests in an economy. They do not have to be political figures who compete under a democratic regime to win a public office. The winner between them can be replaced by a *de facto* power that controls the territory, such as a warlord, a populist leader, or some monopoly in the local economy, as long as this de facto power has economic interests in imports or exports. The model also has a degenerate version where only the out-politician or only the in-politician exists. For example, only the out-politician exists if the territory is seeking independence (discussed below), while only the in-politician exists if the territory is currently uninhabited (discussed in section 3.1). The degeneration makes no difference because the resulting total flow (the current equation (18)) would then be either equation (12) or equation (17), maintaining a similar "gravity with gravitas" form.

Second, in the above model, out-politicians are allowed to let their territories "join" domestic territories, ending up with no change to the sovereignty status of their territories; similarly, in-politicians can choose to "bring in" domestic territories, ending up not incorporating any foreign territory. In fact, considering the market shares in equations (8) and (14), both the in-politician and the out-politician have more interests in their domestic markets than in foreign markets. Such "muted" outcomes (in terms of sovereignty) may take the form of domestic political coalitions or other domestic deals. They are not recorded in the data, even though their potential effects have been taken into account by our framework.

Third, one may consider territories of a country as a national (i.e. country-level) issue rather than a local (i.e. territory-level) issue. Notice that a country j in our setup is no more than a set of trade costs $\{t_{ij}\}_{i=1}^{J}$. Every territory has a positive probability of leaving its current country for a foreign country, such that the notion of a country is transitory here. This might be a disadvantage from a political economic perspective. That is, such "hollow" countries do not provide public goods other than unified domestic markets that are trade-cost free. However, it is an advantage from an international economics perspective because the countries' political regimes do not matter thanks to the hollowness of countries. The analysis here is neutral to the diversity of political regimes in the world.

Fourth, one may think countries that industrialized earlier might have more in-politicians, alluding to unequal probabilities of winning of the two politicians such as $\frac{(1-\theta)q_i+\theta h_j}{q}$ in equation (18), where $0 < \theta < 1$ represents the relative hegemonic tendency of an affluent country j. On the one hand, we are aware of this possibility and control for industrialization levels of both sides in our empirical study. On the other, countries that expanded earlier to colonize more territories would lose more territories once their domestic markets become inadequate to sustain their country sizes.[6] This is largely witnessed by the blossom of new countries in the second half of the 20th century, when many colonies of earlier Western powers sought for independence. This being said, although we address this possibility in our empirical study, we do not think there is a necessary relation between affluence and territory inflows (outflows).

Last, the above model can be extended to analyze the motivation for territories to seek independence from their current countries. Economic motivations could be found behind many independence movements in history. In that case, the territory v and some of its peers in country i choose to join a new "empty" country that did not previously exist. Independence is beyond the scope of this study, because this study focuses on existing countries on the two sides of territory flows. Newly independent countries do not have ex-ante sizes and trade costs, and therefore we exclude them from this study.

[6] A detailed discussion on the relationship between the political endorsements of a given country by its territories and the territory-level overseas economic interests can be found in Lan and Li (2015).

2.4 Scrutinize the Similarity

We should be skeptical about the similarity between gravity equations (7) and (18). Technically, assuming equations (9) and (10) for any territory-level decision related to foreign territories, one can obtain a gravity pattern in that decision. Recall the dartboard metaphor presented in the introduction. A despotic king who randomly shoots missiles abroad to expand her domain would be most likely to land territories of nearby large countries. Similarly, if territories launch outbound hot-air balloons to find their next home countries, they are most likely to join nearby large countries. International incidents, to a large extent, obey the law of large numbers and attenuate in likelihood over space. Such stochastic gravity patterns have little to do with the gravity of goods, which stem from an Armington-CES system. The crux is thus whether the two specific gravity-patterned flows here, goods and territories, interact with each other as characterized by the above model. Below, we introduce three other hypotheses, each of which relates to a different aspect of the model, as well as a different dimension of the data.

First, the gravitas terms in equations (7) and (18) exhibit a natural way to expose spurious similarity between the two flows. Specifically, we insert bilateral goods flow X_{ij} into equation (18) and control for N_i, N_j, and t_{ij} at the same time. The goods flow X_{ij} should retain some explanatory power in the territory gravity regression, driven by the gravitas terms that appear in both equations.[7] This is our second testable hypothesis:

Hypothesis 2 *Conditional on N_i, N_j and t_{ij}, bilateral territory flows and bilateral goods flows remain positively associated with each other.*

Reverting to the dartboard metaphor, with N_i, N_j and t_{ij} controlled for, territory flows that follow the metaphoric dart would have no reason to be correlated with goods flows. This is a placebo check on the relevance of goods-trading to the gravity of territories.

Testing Hypothesis 2 is still inadequate for our purpose, because there may be factors other than the gravitas terms that are omitted from both gravity equations. Lacking a natural experiment setup, we resort to the time dimension of the data. For a country j that takes a territory away from a foreign country i, the goods supplied by the gained territory are no longer counted as imports but rather as domestic trade within country j. This being said, a subsequent decrease in the bilateral goods flows is expected. Although territory-level exports or imports are unobservable in the data, the territory-losing side should export less to the territory-gaining side. To summarize,

Hypothesis 3 *Within a country pair known to have a territory flow, the bilateral goods flow decreases after the territory flow.*

Lastly, standard gravity equations for goods, including equation (7) and its counterparts in the international trade literature, predict positive goods flows within all country pairs, even though

[7] By equations (7) and (18), $Z_{ij}/X_{ij} = \frac{q_i+h_j}{2q_iq_j} > 0$. So, in either log or level terms, Z_{ij} and X_{ij} are positively associated, even with N_i, N_j, and t_{ij} held the same.

zero goods flows are prevalent in bilateral trade data. The trade literature interprets the zeros as a result of low potential trade volumes. That is, foreign destinations incur a fixed cost to serve, such that the potential sales have to be higher than a threshold level to make them worth serving.[8] Our framework does not preclude zero goods flows, despite not having fixed costs. Minimal goods flows could be recorded as zeros because of mishandling of minor amounts traded, transactions lower than minimum recording units, low-value cargo transshipped through a third country, and so on. Such zero recordings are less likely if the two countries have more potential trade with each other. Equations (7) and (18) show that territory flows are more likely to occur between countries that have greater potential goods flows, then we expect that, conditional on seeing a bilateral territory flow within a pair, observing a zero goods flow between them is less likely.

Since goods flows rarely revert back to zeros once turning positive, repeated zeros within a pair should not be treated as independent draws. In other words, the likelihood of observing zero goods flows is not an unconditional probability but a hazard (i.e. the probability of becoming positive conditional on being currently zero). So, the above reasoning is phrased as

Hypothesis 4 *Zero goods flow within a country pair ends sooner if the country pair is known to have a territory flow.*

Intuitively, countries that have more economic interests in each other are more likely to have territory flows; therefore, among pairs that are known to have territory flows, their goods flows are less likely to be below the threshold level and recorded as zero. This is a simple Bayesian inference, but it makes use of the data variations hidden in the zero-goods-trading pairs that would be wasted otherwise.

It is important to note that Hypothesis 3 and Hypothesis 4 are not contradictory. Hypothesis 3 is concerned with countries that have both goods and territory flows, and contends that their goods flows will decline after the territory flows. Hypothesis 4 is concerned with the country pairs that do not (yet) have goods flows. Some of these pairs have territory flows while others do not, and Hypothesis 4 contends that those having territory flows will start having goods flows sooner. The two hypotheses target different samples and data dimensions. It is true that the effects behind Hypothesis 3 tend to mute the pattern predicted by Hypothesis 4, which will be discussed when their test results are reported. We now move on to our empirical study.

[8] See Chaney (2008) and Helpman, Melitz, and Rubinstein (2008) for discussions on the role of fixed costs in bilateral trade flows. The latter, in particular, addresses the zero goods flows in the data caused by potentially low goods flows that do not make the threshold level.

3 Empirical Evidence

3.1 Data

Sources Our major data source is the Correlates of War (COW) Project, which is a database established for international relations studies.[9] Datasets in the COW database are contributed by different researchers. Two datasets in the database constitute our working sample: the territorial change dataset compiled by Jaroslav, Schafer, Diehl, and Goertz (1998), hereafter referred to as the JSDG dataset, and the bilateral trade dataset compiled by Barbieri, Keshk, and Pollins (2009).[10] Both datasets are updated from time to time using a consistent format mandated by the COW Project. The JSDG dataset covers the years 1816-2008, while the bilateral trade dataset covers the years 1870-2009. We use their overlapping years 1870-2008 as the time span of our working sample.[11]

We match the above country pair-year level data with country-year level geographic and socioeconomic data from two sources. One is the CEPII gravity database, compiled by Head, Mayer, and Ries (2010). The CEPII database is widely used in the empirical trade literature. It provides us with geographic coordinates of countries and whether they share the same language, legal origin, and borders.[12] The other is the national material capabilities dataset (version 4) compiled by Singer (1987), which is also part of the COW Project. It has been timely updated since 1987, providing us with data on population and industrialization level, including iron-and-steel production and primary energy consumption.

