Appendix for "Muslim Trade and City Growth before the 19th Century"

Estimating City Population using Power Law

As with other more recent population data series, the main challenge with the Chandler and Fox (1974; 1987) data arises from missing entries of city estimates in the lists of largest cities. In order to deal with this issue, we interpolate missing city population estimates within each given year following the convention that city size can be approximated by the power law. Given that there are many more small cities than large ones, we would expect that the city size distribution is highly skewed with a long tail to the right of distribution. When city ranks are plotted against observed city sizes on a log-log scale, a straight line fits the data well with a negative slope, and the regularity of city size distribution has been well-documented.[1] Using this approach, we obtain the OLS estimate of the log of population for each city on the list (for a given year) with missing information as a linear function of the log of its known rank and a constant[2] :

$$LogPopulation_i = \alpha + \beta LogRank_i + \varepsilon_i \tag{1}$$

Using the slope estimate obtained for each year and the rank from the lists, we calculate the population estimate for each missing city-year observation. Equation (1) obtains the coefficient estimate β using both the available city population data including the size of the largest city and city rank orders. We do not restrict the coefficient estimate to follow Zipf's Law, which imposes that the n-th largest city is the 1/nth the size of the first-ranked city with a slope parameter of -1. While Zipf's Law has been documented as an empirical regularity in city populations, it has been shown mainly in countries with autonomous cities, high internal labor mobility and low transportation costs (Nitsch 2005; Jackson 2008). Cox (2016a) provides both a theoretical argument and empirical evidence in the case of Eurasian city populations between 600 and 1800 CE to show that when goods and people did not flow seamlessly across competing cities, city sizes do not necessarily correspond to Zipf's Law. Cox (2016a) highlights two contrasting cases. First, the rulers of large empires in the Islamic world likely faced few competitive constraints, and drew resources from other cities in favor of enlarging imperial capitals and administrative centers suggesting a city size distribution with a Zipf exponent more than unity. Second, small state rulers in Western Europe competed for commercial traffic and granted autonomy to cities, while at the same time pursuing mercantilist protectionism to inhibit the growth of large cities; this led to a city size distribution with a Zipf exponent less than unity.

[1] Rozenfeld et al. (2011) for example find that the power law holds well for population clusters in the UK and the US. Eeckhout (2004) finds that the power law especially approximates the upper tail of human settlements well. See Gabaix (2009) for a survey of the relevant literature.

[2] For this exercise, we add one to every city population as to avoid undefined population of log(0).

