# *Online Appendix*

# *Political Institutions, Economic Liberty, and the Great Divergence*

# Optimal tariff rates

To elaborate on the remarks in the text, I assume ruler 1 sets his tariff rate on route 1 in order to maximize his revenue from tariffs and tolls. He uses some of this revenue to maintain the route. For simplicity, I focus on cases in which maintenance costs are negligible and symmetric across rulers; the route with the lowest TTC can accommodate all the traffic with no crowding effects; each route is controlled by a distinct ruler (so e = 1 < n); and c1 < c2.

Let σ1(τ1) be the share of merchandise shipped on route 1, as a function of the tariff rate on that road. Formally,

.

Here, m(τ) = |{j > 1: cj + τj + g(πj) = c1 + τ1 + g(π1)}| is the number of routes, other than route 1, with a minimal TTC, given τ = (τ1,…,τn).

Suppose m(τ) > 0. In this case, at least one of the rulers with a route that offers the lowest available TTC could earn more revenue by reducing his tariff rate by a tiny amount. Such a reduction would increase his share of the trade from 1/m(τ) to 1, thereby increasing his revenue. Thus, the only Nash equilibria are such that m(τ) = 0. In other words, the emperor sets his tariff just low enough in order to attract all the traffic to route 1.

I assume rulers cannot operate a road profitably at a zero tariff; the otherwise negligible costs of maintaining the route make this infeasible. Thus, in the limit as maintenance costs approach zero, the emperor can attract all traffic to route 1 by setting τ1 in order to solve c1 + τ1 + g(π1) = . When all rulers are equally likely to impose confiscatory surcharges, this reduces to (a special case of) the condition in the text.

# Top clusters

To identify “top clusters” in a given region and time, I proceeded as follows.

Step 1: Identify all cities whose population growth and urban potential growth were both above the 90th percentile for their region and year. Call these the “seeds.”

Step 2: If two or more seeds are within 100 km of each other, then group them and compute their centroid. Otherwise, each seed is considered separately.

Step 3: Define cities with positive and above-average growth rates that are within +/– 1 degree of the seed centroid as “neighbors.”

Step 4: If a seed has at least one co-seed or neighbor, then it forms cluster with all its co-seeds and neighbors. The top cluster is the one with the largest number of seeds and neighbors.

The tables below identify the top clusters found in each region.

## Table B.1

## Urban Clusters in Western Europe

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Seeds | Neighbors  (Number) | Population  (Number of Cities) |
| 1200 | Brussels,  St Omer | Bruges, Dunkerque, Ghent, Liege (4) | 71,999  (6) |
| 1300.1 | Prato | Arezzo, Bologna, Florence, Modena, Parma, Pisa, San Gimignano, Siena (8) | 268,033  (9) |
| 1300.2 | Ghent,  Leuven,  St Omer | Arras, Bruges, Brussels,  Dordrecht, Dunkerque, Middelburg (6) | 201,075  (9) |
| 1400.1 | Amsterdam,  Gouda,  Haarlem,  Zaandam | Alkmaar, Delft, Dordrecht, Hertogenbosch, Leiden, Utrecht (6) | 65,499  (10) |
| 1400.2 | Copenhagen,  Malmo | Roskilde (1) | 43,000  (3) |
| 1400.3 | Zittau | Bautzen, Gorlitz (2) | 18,000  (3) |
| 1500.1 | Delft,  Gouda,  Leiden | Alkmaar, Amsterdam, Dordrecht, Enkhuizen, Haarlem, Hertogenbosch, Hoorn, Lier, Rotterdam, The Hague, Utrecht, Zaandam (12) | 147,081  (15) |
| 1500.2 | Caltagirone, Mazzarino,  Mineo,  Modica,  Ragusa,  Scicli | Caltanissetta, Catania, Lentini, Lecata, Mascali, Paterno, Piazza Armerina, Randazzo, Siracusa (9) | 104,916  (15) |
| 1600.1 | Alkmaar,  Amsterdam, Enkhuizen,  Haarlem | Delft, Dordrecht, Hoorn, Leeuwarden, Leiden, Rotterdam, The Hague, Utrecht, Zaandam (9) | 251,832  (13) |
| 1600.2 | Altamura,  Andria,  Salerno | Barletta, Bitonto, Gravina di Puglia, Matera (4) | 90,000  (7) |
| 1700.1 | Amsterdam,  Leiden,  Rotterdam,  The Hague,  Zaandam | Alkmaar, Delft, Dordrecht, Enkhuizen, Gouda, Haarlem,  Hoorn, Utrecht (8) | 526,465  (13) |
| 1700.2 | Birmingham,  Liverpool,  Nottingham,  Sheffield | Coventry, Leeds, Leicester, Manchester, Shrewsbury, York (6) | 109,665  (10) |
| 1800 | Birmingham, Blackburn,  Derby, Hereford,  Leeds, Leicester,  Manchester, Nottingham,  Preston, Sheffield (10) | Bradford, Chester,  Coventry,  Shrewsbury (4) | 577,733  (14) |