We use population to proxy for country sizes, which is in line with our model setup in Section 2 (i.e. $L_j = \delta N_j$). The rationale behind this proxy choice is as follows. Measured simply by head counts, population is unaffected by researchers' judgments, such as the method choices involved in GDP calculation.[13] In fact, to our knowledge, there exists no consistently calculated GDP data that span long enough to fit our territory data. Also, as noted earlier, fast economic growth might be accompanied by hegemonic expansion. Therefore, using GDP to measure country sizes would risk forging a mechanical correlation between territory flows and country sizes.

[9] The website for the COW Project is http://www.correlatesofwar.org.

[10] The majority of the post-WWII data in Barbieri et al. (2009) are from the International Monetary Fund's *Direction of Trade Statistics*. See their paper for detailed sources.

[11] The non-overlapping years 1816-1869 do not have goods-flow data. Also, it is difficult to find corresponding country-level geographic and socioeconomic data for that period.

[12] Our measure of bilateral distance is not directly from the CEPII data. We use the geographic coordinates of countries (based on the locations of their capital cities) reported in the CEPII data to calculate bilateral distance with the WGS 1984 reference ellipsoid. For the period 1870-1948, we found those geographic coordinates in historical maps (Barraclough, 1994; McNally, 1992, 2015; Overy, 2010).

[13] Land area is also a real measure, though a larger land area does not have a direct relevance to our model. A territory in our model refers to an economic unit rather than a unit of land. Moreover, all else held equal, countries with larger land areas are more difficult to defend militarily, making land areas mechanically correlated with territory flows and thus unattractive as a country-size measure in this study.

Structure There are in total 203 countries in our dataset, but not all of them coexisted. There are 37,455 co-existing pairs, smaller than $203 \times 203 = 41,209$. Among the 37,455 country pairs (denoted by IJ), 17,403 pairs have goods flows (denoted by IJ^{gd}) and 243 pairs have at least one territory flow (denoted by IJ^{tr}). Correspondingly, IJ^{-tr} (IJ^{-gd}) represent the pairs that never have goods (territory) flows. Thus,

$$IJ = IJ^{tr} \cup IJ^{-tr} = IJ^{gd} \cup IJ^{-gd}. \tag{19}$$

All pairs in the above sets have corresponding years. When the year dimension is incorporated, we add a letter T to their notations. For example, IJT represents all coexisting country pairs and their coexisting years. In addition, we define $IJ^{tr}T^{+}$ as the year(s) when the pairs in IJ^{tr} have ongoing territory flows. Since the pairs in IJ^{tr} have territory flows only during a few (mostly, one) years, we denote the rest of the years (i.e. the "idle" years) by $IJ^{tr}T^{-}$. Combining the two types of years, we have $IJ^{tr}T = IJ^{tr}T^{+} \cup IJ^{tr}T^{-}$. Correspondingly, for goods flows, we have $IJ^{gd}T = IJ^{gd}T^{+} \cup IJ^{gd}T^{-}$. For completeness, we also define $IJ^{-tr}T$ and $IJ^{-gd}T$ for the aforementioned pairs that never have territory and goods flows, where the T represents simply the pairs' coexisting years. To summarize,

$$IJT = \underbrace{IJ^{tr}T^{+} \cup IJ^{tr}T^{-}}_{IJ^{tr}T} \cup IJ^{-tr}T = \underbrace{IJ^{gd}T^{+} \cup IJ^{gd}T^{-}}_{IJ^{gd}T} \cup IJ^{-gd}T. \tag{20}$$

Table 1 reports the summary statistics associated with IJT, $IJ^{tr}T$, $IJ^{gd}T$, respectively. Note that the 243 pairs in IJ^{tr} (corresponding to 329 territory flows in the 139 years) are a reasonable sample size, because bilateral territory flows do not necessarily happen. As explained in Section 3.3, territories may choose "domestic deals" with peer territories in their countries, thereby generating no territory flows between countries. **Figure 1** demonstrates the frequency of territory flows over years. The country pairs are listed in **Table A1**, each labeled with a JSDG ID number that can be linked with the original JSDG dataset (publicly available).[14]

Three notes on the territory flows should be made at this point. First, we have little information on the "flowed" territories. Each JSDG ID number refers to a *territory incident* where a country loses a territory to another country, but the exact name of the lost territory is usually unavailable. Flowed territories often do not have names.[15] For example, the United States and the United Kingdom redrew part of Alaska's borders in 1903 (JSDG ID: 399). If one finds the Hay-Herbert Treaty that stipulated this border change, the map in the treaty shows the flowed territory, in the form of an overlay between old and new borders. The flowed territory, despite being part of the contemporary state of Alaska, did not have a specific name. Such maps are not in the JSDG data and are rarely available in practice. As a result, studying the flowed territories themselves

[14]The original dataset is located at http://www.correlatesofwar.org/data-sets/territorial-change.

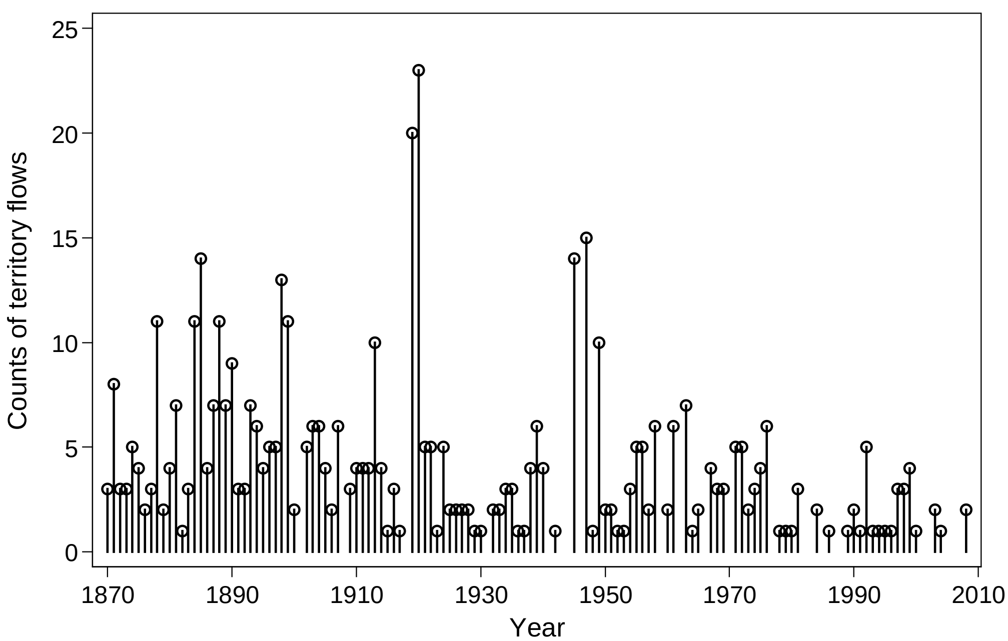
[15]As for those having names, their historical names are often different from their current boundaries. For example, "Canada" refers to different territories over time.

Table 1: Summary Statistics

▼Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sample ▶	Full (IJT)		With territory flows ($IJ^{tr}T$)		With goods flows ($IJ^{gd}T$)	
Population, country i	29463.8	103886.6	64126.47	127689.5	52586.84	151624.9
Population, country j	As above§		As above§		As above§	
Distance	7681.209	4442.782	3151.505	3816.549	6475.963	4359.925
Iron & steel prod., country i¶	4061.757	17302.52	7046.982	19976.19	8811.117	25679.96
Iron & steel prod., country j¶	As above§		As above§		As above§	
Primary energy consum., country i#	87822.53	352846.3	134357	406956.9	187321.8	533592.6
Primary energy consum., country j#	As above§		As above§		As above§	
Shared border dummy	0.02	0.15	0.45	0.50	0.04	0.20
Shared language dummy	0.16	0.37	0.30	0.46	0.18	0.39
Shared legal origin dummy	0.35	0.48	0.53	0.50	0.35	0.48
Trade flow	308.5347	8690.964	187.9228	1462.433	825.516	14201.03
Number of pairs	37,455		243		17,403	

Notes: The covered period is 1870-2008. The sample sizes are 1,541,968 (full), 329 (ever had territory flows), and 576,307 (ever had goods flows), respectively. The mean and standard deviations are based on non-missing values. §The full sample is based on a symmetric country-to-country matrix; therefore, means and standard deviations of either country applies to the other. ¶ The unit is thousands of tons. # The unit is thousands of coal-ton equivalents.

Figure 1: Territory Flows since 1870



is impossible, not to mention their economies. However, remember that our research interest is in the countries on the two sides of the territory flows, rather than the territories themselves. Thus, knowing the country pairs where territory flows occur, as reported by the JSDG dataset, is sufficient for our needs.