Trade Routes

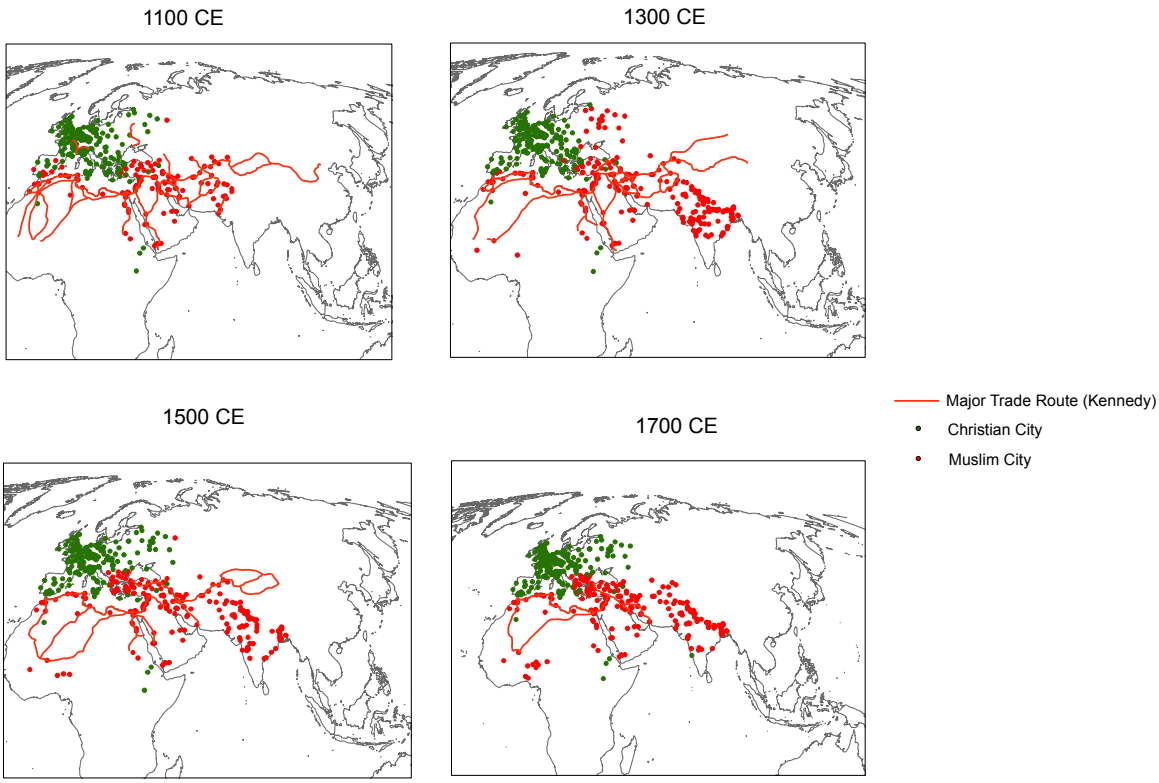

Figure A.1: *Muslim Trade Routes (Kennedy (2002))*

Summary Statistics

Table A.1: Summary Statistics (1200 and 1800)

	mean	sd	min	max	count
Ln(Population Lower Bound)	2.28	1.89	0	7	615
Ln(Population Upper Bound)	3.80	0.61	1	7	615
Initial Distance to Trade Routes	4.98	2.19	0	8	615
Longitude	25.19	26.31	-9	91	615
Latitude	40.77	10.69	7	60	615
In Asia	0.33	0.47	0	1	615
In Africa	0.09	0.29	0	1	615
Mean agricultural suitability index (Ramankutty)	0.54	0.30	0	1	603
Km to nearest coastline	271.28	351.66	0	2029	615
Muslim City Dummy	0.42	0.49	0	1	615
Ln(Christian urban potential)	1.69	0.89	-0	4	615
Ln(Muslim urban potential)	0.95	0.45	0	3	615
Indian Cities	0.07	0.25	0	1	615
Mongolian Empire Dummy	0.10	0.30	0	1	615
Equal to 1 if part of Carolingian Empire in 800 AD	0.26	0.44	0	1	615
Log km to nearest Crusader site	12.33	2.34	6	16	615
Atlantic Country Dummy	0.24	0.43	0	1	615
Low countries	0.04	0.19	0	1	615
European city-belt	0.13	0.34	0	1	615
Roman Empire	0.13	0.33	0	1	615
Equal to 1 if under Ottoman rule	0.11	0.31	0	1	615
Ln(distance to nearest chokeline)	13.63	1.07	8	15	615
Observations	615				

Subset Analysis

Table A.2: The Effect of Distance to Trade Routes on City Size 1200 vs. 1800 CE (OLS)