## Table B.2

## Urban Clusters in East Asia

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Seeds | Neighbors  (Number) | Population  (Number of Cities) |
| 1200 | None | — | — |
| 1300 | None | — | — |
| 1400 | None | — | — |
| 1500 | None | — | — |
| 1600 | Kyoto, Osaka | None | 659,166 (2) |
| 1700 | Kanazawa | Kyoto (1) | 67,000 (2) |
| 1800 | Foshan, Guangzhou | None | 956,000 (2) |

The Japanese clusters in 1600 and 1700 correspond well to the “Little Divergence” in GDP per capita between Japan and China (Broadberry 2013, pp. 8–9).

## Table B.3

## Top clusters in Eastern Europe

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Seeds | Neighbors  (Number) | Population  (Number of Cities) |
| 1200 | Bratislava | 0 | — |
| 1300.1 | Prague | 0 | — |
| 1300.2 | Wroclaw | 0 | — |
| 1400 | None | — | — |
| 1500 | None | — | — |
| 1600 | Silistra | 0 | — |
| 1700.1 | Tula | 0 | — |
| 1700.2 | Tver | 0 | — |
| 1800 | None | — | — |

*Urban Clusters in South Asia*

There were never any seeds in South Asia. That is, no city that was above the 90th percentile in population growth for a particular year in that region was also above the 90th percentile in urban potential growth.

*Urban Clusters in the North Africa and the Middle East*

There were two seeds in North Africa, one in Rabat in 1200 and one in Oran in 1800. However, these seeds had no neighbors (as defined here) and so there was no cluster.

*Alternative Definitions*

If one expands the definition of a neighborhood, so that neighbors are within +/– 2.5 degrees, rather than +/– 1 degree, more clusters can obviously be identified. In Eastern Europe, early Czech growth clusters emerged in 1200 and 1300 but ended with the imposition of serfdom after the Black Death. The most significant top cluster in Eastern Europe emerged in the Moscow area by 1700, 18 years into Peter the Great’s reign. Leading the growth were Nizhny Novgorod, where the Stroganovs (the wealthiest merchant family in Russia) based their operations; and Tula, where Peter established Russia’s first armament factory.

C. Calculating urban potential

Ideally, one would not use great circle distances alone in computing urban potential. Instead, one would assess the “cost of exchange” between each pair of cities, which would depend on the following factors: (1) The great circle distance between the cities. (2) Per-mile transportation costs, which would depend on (a) whether the cities were connected by water or land routes, and (b) transportation technology. (3) Communication and contracting costs between the cities, which would depend on whether they shared religion, language, and culture.

In their study of the western core, Maarten Bosker, Eltjo Buringh, and Jan Luiten Van Zanden (p. 1423) take account of communication and contracting costs by calculating a separate Muslim urban potential and Christian urban potential for each city. Because religious identity has not been determined for all Eurasian cities over the period 600–1800 ce, the pan-Eurasian analyses in the present study (Tables 1 and 2) rely on religion-blind measures. However, within the western core, my results are robust to using either religion-specific or religion-blind urban potentials.

The variable UPGrowth used in Table 3 represents the logarithmic growth rate of co-religious urban potential—i.e., the growth rate of Christian urban potential for Christian cities, and of Muslim urban potential for Muslim cities. The only difference from the variables that Bosker, Buringh, and van Zanden use is that I included the Russian cities when computing the urban potentials (and they do not). Not surprisingly, a city’s total urban potential (counting all cities) and its co-religionist urban potential (counting only co-religionist cities) are highly correlated. Using Bosker, Buringh, and van Zanden’s variables as they originally coded them, the correlation is 0.96 (among cities with population data). The figure is virtually the same when the Russian cities are included.

I have rerun the models in Table 3 using a religion-blind measure of urban potential. The results remain qualitatively the same.

D. Assessing the inter-connectedness of urban growth

Although their primary focus lay elsewhere, Bosker, Buringh, and van Zanden provided a seminal discussion of city interdependence in the western core, based on a regression similar to equation (1). The table below compares the analysis in Table 3 with the analysis Bosker, Buringh, and van Zanden conducted.

The analytic differences that matter the most, in terms of generating different conclusions about inter-urban connections, are controlling for region-specific century effects (rather than for a global century effect) and controlling for lagged population (rather than not). The rationales for controlling for region-specific century effects, controlling for lagged population, and clustering the errors at the country level are as follows.