Second, without knowing the exact flowed territories, we do not know whether they supplied goods, what goods they supplied, and with whom they traded. It is possible that the territory v that joins territory v' has little economic interests in territory v' and vice versa. It is even possible that territory v does not produce goods at all. In both cases, $m_{vv'}^{out}$ and $m_{vv'}^{in}$ are minimal, so that the economic consideration alone is not favorable to the territory flow. The territory flow may happen only owing to some crucial non-economic consideration, represented by a large $\mu_{vv'}$ value. Such possibilities have been taken into account here, as the additive economic consideration and non-economic consideration in equations (10) and (13) allow any combination of the two values.

Third, within a given pair, multiple territory flows are possible. For example, in the earlier example of the United Kingdom and the United States, there was another flow in 1872 (JSDG ID: 212). We will use both indicators (i.e. positive or not) and counts of territory flows in our later econometric analysis. The results turn out to be, as expected, hardly different because as shown in Table A1, most pairs have only one territory flow.

Alignment in Merging Following Section 2, we align the flows of goods and territories in the same direction: from country i to country j. Notice that country i (j) refers to a goods exporter (importer) in a given observation rather than a specific country. In other words, since goods exporters normally import goods as well, a country pair has two observations in goods flows, involving two exporters and two importers. That is, a given country plays exporter i in one observation and importer j in the other observation. This is the standard practice in the gravity literature.

Unlike goods flows, territory flows usually have only one direction. For example, the United Kingdom lost territories to the United States in 1872 and 1903, but the United states never lost any territory to the United Kingdom during our sample period. As a result, in terms of territory flows, the United Kingdom played the role of country i but never played the role of country j. When the goods and territory flows are merged, we keep their directions identical in that the goods flows from the United Kingdom to the United States have corresponding territory flows, whereas the goods flows from the United States to the United Kingdom have no corresponding territory flows. This practice — merging outbound goods with outbound territories — is consistent with our model setup in Section 2. Notice that, empirically speaking, there might be a connection between outbound goods and inbound territories that matters separately from the connection between outbound goods and outbound territories. To empirically address this issue, we will also conduct the reversed alignment and rerun our results as a comparison.

Hypotheses Revisited Our gravity of territories hinges on bilateral economic interests. Having bilateral goods flows (i.e. goods-trading) is sufficient but not necessary for having bilateral economic interests. It is not necessary because bilateral trade in goods might be isolated from each other by the lack of infrastructure (such as sea routes) or institutions (such as diplomatic relations) that "physically" connect them. For example, two economies isolated from each other by the lack of a direct sea route may still have economic interests in each other. This concern is particularly relevant to the time period we study.

To make the most of the above data, we organize our empirical study in the following way. Hypotheses 1 and 2, taking the form of cross-sectional (cross-pair) gravity regressions, will be tested using the pairs that have positive goods flows, namely IJ^{gd}. This ensures that the country pairs assumed to have positive probabilities of having territory flows are those with documented economic interests in each other in the form of goods-trading. Including the pairs without goods flows would risk forcing countries isolated physically by underdeveloped infrastructure/institutions to pair. The practice of excluding zero goods flows in historical bilateral data is also consistent with the literature, and meanwhile accounts for our data needs that goods flows will be included in the gravity regression for territories to test Hypothesis 2.[16]

The time variations in the pairs that have zero goods flows, namely $IJ^{-gd}T \cup IJ^{+gd}T^{-}$, are not wasted. We use them to test Hypothesis 4, which contends that the zero goods flow should end sooner if the two countries are known to have had a territory flow. This is because countries that have greater *potential* goods flows are also more likely to have territory flows. As a result, conditional on observing territory flows between some pairs, their likelihood of having potentially larger (positive) goods flows would be greater than otherwise. By comparing the duration of zero goods flows between the pairs with territory flows and the pairs without, we can test Hypothesis 4 without worrying about whether underdeveloped infrastructure/institutions caused some of the zero goods flows.[17]

The test of Hypothesis 3 involves the country pairs that have both goods and territory flows. Remember that goods flows are usually continual over years, while territory flows are sparse over years. Hypothesis 3 compares the within-pair goods flows across the idle years after a territory flow. When there are multiple territory flows within a pair, the years after the last territory flow are defined as *after*, and the years before the first territory flow as *before*.

Table 2 links the previous hypotheses with their corresponding dependent variables and variations. For convenience, its last column references the tables and figures that later report corresponding results.

[16] Head et al. (2010), who also use historical bilateral trade data, discuss the rationale behind excluding zero trade flows in detail in their Section 3.3.

[17] Underdeveloped infrastructure/institutions and a lack of potential economic interests have a two-way causality. However, both of them contribute to a longer duration of zeros. In other words, conditional on observing a shorter duration of zeros, the potential economic interests within a pair (regardless of whether infrastructure/institutions between them are weak) are expected to be greater.

Table 2: **Hypotheses, Dependent Variables, Data, and Results**

Hypo.	Dep. Variable	Variations in use	Tables & Figures
1 & 2	$\mathrm{Z_{ij}}$	$\mathrm{IJ^{tr}}$ vs. $\mathrm{IJ^{-tr}}$	Tables 3-5
3	$\mathrm{X_{ij}}$	Across the T^- of each pair in $\mathrm{IJ^{tr}T^-}$	Figure 2
4	Zero goods flows*	$\mathrm{IJ^{tr}}$ vs. $\mathrm{IJ^{-tr}}$	Tables 6-7, Figure 3

* They include both $\mathrm{IJ^{-gd}T}$ and $\mathrm{IJ^{gd}T^-}$ and are used in the form of duration analysis ($\mathrm{IJ^{-gd}T}$ is treated as right-censoring). See Section 3.3 for details.

3.2 Gravity Patterns

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

$$Z_{ij} = \exp[\alpha \ln L_i + \beta \ln L_j + \gamma \ln Distance_{ij} + \bar{\eta}' C_{ij}] \cdot \epsilon_{ij}, \tag{21}$$

where Z_{ij} is the territory flow (count) from country i to country j, and C_{ij} is a vector of control variables, including the indicators of sharing borders, languages, and legal origins between two countries, and country-specific control variables. ϵ_{ij} is the error term. As explained in detail in Section 3.1, we use population to proxy for country sizes. Their values averaged across years are used here. The Poisson pseudo-maximum-likelihood (PPML) estimation is used to estimate the regression, which is known for its econometric consistency and robustness to heteroskedasticity. The PPML estimation is extensively used to estimate the gravity regressions for goods (including ours; see Table A2 below).[18] This count-data estimation technique fits our study well, as the multiple territory flows within pairs are recorded as counts.

According to Hypothesis 1, the expected signs of the estimated coefficients are $\hat{\alpha} > 0$, $\hat{\beta} > 0$, and $\hat{\gamma} < 0$. The estimation results are reported in columns (1)-(4) of **Table 3**, which display a clear gravity pattern. When control variables C_{ij} are included, sample size shrinks by approximately 7 percent (from 17,120 to 15,945) due to the unavailability of the control-variable data. The estimated coefficients of control variables are also in line with our expectation.

We also experiment with a more conservative use of the territory-flow variations. In columns (5)-(8) of Table 3, the dependent variable is an indicator variable that represents whether there is any bilateral territory flow between the two countries: $\mathbb{I}(Z_{ij} > 0)$, which equals 1 if and only if there is at least one territory flow from country i to country j. Using only the difference between $Z_{ij} > 0$ and $Z_{ij} = 0$, this specification is less driven by countries that frequently change their

[18] See Cameron and Trivedi (2013) for a discussion on the PPML estimator, and Silva and Tenreyro (2006) for its application to the gravity-equation estimation.

territories.[19] Now, the exponential function in regression (21) is removed. The results are also in line with Hypothesis 1, and show expected signs of control-variable coefficients.

Table 3: Gravity of Territories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:†	Territory flow				Territory-flow indicator			
ln(Population, country i)	0.665***	0.625***	0.356***	0.336***	0.594***	0.581***	0.263***	0.200**
	(0.0521)	(0.0525)	(0.0702)	(0.0932)	(0.0525)	(0.0559)	(0.0703)	(0.0911)
ln(Population, country j)	0.662***	0.597***	0.470***	0.445***	0.596***	0.545***	0.425***	0.394***
	(0.0517)	(0.0558)	(0.0753)	(0.0955)	(0.0583)	(0.0628)	(0.0817)	(0.101)
ln(Distance)	-1.165***	-0.853***	-0.820***	-0.860***	-1.304***	-0.791***	-0.691***	-0.740***
	(0.0753)	(0.140)	(0.152)	(0.146)	(0.0926)	(0.144)	(0.135)	(0.139)
▼ Time-invariant pair-level control variables								
Sharing border dummy		1.058***	1.029**	1.052***		1.645***	1.772***	1.746***
		(0.387)	(0.400)	(0.394)		(0.339)	(0.353)	(0.347)
Sharing language dummy		0.521**	0.887***	0.797***		0.798***	1.197***	1.094***
		(0.243)	(0.234)	(0.243)		(0.247)	(0.253)	(0.249)
Sharing legal origin dummy		0.0249	0.0944	0.0637		0.0791	0.103	0.118
		(0.244)	(0.245)	(0.242)		(0.245)	(0.262)	(0.246)
▼ Control variables related to industrialization								
ln(Iron & steel prod., country i)			0.229***				0.234***	
			(0.0374)				(0.0400)	
ln(Iron & steel prod., country j)			0.120***				0.0997***	
			(0.0398)				(0.0353)	
ln(Primary Energy consum., country i)				0.343***				0.402***
				(0.0804)				(0.0871)
ln(Primary Energy consum., country j)				0.202***				0.181**
				(0.0777)				(0.0733)
Observations	17,120	15,945	15,945	15,945	17,120	15,945	15,945	15,945