	Baseline	Geography	Distance	Muslim	Urban Potential	India	Mongol
Initial Distance to Trade	-0.139***	-0.135***	-0.129***	-0.131***	-0.149***	-0.162***	-0.150***
Routes	(0.025)	(0.028)	(0.028)	(0.027)	(0.029)	(0.029)	(0.030)
Distance X 1800 CE	0.157***	0.166***	0.164***	0.166***	0.179***	0.181***	0.156***
	(0.032)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)	(0.036)
1800 CE	-0.774***	-0.805***	-0.781***	-0.789***	-0.692***	-0.677***	-0.448**
	(0.148)	(0.159)	(0.157)	(0.158)	(0.177)	(0.177)	(0.213)
Ln(distance to nearest choke)			-0.130*	-0.145*	-0.194**	-0.217**	-0.204**
			(0.073)	(0.077)	(0.096)	(0.095)	(0.093)
Muslim City Dummy				-0.178	-0.029	-0.038	-0.071
				(0.150)	(0.170)	(0.168)	(0.162)
Ln(Christian urban potential)					-0.263*	-0.267*	-0.366**
					(0.140)	(0.138)	(0.148)
Ln(Muslim urban potential)					-0.367*	-0.351*	-0.329
					(0.213)	(0.210)	(0.205)
Indian Cities						0.533**	0.372
						(0.225)	(0.241)
Mongolian Empire Dummy							-0.317**
							(0.138)
Constant	4.359***	4.110***	5.879***	6.149***	7.207***	7.512***	7.160***
	(0.099)	(0.410)	(1.005)	(1.102)	(1.330)	(1.319)	(1.312)
N	378	367	367	367	367	367	367
Geography	No	Yes	Yes	Yes	Yes	Yes	Yes

1100 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.* p <0.1, ** p <0.05, *** p <0.01.

Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

Table A.3: The Effect of Distance to Trade Routes on City Size 1200 vs. 1800 CE (Excluding cities on the travel routes)

	Baseline	Geography	Distance	Muslim	Urban Potential	India	Mongol
Initial Distance to Trade	-0.134**	-0.141**	-0.137**	-0.140**	-0.183***	-0.206***	-0.211***
Routes	(0.057)	(0.065)	(0.062)	(0.063)	(0.066)	(0.064)	(0.064)
Distance X 1800 CE	0.202***	0.228***	0.233***	0.236***	0.260***	0.265***	0.255***
	(0.069)	(0.076)	(0.075)	(0.076)	(0.075)	(0.073)	(0.073)
1800 CE	-0.719*	-0.830**	-0.853**	-0.868**	-0.837**	-0.836**	-0.707*
	(0.383)	(0.417)	(0.410)	(0.416)	(0.422)	(0.414)	(0.415)
Ln(distance to nearest choke)			-0.103	-0.108	-0.169*	-0.201**	-0.193**
			(0.076)	(0.080)	(0.097)	(0.097)	(0.096)
Muslim City Dummy				-0.052	0.110	0.123	0.101
				(0.132)	(0.150)	(0.149)	(0.149)
Ln(Christian urban potential)					-0.250*	-0.273**	-0.345**
					(0.137)	(0.135)	(0.142)
Ln(Muslim urban potential)					-0.402*	-0.421**	-0.416**
					(0.210)	(0.207)	(0.205)
Indian Cities						0.490**	0.387*
						(0.219)	(0.231)
Mongolian Empire Dummy							-0.241*
							(0.146)
Constant	3.945***	3.880***	5.284***	5.375***	6.727***	7.187***	7.059***
	(0.318)	(0.518)	(1.029)	(1.127)	(1.328)	(1.326)	(1.315)
lnsigma	-0.386***	-0.400***	-0.406***	-0.406***	-0.420***	-0.426***	-0.432***
	(0.064)	(0.062)	(0.061)	(0.061)	(0.058)	(0.058)	(0.059)
N	533	521	521	521	521	521	521
Geography	No	Yes	Yes	Yes	Yes	Yes	Yes

1100 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.* p <0.1, ** p <0.05, *** p <0.01.

Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

Conflict History and City Growth

In order to check whether the effect of proximity to trade route remains robust to past conflict, we utilize Dincecco and Onorato (2017)'s city-level conflict data of Europe between the 11th and 18th century. We create a dummy variable for each city-year observation in Europe.[3] For each observation, we look for any conflict over the past 100 years, starting from the beginning of the previous century up to the previous year (ex. for 1200 CE, we look for any conflict between 1100 and 1199 CE), within 100 kilometers of the city location. We then code the dummy as one if there is any incident of conflict.