1. We know that natural disasters often had regionalized effects. Droughts and cold weather, for example, might ravage particular regions during a century, while leaving other regions untouched. By including region-century fixed effects, we can control for the average impact of natural disasters within each region-century, which allows us to better discern the effect of trade. If we include only year effects, we will tend to find larger positive correlations between cities’ growth rates, reflecting the correlative effect of similar climatic conditions. Since my purpose is to isolate the correlative effects of trade, it is crucial to control for region-century effects.

2. During the period of study, the largest cities should have grown more slowly because they faced convex increasing costs of transporting food. Consistent with this observation, lagged population is always significant and negative in the regressions.

3. Bosker, Buringh, and van Zanden provide persuasive evidence that trade between two cities depended both on their physical distance and their cultural distance. Bosker, Buringh, and van Zanden dealt with this by computing separate Christian and Muslim urban potentials. Another approach, taken here, is to cluster the errors at a higher level—one that reflects commonalities in language, culture, and religion.

Table D.1

|  |  |  |
| --- | --- | --- |
|  | Table 3, Present Article | Table 3, Bosker, Buringh, and van Zanden |
| Dependent Variable | Logarithmic Growth Rate of Population:  ln(popjt) – ln (popj,t-1) | ln(popjt) |
| Urban potential included? | Yes, as a growth rate | Yes, as a level |
| City fixed effects? | Yes | Yes |
| Bosker, Buringh, and van Zanden’s time-varying controls? | Yes | Yes |
| Region-specific century effects? | Yes | No, just century effects |
| ln(popj,t-1) included? | Yes | No |
| Error clustering | Country level | City level |

E. Growth interconnections in the early Islamic Golden Age

Bosker, Buringh, and van Zanden (2013, p. 1430) report a significant interconnection between cities in the Islamic World between 800 and 1000 ce. Downloading their data and Stata code, I first replicated their results (see the “Replication” column in the table below). I then modified their Stata code in two ways: by adding region-specific century effects (the regions were Western Europe, Southern Europe, North Africa, the Middle East, and Eastern Europe), and by clustering the errors at the country level. These changes reduced the size of the connection and removed its statistical significance, as reported in the column labeled “Rerun #1.”

Table E.1

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Replication: | Rerun #1 | Rerun #2 |
| 800 | 0.90\*\*\* (0.22) | 0.60 (0.37) | NA |
| 900 | 0.81\*\*\* (0.23) | 0.51 (0.37) | 0.01 (0.32) |
| 1000 | 0.45\*\* (0.22) | 0.22 (0.32) | –0.16 (0.26) |

Finally, in “Rerun #2” I also included the lagged population of each city as a control. This specification comes at the cost of losing the ability to examine the year 800, since the Bosker, Buringh, and van Zanden dataset does not include data on the lagged population for that year. For the two years that can be estimated, however, there is no remaining positive relationship.

F. The mediating effects of representative institutions

Bosker, Buringh, and van Zanden (p. 1434) report some seminal findings on how representative institutions mediate the effect of urban potential on city size. The table below first reports a replication of their published results. The entries give the effect of increasing a city’s co-religionist urban potential, for various types of city. The second column presents a re-analysis that differs only in that region-specific century effects are included. As can be seen, including this additional control suggests that non-communal/non-parliamentary Christian cities were only weakly connected to urban growth in other Christian cities.

Table F.1

|  |  |  |
| --- | --- | --- |
|  | Replication | Rerun (with Region-Specific Century Effects Added) |
| Effect in cities that were neither communal nor parliamentary | 0.46\*\*\* (0.14) | 0.21 (0.19) |
| Effect in cities that were communal but not parliamentary | 0.61\*\*\* (0.15) | 0.33 (0.20) |
| Effect in cities that were parliamentary but not communal | 0.50\*\*\* (0.14) | 0.31\* (0.18) |
| Effect in cities that were both communal and parliamentary | 0.65\*\*\* (0.14) | 0.42\*\* (0.18) |

G. Parliamentary urban potential

The parliamentary urban potential for city j in century t, PUPjt, is calculated as follows:

 = .

Here, Parliamentit = 1 if city i is in a parliamentary realm in century t, = 0 otherwise; popit is city i’s population at time t; and Dij is the great circle distance between cities i and j. The results mentioned in the text, for non-parliamentary West European cities 1200–1500 ce, are displayed below. The results are similar, if errors are clustered at the country level rather than the gridcell level, and if gridcell-century interactions are included.