Territory flows are from country i to country j. † Poisson pseudo-maximum-likelihood (PPML) estimation is used when the dependent variable is territory flow. Logit estimation is used when the dependent variable is territory-flow indicator. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

In addition, we average the sample using different subsamples to see if the findings differ. We divide the original 139 years into three subperiods, 1870-1909, 1910-1949, and 1950-2008 and recreate an averaged cross-sectional subsample for each of the three subperiods. Each subperiod is about 40 years in length, and the last subperiod is longer (56 years) as territorial changes were infrequent after the 1990s. The results from subperiods are reported in **Table 4**, which highly resemble those in Table 3.[20] Such subperiod robustness has another implication: the gravity equation of territories holds for different global political landscapes and climates. The first subperiod was generally peaceful, during which there were only a few conflicts in the Western world. The second subperiod featured two world wars as well as periods of pre-war tensions and post-war territorial redistributions. The third subperiod encompassed both the cold-war decades and the subsequent two decades of globalization.

[19]This specification has a slightly different micro-foundation:

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

which also implies the gravity pattern (i.e. $\hat{\alpha} > 0$, $\hat{\beta} > 0$ and $\hat{\gamma} < 0$).

[20]The infrequent territorial changes in the third subperiod may explain the statistical insignificance of the coefficient of distance in Panel C.

Table 4: Gravity of Territories, by Period

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:†	Territory flow			Territory-flow indicator		
Panel A: 1870-1909						
ln(Population, country i)	0.563***	0.685***	0.643***	0.464***	0.633***	0.624***
	(0.134)	(0.143)	(0.153)	(0.148)	(0.157)	(0.210)
ln(Population, country j)	0.696***	0.792***	0.567***	0.674***	0.831***	0.585***
	(0.119)	(0.129)	(0.157)	(0.145)	(0.171)	(0.210)
ln(Distance)	-0.718***	-0.819***	-0.687***	-0.758***	-0.901***	-0.802***
	(0.204)	(0.261)	(0.235)	(0.203)	(0.256)	(0.256)
Observations	608	560	560	608	560	560
Panel B: 1910-1949						
ln(Population, country i)	0.588***	0.575***	0.498***	0.614***	0.615***	0.402***
	(0.0885)	(0.0993)	(0.172)	(0.0900)	(0.0949)	(0.142)
ln(Population, country j)	0.515***	0.473***	0.398**	0.452***	0.421***	0.340*
	(0.107)	(0.123)	(0.198)	(0.115)	(0.123)	(0.176)
ln(Distance)	-1.264***	-1.052***	-0.951***	-1.377***	-1.039***	-0.887***
	(0.135)	(0.192)	(0.214)	(0.184)	(0.229)	(0.237)
Observations	2,674	2,444	2,444	2,674	2,444	2,444
Panel C: 1950-2008						
ln(Population, country i)	0.615***	0.541***	0.266***	0.521***	0.475***	0.208**
	(0.0957)	(0.0808)	(0.0934)	(0.0885)	(0.0877)	(0.101)
ln(Population, country j)	0.628***	0.513***	0.714***	0.589***	0.494***	0.682***
	(0.0878)	(0.0791)	(0.128)	(0.0935)	(0.0913)	(0.124)
ln(Distance)	-1.084***	-0.363	-0.385	-1.112***	-0.258	-0.267
	(0.107)	(0.227)	(0.250)	(0.109)	(0.172)	(0.181)
Observations	17,096	15,945	15,945	17,096	15,945	15,945
(For all panels)						
Pair-level controls§	No	Yes	Yes	No	Yes	Yes
Industrialization controls△	No	No	Yes	No	No	Yes

Territory flows are from country i to country j. † Poisson pseudo-maximum-likelihood (PPML) estimation is used when the dependent variable is territory flow. Logit estimation is used when the dependent variable is territory-flow indicator. § They include dummy variables for sharing borders, languages, and legal origins, respectively. △ Iron and steel production of both sides are used. Using primary energey leads to similar results. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

We also estimate the gravity equation for goods. The results are reported in **Table A2**, where the specifications follow Tables 3-4 in general. They display a pattern conforming to the gravity pattern in equation (7). Notice that the purpose of estimating the gravity equation for goods is not to test the gravity equation itself, which has been tested extensively in the literature.[21] Also, the gravitas term is not controlled for in Table A2. Here, the gravity of goods is auxiliary in providing

[21] See Anderson (2011) and Head and Mayer (2014) for reviews of the empirical evidence.

a comparison with the gravity of territories. Their interaction, either through the gravitas term or not, will be the focus of the next subsection.

3.3 Interplay between the Two Flows

Hypothesis 2 Results We are now ready to examine the relationship between territory and goods flows. Hypothesis 2 contends that, conditional on sizes and bilateral trade costs, bilateral goods flows should still have explanatory power in the gravity regression for territories. To test it, we include $\ln X_{ij}$ in the territory-gravity regression (21). The results are reported in **Table 5**, the structure of which follows Table 4. Our model in Section 2 is concerned with outbound flows (namely, from i to j) in both goods and territories. However, as explained in Section 3.1, we experiment with alignments in both directions. In Table 5, outbound territory flows are merged with outbound goods flows in Panel A, while inbound territory flows are merged with outbound goods flows in Panel B. In other words, the goods-exporters lose (respectively, gain) territories in Panel A (respectively, B).

Three observations emerge from Table 5. First, the gravity pattern still applies; namely, countries that are larger in size and closer to each other continue to have more territory flows. Second and more importantly, the volume of trade flows has a positive and statistically significant association with territory flows, lending support to Hypothesis 2. Lastly, altering the direction of alignment makes no remarkable difference. This is not surprising, as bilateral exports and imports have a tendency to break even although they do not have to be equal.

Notice that the gravitas term is implicitly controlled for by including the goods flow, as it is present in both gravity equations (7) and (18). Strictly speaking, the gravitas term in the gravity regressions in the previous Table 4 is an omitted variable. The regressions in Table 4 resemble the early generation of gravity equations, where the gravitas term was not included but a gravity pattern was extensively found.[22] In this study, the data on territory flows are sparse; therefore, it is impossible to use the fixed effects to absorb the gravitas term. The fixed effects are widely used in the gravity regressions for goods to control for the unobserved gravitas term. We do the same to test Hypothesis 3 below. Hypothesis 3 is concerned with goods flows within pairs that have territory flows. We use the *tetrad* technique in the gravity literature that can handle arbitrarily large numbers of gravitas-induced fixed effects.

Hypothesis 3 Results The test of Hypothesis 3 exploits the panel structure of the data. To guide our use of the panel data, we now add a time dimension to the gravity equation for goods (i.e. equation (7)):

$$X_{ijt} = \underbrace{N_{it} \times N_{jt} \times t_{ijt}^{1-\sigma}}_{Gravity} \times \underbrace{\frac{q_{it} h_{jt}}{q_t} \times \frac{1}{\Pi_{it}^{1-\sigma}} \times \frac{1}{P_{jt}^{1-\sigma}}}_{Gravitas}. \tag{22}$$

[22] See Anderson (2011) and Head and Mayer (2014) for reviews of those studies.