Table A.4: The Effect of Distance to Trade Routes on City Size in Europe

	Baseline	Conflict only	No Conflict	Interaction
Distance to Muslim Trade Route	-0.252***	-0.739**	-0.188***	-0.244***
	(0.050)	(0.290)	(0.046)	(0.049)
Distance X 1800 CE	0.231***	0.684***	0.131*	0.222***
	(0.078)	(0.210)	(0.071)	(0.078)
1800 CE	-0.311	-1.786	-0.165	-0.323
	(0.470)	(1.295)	(0.445)	(0.474)
Distance to Chokepoint	0.049	0.723***	-0.210	0.057
	(0.166)	(0.263)	(0.138)	(0.164)
Muslim City Dummy	-0.194	-0.111	-0.180	-0.193
	(0.297)	(0.284)	(0.264)	(0.286)
Conflict Dummy	0.256***			-0.033
	(0.096)			(0.170)
Conflict X 1800 CE				0.354*
				(0.194)
Christian Urban Potential	-0.571***	-1.667***	-0.167	-0.602***
	(0.194)	(0.521)	(0.209)	(0.193)
Muslim Urban Potential	0.182	-1.330*	0.390	0.187
	(0.487)	(0.776)	(0.422)	(0.458)
Constant	4.572**	3.568	6.453***	4.470**
	(1.921)	(3.404)	(1.761)	(1.895)
N	314	95	219	314

Robust standard errors corrected for clustering at the city level. * p <0.1, ** p <0.05, *** p <0.01. Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

We run a series of alternative specifications with the conflict dummy control in Table A.4. In Column 1, we show the effect of distance to trade with the conflict dummy included as a control. In Column 2, only the cities that had experienced any conflict in the past

[3]This essentially removes the Indian City and Mongol Empire dummy variables from our analysis. We also remove cities in Russia and Ukraine as they are not covered by Dincecco and Onorato (2017).

according to Dincecco and Onorato (2017) are included in the regression. Column 3 includes only the cities that are coded as not having had conflict in the previous period, because they are more than 100 kilometers away from any recorded past conflict over the span of 100 years. Column 4 allows for the past conflict dummy to interact with the year 1800 dummy variable. We find similar patterns across the columns; that is, the distance to trade route effect holds with the same sign and statistical significance as before, controlling for presence of past conflict.

Time Trends in 900 CE

Table A.5: Time Trends — 900, 1200 and 1800

	900,1200,1800CE
Distance to Muslim Trade Route	-0.152***
	(0.026)
Distance X 900 CE	-0.041
	(0.038)
Distance X 1800 CE	0.177***
	(0.030)
900 CE	-0.394*
	(0.209)
1800 CE	-0.334*
	(0.171)
Constant	7.004***
	(1.453)
N	867

1100 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.
* p <0.1, ** p <0.05, *** p <0.01.
Includes the full set of controls from Table 1 column 7.

Further Robustness Checks

In this section we report the results of additional regression analyses. In Table A.6 we replicate Table 1 results, where observations are drawn from 1300 and 1700 (rather than 1200 and 1800) respectively. In Tables A.7 and A.8 we replicate Table 2 results, where observations are drawn from 1400 and 1600, and from 1300 and 1700 (rather than 1200 and 1800) respectively. In Table A.9 we replicate our Table 6 results where the observations are drawn from 1400 and 1600 instead of 1200 and 1800. In Table A.10 we do the same but for observations from 1300 and 1700. In other words, the results here combine our two strategies for robustness — additional control variables and alternative time spans. We report highly similar results in these tables as found in the main specifications of the paper.