Table G.1

|  |  |  |
| --- | --- | --- |
| Independent Variables | Model 1 | Model 2 |
| ln[popt-1] | –1.05\*\*\*  (0.08) | –1.12\*\*\*  (0.10) |
| UPGrowth | 0.107  (0.50) | — |
| PUPGrowth | — | 0.35\*\*\*  (0.07) |
| Battles | 0.12  (0.72) | 0.56  (0.46) |
|  |  |  |
| City fixed effects? | Yes | Yes |
| Century fixed effects? | Yes | Yes |
| Bosker, Buringh, and van Zanden’s other controls? | Yes | Yes |
| Number of observations | 198 | 198 |
| Number of cities | 101 | 101 |
| Errors clustered at the gridcell level; number of gridcells = | 18 | 18 |
| R2 (within) | 0.70 | 0.72 |

Dependent variable = logarithmic growth rate of population.

\*\*\* p < 0.01; \*\* p < 0.05; \* p < 0.10

H. Arrellano-Bond analyses

The datasets analyzed here are “small T, large N” panels. As such, dynamic panel bias (Nickell 1981) is a worry. As a robustness check on Table 2, Model 1, I ran separate Arrellano-Bond regressions for each region. The dependent variable, city population, was regressed on lagged population, the growth rate of urban potential (UPGrowth), and century fixed effects. Estimation (using the xtabond2 command in Stata) was via one-step difference GMM, taking the lagged dependent variable as endogenous. The estimated coefficients on the urban potential variable for each region were as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Western Europe | Eastern Europe | North Africa and Mideast | East Asia | South Asia |
| Coefficient on UPGrowth  (se) | 1.65\*\*\* (0.20) | 0.39  (0.75) | –0.08  (0.26) | –0.15  (0.19) | –0.43  (0.20) |

Two caveats should be registered about these analyses. First, this class of estimator assumes that the idiosyncratic errors are uncorrelated across individuals but that assumption seems questionable in the present context. Second, the tests of the over-identifying restrictions looked reasonable for all regions except Western Europe.

I. Weak and strong parliaments

The table below provides the results of estimating equation (2) in the text.

|  |  |
| --- | --- |
| Independent Variable | Coefficient (Standard Error) |
| Meangrowth | 0.81\*\*\* (0.13) |
| Weak | –0.17 (0.14) |
| Strong | –0.17\* (0.09) |
| UPGrowth | –0.28\* (0.16) |
| UPGrowth×Weak | 0.40 (0.43) |
| UPGrowth×Strong | 0.58\*\*\* (0.20) |
| Constant | 0.14\*\* (0.07) |
| City fixed effects? | Yes |
| Number of observations | 501 |
| Number of cities | 139 |
| Within R2 | 0.24 |

The overall effect of UPGrowth in strong parliamentary cities, –0.28 + 0.58 = 0.30, is statistically greater than zero. The results are very similar if one drops Meangrowth and replaces it with a full battery of country-specific century effects and/or includes lagged population as a regressor.

J. High-growth areas

The text mentioned a comparison between the Yangzi Delta and the Netherlands.

I first restricted the sample to cities contained in gridcell 94, which corresponds well to the Delta. I then regressed each city’s growth rate on a city fixed effect, a century fixed effect, the lagged growth rate, and the growth rate of urban potential. The coefficient on UPGrowth was negative and significant at the 0.10 level (b = –01.41, p = 0.054).

Next I restricted the sample to all cities in the Netherlands. Performing the same analysis on these cities, the coefficient on UPGrowth was positive and significant at the 0.10 level (b = +0.88, p = 0.074).

The replication of Model 1 restricted to cities from high-growth gridcells is reported below.

|  |  |
| --- | --- |
| Independent Variables | Model 1  (All Cities, 1200–1800) |
|  |  |
| ln(popt-1) | –0.35\*\*\*  (0.04) |
| Western Europe: UPGrowth | 2.15\*\*\*  (0.51) |
| Eastern Europe: UPGrowth | 0.97  (0.98) |
| East Asia: UPGrowth | 0.01  (0.82) |
| South Asia: UPGrowth | –1.38\*\*\*  (0.33) |
|  |  |
| City fixed effects? | Yes |
| Region-century fixed effects? | Yes |
| N of observations | 1,652 |
| N of cities | 354 |
| Errors clustered at country level; number of countries = | 33 |
| R2 (within) | 0.28 |

Dependent variable = logarithmic growth rate of population.

References

Bosker, Maarten, Eltjo Buringh, and Jan Luiten van Zanden. “From Baghdad to London: Unraveling Urban Development in Europe, the Middle East, and North Africa, 800–1800.” *Review of Economics and Statistics* 95, no. 4 (2013): 1418–37.

Broadberry, Stephen. “Accounting for the Great Divergence.” Economic History Working Paper No. 184/2013, London School of Economics and Political Science, London, UK, 2013.

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