Table 5: Inserting Goods into the Gravity Equation for Territories (Hypo. 2)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:†	Territory flow			Territory-flow indicator		
Panel A: Dependent variable: territory-flow indicator (from country i to country j)¶						
ln(Population, country i)	0.441***	0.419***	0.346***	0.347***	0.323***	0.215***
	(0.0772)	(0.0730)	(0.0856)	(0.0609)	(0.0606)	(0.0745)
ln(Population, country j)	0.447***	0.405***	0.447***	0.367***	0.307***	0.380***
	(0.0764)	(0.0710)	(0.0865)	(0.0772)	(0.0763)	(0.0873)
ln(Distance)	-0.898***	-0.619***	-0.628***	-0.948***	-0.458***	-0.474***
	(0.114)	(0.157)	(0.158)	(0.102)	(0.138)	(0.140)
ln(Goods flows)	*0.378****	*0.400****	*0.363****	*0.399****	*0.427****	*0.383****
	(0.0572)	*(0.0557)*	*(0.0743)*	*(0.0505)*	*(0.0517)*	*(0.0709)*
Panel B: Dependent variable: territory-flow indicator (from country j to country i)¶						
ln(Population, country i)	0.451***	0.409***	0.510***	0.348***	0.293***	0.437***
	(0.0834)	(0.0775)	(0.0912)	(0.0740)	(0.0727)	(0.0863)
ln(Population, country j)	0.436***	0.425***	0.307***	0.375***	0.362***	0.190**
	(0.0740)	(0.0687)	(0.0843)	(0.0680)	(0.0666)	(0.0781)
ln(Distance)	-0.920***	-0.667***	-0.680***	-0.959***	-0.505***	-0.527***
	(0.116)	(0.153)	(0.152)	(0.103)	(0.133)	(0.134)
ln(Goods flows)	*0.385****	*0.396****	*0.378****	*0.414****	*0.431****	*0.405****
	(0.0586)	*(0.0577)*	*(0.0741)*	*(0.0497)*	*(0.0507)*	*(0.0660)*
For both panels:						
Observatitons	17,120	15,945	15,945	17,120	15,945	15,945
Pair-level controls§	No	Yes	Yes	No	Yes	Yes
Industrialization controls△	No	No	Yes	No	No	Yes

† Poisson pseudo-maximum-likelihood (PPML) estimation is used when the dependent variable is territory flow. Logit estimation is used when the dependent variable is territory-flow indicator. ¶ As explained in Section 3.1, goods flows in this paper are consistently defined as the value of goods flows from country i to country j. Within a given i-j pair, the territory flow has two possible directions. Panel A (B) is concerned with the territory flows from i to j (from j to i); that is, exporters lose (gain) territories in Panel A (B). § They include dummy variables for sharing borders, languages, and legal origins, respectively. △ Iron and steel production of both sides are used. Using primary energey leads to similar results. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Apparently, the gravitas term involves numerous *it*- and *jt*-specific effects and therefore it is impossible to use dummy variables to absorb all of them. We use the *tetrad* technique developed by Head, Mayer, and Ries (2010). Their technique can be applied to any gravity equation (for goods) that has a gravitas term, as it double-deflates the trade volume into a ratio to generate a gravitas-free dependent variable:

$$r_{ijt|k,l,t} \equiv \frac{X_{ijt}/X_{ikt}}{X_{ljt}/X_{lkt}}, \tag{23}$$

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

$$r_{ijt|k,l,t} = \left(\frac{t_{ijt}/t_{ikt}}{t_{ljt}/t_{lkt}}\right)^{1-\sigma}. \tag{24}$$

Now, by using $r_{ijt|k,l,t}$ instead of X_{ijt} as the dependent variable, the gravitas term is no longer a concern. Also removed are (1) all country-specific characteristics, whether time-varying (such as N_{it} and N_{jt}) or not, and (2) all time-invariant pair-specific characteristics such as the indicators of language, border, and legal-origin sharing.

The variations that remain in $r_{ijt|k,l,t}$ are the bilateral relative share in trade volumes, namely the share of country j in country i's total exports and the share of country i in country j's total imports. Recall equation (14) that represents the market share of any origin $v \in N_i$ within a given destination $v' \in N_j$. From the perspective of destination v', country i now has a smaller (supply) share in the market. This applies equally to every destination territory in country j, thereby penalizing the goods flows from country i to country j. Meanwhile, from the perspective of origin v, country j now has a smaller (demand) share in the market. This applies equally to every remaining origin territory in country i, also penalizing the goods flows from country i to country j.[23]

Notice that there are other contemporary changes on both the export side and the import side, such that the reference countries are introduced to deflate the volume. Take the reference exporter l. Unlike exporter i, exporter l does not lose a territory to importer j. So the change to exporter i does not apply to exporter l. By taking the ratio, the forces that affect all countries that export to country j cancel out each other. Similarly, the forces that affect all countries that import from country i also cancel out each other through the ratio. In particular, notice that country i (country j) becomes smaller (larger) in size as a result of the territory flow, an effect that is absorbed by the double-deflation and thus does not affect $r_{ijt|k,l,t}$.

We use the rest of the world as reference countries l and k. Following Head et al. (2010), we construct a dummy variable $DUMa_{ijt}$ that represents the a-th year, $a = 1, ..., 120$, after countries i and j have a territory flow.[24] As noted in Table 2, the variations used here stem from comparing $r_{ijt|k,l,t}$ across the years of each pair in IJ^{tr} after the territory flow. Put differently, the variations are from the within-pair T^- part of the sample $IJ^{tr}T^-$.

A related question is whether the territory-gaining country should have an increase in bilateral

[23]The origin-side market share can be written in the form of equation (8), but notice that equation (8) itself was introduced to model the behavior of territory $v \in N_i$'s out-politician.

[24]As noted in Section 3.1, when there are multiple territory flows within a pair, the years after the last territory flow are defined as *after*, and the years before the first territory flow as *before*.

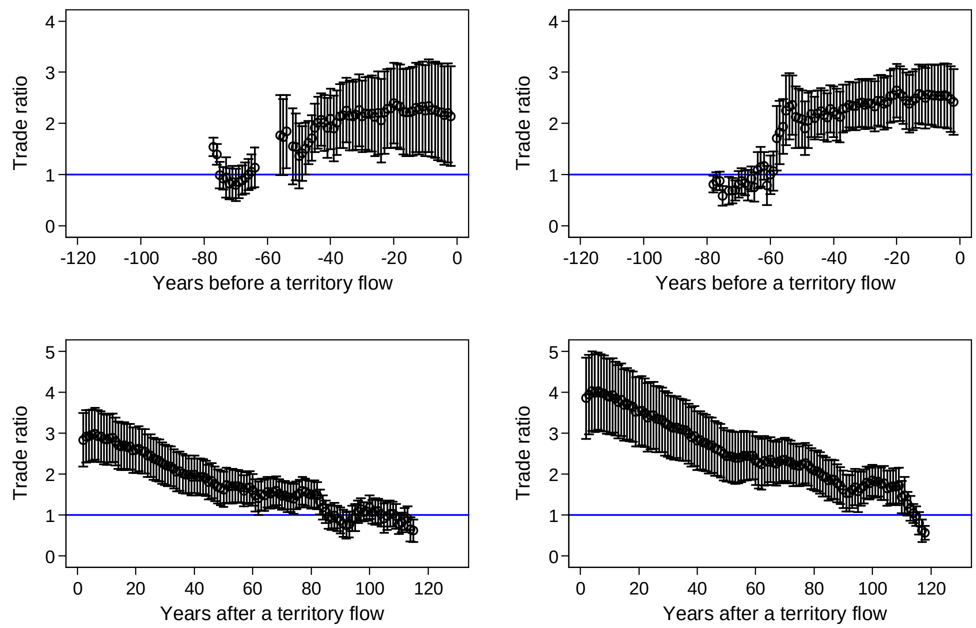
imports from the territory-losing country before the territory flow occurs. Our model in Section 2 does not predict such an increase but does not preclude it. Conceivably, an increase in the goods flow driven by reasons outside of our model may incentivize the territory flow through market shares (see equations (8) and (14)). Exploring this possibility is easy given the above estimation setting that we have designed for the years after the territory flow. The only additional work is to construct a dummy variable $DUMb_{ijt}$ that represents the b-th year, $b = 1, ..., 120$, before the territory flow. Notice that, strictly speaking, this is not a hypothesis derived from our model.

We report the estimated coefficients of $DUMb_{ijt}$ and $DUMa_{ijt}$ in the first (second) row of **Figure 2**. Recall that country i (j) refers to a goods exporter (goods importer). As discussed in Section 3.1, territory flows can be merged with the goods flows from country i to country j using two opposite alignments. Within each row, the territorial trade in the left (right) column corresponds to territory flows from i to j (from j to i). The two columns and two rows contain four panels in total, which cover all possible combinations between the pairs that have both flows over time. In each panel of the figure is the locus of a bar against the year indicators. The midpoint of the bar represents the mean of $\widehat{DUMb}_{ijt}$ or $\widehat{DUMa}_{ijt}$, and the two ends of the bar represent the 5th and 95th percentiles. We limit the reported estimates to those significant at least at the 95% level; that is, blank areas in the plots correspond to year-indicator estimates that are not significantly different from zero. We mark the trade ratio $r = 1$ as the baseline in every panel.

Figure 2 demonstrates three patterns. First and foremost, trade flows decline after having a territory flow, which is in line with Hypothesis 3. Notice that involuntary territory flows may cause the diplomatic relation between two countries to deteriorate, which affects bilateral commerce negatively. However, such possibilities cannot explain the beforehand rise in goods flows. Second, the subsequent decline is larger in magnitude than the antecedent rise. Apart from the different magnitudes, the rise-then-decline pattern does not differ between the two directions of goods flows. Last, the effect of having a territory flow on goods flows is transitory. By looking either sixty years earlier or ninety years later, one would find no noticeable effect.

The two lower panels remind us of the findings by Head et al. (2010). They find that the trade between an ex-colony and its metropole declined after the colony became a sovereign country. Unlike their study, our study investigates the country pairs where territory flows occur, with independence cases excluded on purpose. The two sides in every pair here retain their sovereignty all the time, while territories flow from one side to the other. The similarity between the two studies is that both find a decline in goods flows after the territory incidents. The difference between the two studies is in the mechanism. In their case, the declining trade between the ex-colonies and their metropoles is due to the depreciation of trade-promoting capital and business networks. In our case, the declining trade between the territory gainers and losers is owing to the reoptimization of market shares in both countries.