Table A.6: The Effect of Distance to Trade Routes on City Size: 1300 vs 1700 CE

	Baseline	Geography	Distance	Muslim	Urban Potential	India	Mongol
Distance to Muslim Trade Route	-0.104***	-0.145***	-0.131***	-0.129***	-0.135***	-0.160***	-0.158***
	(0.026)	(0.035)	(0.037)	(0.037)	(0.037)	(0.038)	(0.037)
Distance X 1700 CE	0.057**	0.061**	0.061**	0.062**	0.065**	0.067**	0.067**
	(0.028)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
1700 CE	0.098	0.086	0.085	0.082	0.238	0.272	0.268
	(0.173)	(0.177)	(0.180)	(0.181)	(0.210)	(0.209)	(0.209)
Distance to Chokepoint (ln)			-0.138	-0.135	-0.220*	-0.285**	-0.288**
			(0.096)	(0.098)	(0.113)	(0.126)	(0.126)
Muslim City Dummy				0.070	0.249	0.292*	0.290*
				(0.145)	(0.156)	(0.159)	(0.158)
Christian Urban Potential (ln)					0.084	0.111	0.124
					(0.164)	(0.166)	(0.170)
Muslim Urban Potential (ln)					-0.497**	-0.621**	-0.622**
					(0.245)	(0.260)	(0.260)
Indian City Dummy						0.556*	0.592
						(0.325)	(0.366)
Mongol Empire Dummy							0.057
							(0.194)
Constant	3.641***	4.252***	6.029***	5.975***	7.307***	8.195***	8.245***
	(0.161)	(0.524)	(1.181)	(1.214)	(1.494)	(1.652)	(1.668)
N	689	677	677	677	677	677	677
Geography	No	Yes	Yes	Yes	Yes	Yes	Yes

1300 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.* p <0.1, ** p <0.05, *** p <0.01.

Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

Table A.7: The Effect of Distance to Trade Routes on City Size: 1400 vs. 1600 CE

	Muslim Cities	Christian Cities	Interaction
Distance to Muslim Trade Route	-0.199***	-0.190*	-0.194***
	(0.048)	(0.103)	(0.039)
Distance X 1600 CE	0.039	-0.062	0.034
	(0.036)	(0.130)	(0.033)
1600 CE	0.085	0.662	0.195
	(0.228)	(0.838)	(0.216)
Distance to Chokepoint	-0.525***	-0.293	-0.439***
	(0.185)	(0.185)	(0.117)
Muslim City Dummy			-0.120
			(0.162)
Muslim City X 1600 CE			-0.181
			(0.188)
Christian Urban Potential	0.079	0.357*	0.431***
	(0.594)	(0.198)	(0.157)
Muslim Urban Potential	-0.458*	-0.013	-0.435*
	(0.254)	(0.406)	(0.231)
Indian City Dummy	1.181**	1.666	1.122**
	(0.532)	(1.130)	(0.447)
Mongol Empire Dummy	-0.034	0.206	0.019
	(0.363)	(0.365)	(0.238)
Constant	11.043***	7.343***	9.836***
	(2.781)	(2.535)	(1.630)
N	354	350	704

Robust standard errors corrected for clustering at the city level.

* p <0.1, ** p <0.05, *** p <0.01.

Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

Table A.8: The Effect of Distance to Trade Routes on City Size: 1300 vs. 1700 CE

	Muslim Cities	Christian Cities	Interaction
Distance to Muslim Trade Route	-0.164***	-0.189*	-0.167***
	(0.044)	(0.104)	(0.038)
Distance X 1700 CE	0.089**	0.397**	0.085**
	(0.039)	(0.172)	(0.036)
1700 CE	0.765**	-1.972*	0.101
	(0.303)	(1.076)	(0.267)
Distance to Chokepoint	-0.396**	-0.160	-0.290**
	(0.160)	(0.191)	(0.125)
Muslim City Dummy			0.217
			(0.176)
Muslim City X 1700 CE			0.169
			(0.185)
Christian Urban Potential	-0.836*	0.024	0.119
	(0.469)	(0.216)	(0.169)
Muslim Urban Potential	-0.767***	-0.778	-0.647**
	(0.282)	(0.577)	(0.264)
Indian City Dummy	0.629	-2.542*	0.620*
	(0.422)	(1.412)	(0.367)
Mongol Empire Dummy	-0.007	0.190	0.073
	(0.244)	(0.387)	(0.192)
Constant	9.803***	8.715***	8.399***
	(2.397)	(2.921)	(1.682)
N	339	338	677

Robust standard errors corrected for clustering at the city level.