Figure 2: Trade in Goods before and after Having a Territory Flow



Notes: The first (second) row is for years before (after) having a territory flow. The left (right) column is based on merging outbound (inbound) territory flows with outbound goods flows; that is, exporters lose (gain) territories in the left (right) column. Trade ratio is as defined in the text. Only coefficients that are statistically significant at the 95% level or above are plotted. The midpoint (endpoints) of every bar refers to the mean (5^{th} and 95^{th} percentiles) of the corresponding coefficients.

Hypothesis 4 Results Up to this point, we have not made use of the zero goods flows between countries. Given a panel dataset at the country pair-year level, not all zero goods flows within a country pair last over time. To explore the distribution of zero goods flows across country pairs, we first count the number of zero goods flows within each pair. Likewise, we also count the number of zero territory flows within each pair. **Table 6** demonstrates the correlation between the two types of zero flows, as explained below.

Panel A in Table 6 uses the universe of pair-year combinations. The dependent variable is an indicator of zero goods flow (which equals 1 if the goods flow within a pair in a year is zero). The regressors include the gravity-related variables used earlier, and an indicator of territory flow that equals 1 if the territory flow within a pair in a year is zero. Conceivably, the indicator of zero territory flow equals 1 most of the time. This is because both (i) country pairs without territory flows and (ii) the idle years of country pairs with territory flows are included in the sample. Again, as territory flows and goods flows can be merged using two opposite alignments, we report both sets of results. Goods-exporters have outbound territory flows in columns (1) and (3), and have inbound territory flows in columns (2) and (4).

Table 6: Gravity of Zeros in Goods and Territory Flows

	(1)	(2)	(3)	(4)
Direction of territory flows:¥	Outbound	Inbound	Outbound	Inbound
Panel A: Dep. Variable is the indicator of zero goods flows				
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
Observations	1,541,968	1,541,968	1,365,435	1,365,435
R-squared	0.009	0.010	0.241	0.241
Panel B: Dep. Variable is the count of zero goods flows				
Cross-sectionalized sample: all periods∆				
Count of zero territory flows	0.257***	0.257***	0.349***	0.349***
	(0.00863)	(0.00863)	(0.00944)	(0.00944)
Observations	37,455	37,455	33,307	33,307
R-squared	0.078	0.078	0.182	0.182
Cross-sectionalized sample: 1870-1909∆				
Count of zero territory flows	0.213***	0.213***	0.207***	0.207***
	(0.0149)	(0.0149)	(0.0167)	(0.0167)
Observations	2,462	2,462	1,858	1,858
R-squared	0.066	0.066	0.282	0.282
Cross-sectionalized sample: 1909-1949∆				
Count of zero territory flows	0.355***	0.355***	0.342***	0.341***
	(0.00984)	(0.00984)	(0.00985)	(0.00986)
Observations	7,002	7,002	5,782	5,782
R-squared	0.158	0.159	0.320	0.319
Cross-sectionalized sample: 1949-2008∆				
Count of zero territory flows	0.212***	0.212***	0.353***	0.353***
	(0.00629)	(0.00629)	(0.00674)	(0.00675)
Observations	37,171	37,171	33,307	33,307
R-squared	0.031	0.031	0.156	0.156

¥ An outbound territory flow means a territory flows from a goods exporter to a goods importer, while an inbound territory flow means a territory flows from a goods importer to a goods exporter. § They include dummy variables for sharing borders, languages, and legal origins, respectively. ∆ Regressors in the top panel are also used in these panels. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Two observations emerge from Panel A, which are in line with our expectation. First, the estimated coefficients of country sizes and distance are opposite of their counterpart signs in gravity regressions, because having zero goods flows is the opposite of having positive goods flows. Second and more importantly, country pair-year combinations that have zero territory flows are more likely to have zero goods flows, suggesting a lack of economic interests in each other. To use these variations more conservatively, we aggregate the numbers of zeros at the country pair-year level to the country pair level. That is, we use cross-sectional data instead of panel data to rerun the regressions in Panel A. The results are reported in Panel B, where the same "zero-goods-zero-territory" association is obtained just as in Panel A. Aggregating the numbers of zeros using different subperiods makes no difference.

Table 6 is a preparation for testing Hypothesis 4, which contends that the zero goods flows would last shorter within pairs that have territory flows than within pairs that do not have territory flows. The zero goods flows within a pair over time are not independently distributed. Both here and in the literature, the goods flow within a given pair, once it becomes positive, rarely returns to zero.[25] This being said, Hypothesis 4 is about hazard, namely the possibility of having a positive goods flow conditional on currently having a zero goods flow, rather than an unconditional probability of having a positive goods flow.

The number of zero goods flows is a measure of the duration of zeros over time. We next conduct a duration analysis (also known as survival analysis). Our following analysis treats the cases of not having positive goods flows later as right-censoring. When fitted in a duration analysis, the gravity regression now takes the form of a Cox proportional hazard regression:

$$\mathbb{h}(d|G_{ij}) = \mathbb{h}_0(d)\exp(\bar{\phi}'G_{ij}), \tag{25}$$

where $\mathbb{h}(d|G_{ij})$ is the hazard function at the point of duration time d (e.g. $d = 5$ for the 5th year of having a zero good flow), the baseline hazard $\mathbb{h}_0(d)$ characterizes how the hazard function evolves over time. G_{ij} denotes the previous gravity variables, among which time-varying ones take their first available year's values. Regression (25) stipulates that the differences in the gravity variables alter the hazard of having positive goods flows in proportions. The Cox regression is a semiparametric method that leaves the baseline hazard $\mathbb{h}_0(d)$ unspecified to allow for flexibility. It focuses on estimating the coefficients $\bar{\phi}$, namely testing the gravity pattern. The gravity pattern here refers to the fact that countries that are larger and closer to each other should have a higher hazard of having positive goods flows (i.e. a shorter duration of zero goods flows).

The Cox-regression estimates are reported in **Table 7**, where we see a clear gravity pattern in the hazard of having positive goods flows. Specifically, the first two columns use the full sample of zero counts (as described above). Within them, some have territory flows while others do not. As shown by the following four columns, there is a gravity pattern found in each subsample.

With the gravity of non-zero goods flows — in both counts and hazards — established above, we are now ready to test Hypothesis 4. We use the Kaplan-Meier estimator, which is another com-

[25] We checked the data and confirmed that the goods flows within pairs are unlikely to return to zero once they have switched from zero to positive. As discussed in Section 2.3, this suggests a fixed cost of exporting.

Table 7: Duration of Zero Goods Flows

	(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)
Sharing border dummy		-0.163**		-0.132		-0.112
		(0.0642)		(0.261)		(0.264)
Sharing language dummy		0.278***		0.181		0.179
		(0.0295)		(0.235)		(0.234)
Sharing legal origin dummy		0.0106		0.296		0.344
		(0.0217)		(0.233)		(0.235)
Observations	31,681	28,564	123	101	124	102

§ An outbound territory flow means a territory flows from a goods exporter to a goods importer, while an inbound territory flow means a territory flows from a goods importer to a goods exporter. Coefficients reported in the table are estimated using Cox proportional-hazards regressions. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

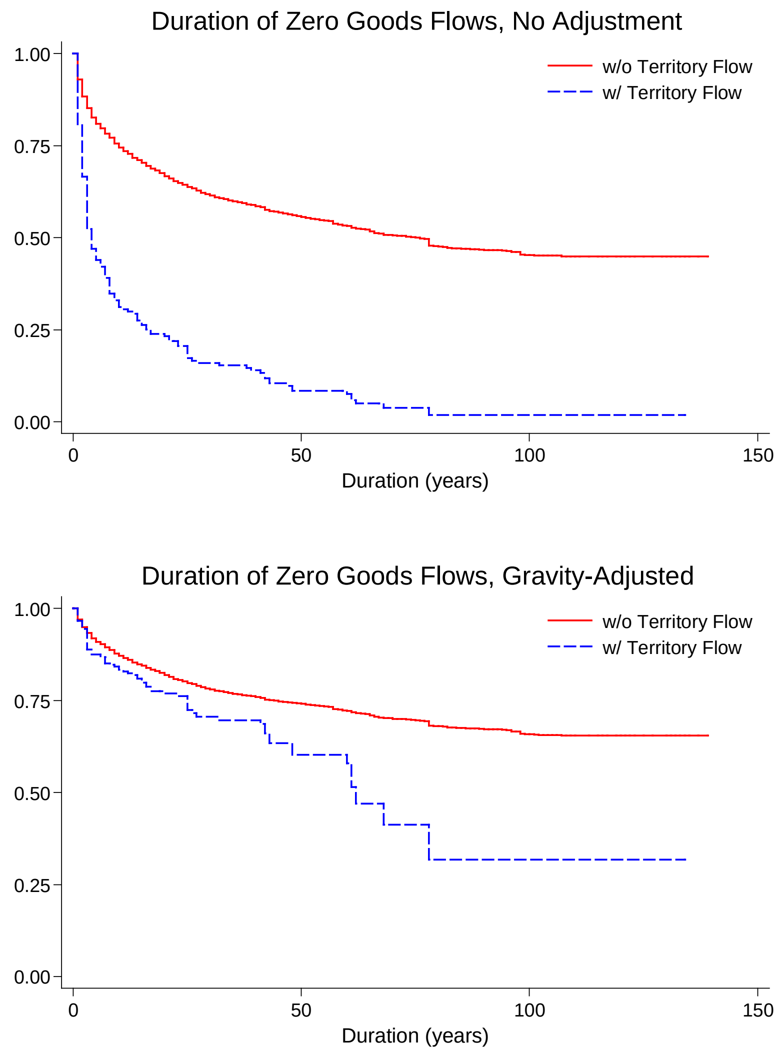
mon tool in duration analysis, to estimate the duration function $S(d) = \Pr(D > d)$, defined as the probability of retaining zero goods flows for a duration time D longer than d. The Kaplan-Meier estimator estimates $S(d)$ for every d non-parameterically. The estimates for the two subsamples — with and without territory flows — are plotted in the upper panel of **Figure 3**. They display two prominent patterns. One, zero goods flows decline over time for about 80 years, and become persistent after that. Two, the zero goods flows of pairs with territory flows decline faster, conforming to Hypothesis 4.

The upper panel has not adjusted for the gravity pattern. Since countries that are larger and closer to each other are also more likely to have territory flows, the distinct patterns between the two groups shown in the upper panel could be, at least partly, explained by the fact that the pairs of larger and closer countries are more likely to have both territory and goods flows. In other words, the duration of zero goods flows and the presence of territory flows are associated, at least partly, through the economic-geography fundamentals. The Kaplan-Meier estimates can be adjusted using the connection between the hazard function and the duration function, namely

$$\mathbb{h}(d|K_{ij}) = -\frac{S'(d)}{S(d)}. \tag{26}$$

The adjusted $S(d)$ is plotted against time in the lower panel of Figure 3. The zero-goods flows still

Figure 3: Duration of Zero Good Flows



last shorter between pairs that have territory flows than between pairs that do not have territory flows. The difference between the two groups of pairs is now smaller, suggesting the gravity forces shared by the two types of zero flows.

It should be noted that there is a subtle linkage between Hypotheses 3 and 4. Territory flows tend to reduce goods flows, as shown in Figure 2 (in support of Hypothesis 3). This tendency works against finding the different duration patterns in Figure 3. Put differently, territory flows substitute goods flows to some extent and thus tend to extend the duration of zeros goods flows. Without this potential substitution, the duration patterns of the two groups shown in Figure 3 would differ from each other even more.

4 Concluding Remarks

Altering the sovereignty status of territories is probably the most consequential aspect of international relations. We find that territory flows in the world between 1870 and 2008 are more likely to occur between countries that have larger sizes and that are closer to each other. Such a gravity pattern resembles the gravity pattern in international trade (i.e. goods flows). We find three other pieces of evidence supporting that the two flows interact through similar economic motives. This study illustrates that the gravity model in the international trade literature is more versatile than one might expect. It may lead to a unified framework of a more broadly defined international economics.

This study treats the world as a large-scale exchange economy, where territories are symmetric hoarders of endowment goods. This setting is informed by the contest for critical resources and industrial inputs during our sample period. The assumption of symmetric territories stems from our interest in territory-hosting countries and the fact that territory-level details are unavailable in our data. As the recent GIS technologies make high-resolution historical maps digitizable, the empirical investigation can be extended to incorporate asymmetric territories and their flows.

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Appendix

A1. Derivations of Equations (11) and (15)-(16)

Equation (11) Recall $v \in N_i$ and $v' \in N_j$. For the out-politician of territory v,

$$e^{\ln m_{vv'}^{out}} = \frac{\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q}}{\Pi_i^{1-\sigma}}, \tag{27}$$

which follows from equation (8). Thus,

$$\sum_{v' \in N} e^{\ln m_{vv'}^{out}} = \frac{1}{\Pi_i^{1-\sigma}} \sum_{v' \in N} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{h_j}{q} = 1, \tag{28}$$

where the second equality stems from the $\Pi_i^{1-\sigma}$ in equation (5).

Now, by equations (9) and (10), the (outbound) probability of territory v joining territory v' is

$$\text{Prob}^{out}(Z_{vv'} = 1) = \int_{s=-\infty}^{\infty} \left(\prod_{u \neq v'} e^{-e^{s + \ln m_{vv'}^{out} - \ln m_{vu}^{out}}} \right) e^{-s} e^{-e^{-s}} ds = \frac{e^{\ln m_{vv'}^{out}}}{\sum_{v' \in N} e^{\ln m_{vv'}^{out}}}. \tag{29}$$

With equations (27) and (28) inserted, equation (29) becomes

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

Equations (15)-(16) By equations (9) and (10), the (inbound) probability of territory v' in country j obtaining territory v in country i is

$$\text{Prob}^{in}(Z_{vv'} = 1) = \int_{s=-\infty}^{\infty} \left(\prod_{u \neq v} e^{-e^{s + \ln m^{in}_{vv'} - \ln m^{in}_{uv'}}} \right) e^{-s} e^{-e^{-s}} ds, \tag{30}$$

$$= \frac{e^{\ln m^{in}_{vv'}}}{\sum_{v \in N} e^{\ln m^{in}_{vv'}}} = \frac{(p_v t_{vv'})^{1-\sigma}}{\sum_{v \in N} (p_v t_{vv'})^{1-\sigma}} = p_v^{1-\sigma} \frac{t_{vv'}^{1-\sigma}}{P_i^{1-\sigma}}. \tag{31}$$

Note that in the last line, the second equality follows from the $m^{in}_{vv'}$ equation (14), and the third equality from the $P_j^{1-\sigma}$ in equation (3). With the $p_v^{1-\sigma}$ in equation (4) inserted into equation (31), we have

$$\text{Prob}^{in}(Z_{vv'} = 1) = t_{ij}^{1-\sigma} \times \frac{q_i}{q} \times \frac{1}{\Pi_i^{1-\sigma}} \times \frac{1}{P_j^{1-\sigma}}.$$

A2. Additional Tables (next page)

Table A1: List of Territory Flows (For Online Publication Only)

Country i	Country j	JSDG ID*	Country i	Country j	JSDG ID	Country i	Country j	JSDG ID
United States	Mexico	726	United Kingdom	Liberia	436	Germany	France	481,482,478,480,479
United States	Honduras	777	United Kingdom	Ghana	679	Germany	Portugal	483
United States	Nicaragua	765	United Kingdom	Cameroon	711	Germany	Poland	484,539,592
United States	Panama	812	United Kingdom	Nigeria	712	Germany	Russian Fed	597
United States	Colombia	822	United Kingdom	Somalia	707	Germany	Denmark	517
United States	Netherlands	555	United Kingdom	Seychelles	806	Germany	South Africa	494
United States	Japan	655,756,780	United Kingdom	Egypt	675	Germany	Japan	456,522
Mexico	France	560	United Kingdom	Oman	752	Germany	Australia	495,524
Nicaragua	United States	459	United Kingdom	China	559,871	Germany	New Zealand	526
Nicaragua	Honduras	688	United Kingdom	Australia	623,668,687	German Fed Rep	Netherlands	634
Panama	United States	400	United Kingdom	New Zealand	551	German Fed Rep	France	613
Panama	Costa Rica	528	Netherlands	United Kingdom	204	German Dem Rep	Germany	837
Colombia	Brazil	419	Netherlands	German Fed Rep	727	Baden	Germany	207
Venezuela	Colombia	536	Netherlands	Indonesia	734	Wuerttemburg	Germany	208
Venezuela	United Kingdom	383	Belgium and Luxembourg	United Kingdom	429	Poland	Germany	538
Ecuador	Peru	589	Belgium and Luxembourg	France	347	Poland	Czechoslovakia	506
Ecuador	Brazil	406	Belgium and Luxembourg	Portugal	284,334,553	Poland	Russian Federation	598,651
Peru	Colombia	565	Belgium and Luxembourg	German Fed Rep	669	Austria	Germany	573
Peru	Chile	262	France	Mexico	360	Austria	Poland	485
Brazil	Bolivia	403	France	United Kingdom	372	Austria	Hungary	531
Bolivia	Peru	426	France	Spain	461	Austria	Yugoslavia	492
Bolivia	Brazil	402,420	France	Germany	206,435,569	Hungary	Czechoslovakia	507,594,614
Bolivia	Paraguay	568	France	German Fed Rep	677	Hungary	Yugoslavia	510
Bolivia	Chile	265	France	Italy	488,566,570	Hungary	Romania	512
Paraguay	Brazil	200,351	France	Morocco	432	Czechoslovakia	Germany	574,577
Paraguay	Argentina	201	France	Turkey	583	Czechoslovakia	Poland	503,575
Chile	Peru	557	France	India	648,660	Czechoslovakia	Hungary	576,579
Chile	Argentina	255,395	France	Thailand	411,424	Czechoslovakia	Russian Fed	599
Argentina	Paraguay	232	Spain	Germany	388	Czech Republic	Slovakia	870
Argentina	Chile	254,394	Spain	Mauritania	804	Slovakia	Czechoslovakia	595
United Kingdom	United States	212,399	Spain	Morocco	671,682,760,807	Slovakia	Czech Republic	869
United Kingdom	Canada	628	Portugal	Belgium and Luxembourg	333,552	Italy	United Kingdom	361
United Kingdom	Venezuela	380	Portugal	Benin	709	Italy	France	612
United Kingdom	Belgium and Luxembourg	418,431	Portugal	China	878	Italy	Albania	615
United Kingdom	France	375,407,408,410	Portugal	India	717	Italy	Yugoslavia	509,546,616
United Kingdom	Portugal	223	Portugal	Indonesia	809	Italy	Greece	617
United Kingdom	Germany	329,330,387	Bavaria	Germany	209	Italy	Egypt	549
United Kingdom	Italy	337,545	Germany	United Kingdom	325,381,382,474,475	Papal States	Italy	203
United Kingdom	Greece	447	Germany	Belgium and Luxembourg	476,543,635	Albania	Italy	453,581
United Kingdom	Norway	556	Germany	Luxembourg	477,636	Yugoslavia	Austria	505