* p <0.1, ** p <0.05, *** p <0.01.

Geographic controls include longitude and latitude, continental dummies for Asia and Africa, distance to coast, and agricultural suitability index.

Table A.9: Robustness Checks on City Size: 1400 vs 1600 CE

	Carolingian	Crusader	Low Countries	European City-belt	Roman	Ottoman	Atlantic
Distance to Muslim Trade Route	-0.205***	-0.214***	-0.211***	-0.205***	-0.213***	-0.187***	-0.204***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.041)	(0.040)
Distance X 1600 CE	0.054**	0.053**	0.053**	0.054**	0.051**	0.029	0.052**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.024)	(0.024)
1600 CE	0.066	0.093	0.043	0.033	0.015	0.174	0.031
	(0.146)	(0.143)	(0.139)	(0.142)	(0.140)	(0.158)	(0.142)
Carolingian Empire Dummy	0.212						
	(0.212)						
Distance to Crusader Location		-0.120**					
		(0.052)					
Low Countries Dummy			0.493***				
			(0.181)				
European City-belt Dummy				0.057			
				(0.167)			
Roman Empire Dummy					-0.352*		
					(0.179)		
Ottoman Empire Dummy						-0.381**	
						(0.166)	
Atlantic Country Dummy							-0.133
							(0.206)
Atlantic Country X 1600 CE							0.045
							(0.151)
Constant	10.373***	12.552***	10.279***	10.094***	9.805***	9.999***	10.116***
	(1.624)	(1.903)	(1.583)	(1.607)	(1.575)	(1.542)	(1.641)
N	704	704	704	704	704	704	704

1300 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.* p <0.1, ** p <0.05, *** p <0.01.
All columns include the full set of controls in Table 1 Column 7.

Table A.10: Robustness Checks on City Size: 1300 vs 1700 CE

	Carolingian	Crusader	Low Countries	European City-belt	Roman	Ottoman	Atlantic
Distance to Muslim Trade Route	-0.160***	-0.168***	-0.164***	-0.159***	-0.158***	-0.143***	-0.164***
	(0.037)	(0.037)	(0.036)	(0.037)	(0.037)	(0.037)	(0.037)
Distance X 1700 CE	0.071**	0.071**	0.068**	0.068**	0.067**	0.037	0.077***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.031)	(0.030)
1700 CE	0.409*	0.401*	0.293	0.292	0.264	0.468**	0.285
	(0.224)	(0.222)	(0.209)	(0.214)	(0.208)	(0.228)	(0.209)
Carolingian Empire Dummy	0.418**						
	(0.203)						
Distance to Crusader Location		-0.158**					
		(0.064)					
Low Countries Dummy			0.388**				
			(0.171)				
European City-belt Dummy				0.102			
				(0.156)			
Roman Empire Dummy					-0.148		
					(0.207)		
Ottoman Empire Dummy						-0.483***	
						(0.168)	
Atlantic Country Dummy							0.097
							(0.177)
Atlantic Country X 1700 CE							-0.214
							(0.163)
Constant	8.910***	11.346***	8.429***	8.351***	8.140***	8.114***	8.403***
	(1.709)	(2.138)	(1.658)	(1.685)	(1.667)	(1.567)	(1.688)
N	677	677	677	677	677	677	677

1300 CE Muslim trade routes. Robust standard errors corrected for clustering at the city level.* p <0.1, ** p <0.05, *** p <0.01.
All columns include the full set of controls in Table 1 Column 7.

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