* The JSDG IDs can be matched to the original dataset at http://www.correlatesofwar.org/data-sets/territorial-change.

Table A1: List of Territory Flows (For Online Publication Only), Cont'd

Country i	Country j	JSDG ID*	Country i	Country j	JSDG ID	Country i	Country j	JSDG ID
Yugoslavia	Italy	508,544	Ethiopia	United Kingdom	362,396	Yemen Arab Republic	Saudi Arabia	567
Greece	Albania	454	Ethiopia	Italy	571	Yemen	Oman	859
Greece	Turkey	364	Ethiopia	Egypt	248	Yemen People's Republic	Yemen Arab Republic	778
Cyprus	Turkey	789	South Africa	Namibia	865	Yemen People's Republic	Yemen	836
Bulgaria	Yugoslavia	442,491	Swaziland	United Kingdom	326	Kuwait	United Kingdom	384
Bulgaria	Greece	445,493	Madagascar	France	280,359	Kuwait	Saudi Arabia	761
Bulgaria	Romania	450	Comoros	France	803	Qatar	United Kingdom	460
Moldova, Repof	Ukraine	873	Morocco	France	405,422,437	Qatar	Turkey	213
Romania	Bulgaria	584	Morocco	Spain	438	United Arab Emirates	United Kingdom	336
Romania	Russian Federation	245,618	Tunisia	France	257	Oman	Yemen	858
Russian Fed	Poland	530,650	Libyan Arab Jamahiriya	France	664	Oman	Pakistan	686
Russian Fed	Romania	511	Sudan	United Kingdom	385	Afghanistan	United Kingdom	227,338
Russian Fed	Estonia	876	Sudan	Egypt	880	Afghanistan	Russian Fed	353
Russian Fed	Lithuania	582	Turkey	United Kingdom	233,377,417,498,499	Turkmenistan	Russian Fed	228
Russian Fed	China	260,413,868,887	Turkey	France	502	Kyrgyzstan	Russian Fed	216
Russian Fed	Japan	226,414,415,676	Turkey	Yugoslavia	239,443	Kazakstan	China	872
Estonia	Russian Federation	585,875	Turkey	Greece	258,446,448	China	Russian Fed	210,376,392
Latvia	Russian Federation	586	Turkey	Bulgaria	449	China	Japan	354,562,564,572
Lithuania	Germany	578	Turkey	Romania	243	China	Pakistan	730
Lithuania	Poland	504	Turkey	Russian Federation	246,532	China	Nepal	718
Lithuania	Russian Fed	587	Turkey	Saudi Arabia	451	Taiwan	China	667
Ukraine	Moldova, Repof	874	Iraq	Saudi Arabia	800	Korea	Japan	416
Ukraine	Russian Fed	516	Iraq	Kuwait	864	Japan	United States of America	591,611
Armenia	Russian Fed	513	Egypt	United Kingdom	261	Japan	Russian Fed	224,600
Georgia	Russian Fed	515	Egypt	Italy	548	Japan	China	541,601,602
Azerbaijan	Russian Fed	514	Egypt	Ethiopia	275	India	Bhutan	644
Finland	Russian Fed	619	Egypt	Israel	748	India	Pakistan	646,685,758,775,782
Sweden	Finland	533	Syrian Arab Republic	Egypt	683	India	Bangladesh	860
Denmark	United States	462	Syrian Arab Republic	Israel	749,785	India	Sri Lanka	791
Mauritania	Morocco	820	Jordan	Israel	750	Bhutan	United Kingdom	430
Burkina Faso	Mali	833	Jordan	Saudi Arabia	741	Pakistan	India	643,684,757,774,781
Liberia	United Kingdom	433	Israel	Egypt	639,790,799,817,834	Myanmar	United Kingdom	291
Cameroon	Nigeria	882	Israel	Syrian Arab Republic	808	Myanmar	China	716
Nigeria	Cameroon	883,886	Israel	Jordan	640,867	Maldives	United Kingdom	298
Chad	Libyan Arab Jamahiriya	784	Saudi Arabia	Iraq	798	Thailand	United Kingdom	427
Zanzibar	United Kingdom	299,317,324	Saudi Arabia	Jordan	740	Thailand	France	409,423
Zanzibar	Portugal	294	Saudi Arabia	Yemen	884	Lao People's Dem Rep	France	342
Zanzibar	Germany	312	Saudi Arabia	Kuwait	762	Republic of Vietnam	Viet Nam	801
Zanzibar	Italy	322	Yemen Arab Republic	United Kingdom	457	Brunei Darussalam	United Kingdom	306
Zanzibar	Tanzania, United Rep of	736	Yemen Arab Republic	Turkey	214	Fiji	United Kingdom	218
Tonga	United Kingdom	391	Samoa	Russian Fed	378	Samoa	Germany	389

* The JSDG IDs can be matched to the original dataset at http://www.correlatesofwar.org/data-sets/territorial-change.

Table A2: Gravity of Goods

Panel A: Simple gravity regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method:	OLS			PPML		
ln(Population, country i)	0.549***	0.540***	0.161***	0.208***	0.207***	0.0566***
	(0.0593)	(0.0602)	(0.0550)	(0.00328)	(0.00343)	(0.00380)
ln(Population, country j)	0.526***	0.514***	0.175***	0.199***	0.197***	0.0654***
	(0.0555)	(0.0574)	(0.0484)	(0.00336)	(0.00353)	(0.00392)
ln(Distance)	-0.730***	-0.696***	-0.627***	-0.272***	-0.277***	-0.211***
	(0.0692)	(0.0745)	(0.0467)	(0.00587)	(0.00692)	(0.00523)
Pair-level controls§	No	Yes	Yes	No	Yes	Yes
Industrialization controls△	No	No	Yes	No	No	Yes
Observations	17,120	15,945	15,945	17,120	15,945	15,945
R-squared	0.309	0.307	0.540	0.306	0.301	0.551

Panel B: Simple gravity regressions by period						
	(1)	(2)	(3)	(4)	(5)	(6)
Sample period	1870-1909		1910-1949		1950-2008	
Estimation methods:	OLS	PPML	OLS	PPML	OLS	PPML
ln(Population, country i)	0.138**	0.0733**	0.176***	0.116***	0.168***	0.0569***
	(0.0568)	(0.0296)	(0.0605)	(0.0129)	(0.0563)	(0.00377)
ln(Population, country j)	0.0553	0.0251	0.160***	0.105***	0.183***	0.0658***
	(0.0717)	(0.0312)	(0.0534)	(0.0141)	(0.0501)	(0.00388)
ln(Distance)	-0.227***	-0.116***	-0.214***	-0.149***	-0.644***	-0.210***
	(0.0785)	(0.0318)	(0.0472)	(0.0161)	(0.0485)	(0.00520)
Pair-level controls§	Yes	Yes	Yes	Yes	Yes	Yes
Industrialization controls△	Yes	Yes	Yes	Yes	Yes	Yes
Observations	560	560	2,444	2,444	15,945	15,945
R-squared	0.429	0.470	0.393	0.429	0.557	0.575

Dep. variable is exports from country i to country j. It is logged except when the PPML estimation is used. § They include dummy variables for sharing borders, languages, and legal origins, respectively. △ Iron and steel production of both sides are used. Using primary energey leads to similar results. Robust standard errors in parentheses (clustered using the Cameron-Gelbach-Miller (2011) method when the OLS esimation is used). *** p<0.01, ** p<0.05, * p<0.1.