Unified China and Divided Europe

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Abstract

This paper studies the persistence and consequences of political centralization and fragmentation in China and Europe. We argue that the severe and unidirectional threat of external invasion fostered political centralization in China while Europe faced a wider variety of external threats and remained politically fragmented. Our model allows us to explore the economic consequences of political centralization and fragmentation. Political centralization in China led to lower taxation and hence faster population growth during peacetime than in Europe. But it also meant that China was relatively fragile in the event of an external invasion. We argue that the greater volatility in population growth during the Malthusian era in China can help explain the divergence in economic development that had opened up between China and Europe at the onset of the Industrial Revolution.

Keywords: China; Europe; Great Divergence; Political Fragmentation; Political Centralization

JEL Codes: N33; N35; N43; N45; H56

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1 Introduction

Since Montesquieu, scholars have attributed Europe's success to its political fragmentation (Montesquieu, 1748, 1989; Jones, 1981; Mokyr, 1990; Diamond, 1997). Nevertheless throughout most of history, the most economically developed parts of the world belonged to large empires, the most notable of which was imperial China. This contrast poses a puzzle that has important implications for our understanding of the origins of modern economic growth: Why was Europe perennially fragmented after the collapse of Rome, whereas political centralization was a stable equilibrium for most of Chinese history? Can this fundamental difference in political institutions account for why modern economic growth began in Europe and not in China?

This paper proposes a unified explanation for this twin divergence. We emphasize the role of geography in shaping the external threats confronting continental landmasses such as China and Europe. Our model predicts when and where empires are more likely be stable based on the extent and nature of the external threats that they face. It also sheds light on the growth consequences of political centralization and fragmentation.

Historically, China faced a large unidirectional threat from steppe nomads. Europe confronted several less powerful external threats from Scandinavia, Central Asia, the Middle East, and North Africa. We show that if multitasking is inefficient, empires will be unstable in Europe and political fragmentation the norm On the other hand, empires were more likely to emerge and survive in China because the nomadic threat threatened the survival of small states more than larger ones. Political centralization allowed China to avoid wasteful interstate competition and thereby enjoy faster economic and population growth during peacetime. However, the presence of multiple states to protect different parts of the continent meant that Europe would be relatively robust to negative shocks.

To substantiate the mechanisms identified in our model, we show that the predictions of our model are consistent with data on the number of internal and external wars and the level of taxation in Europe and China. Furthermore, the main prediction of our framework is borne out by evidence on the greater volatility of China population.

The framework we introduce has important implications for growth theory. Models of unified growth predict that once an economy accumulates some critical stock of knowledge, economic takeoff occurs (Galor and Weil, 2000; Galor, 2005, 2011). In the benchmark unified growth model, knowledge (A) is an increasing function of population (N) i.e. $A = f(N)$, and this scale-effect implies that the largest economy will experience the transition to sustained economic growth first. This prediction is at odds with the empirical evidence since the industrial revolution did not occur in China but in western Europe. In the literature, this puzzle is explained by away by the argument that $A = f(N, X)$, which X are institutions that promote innovation or growth (Galor, 2011). This remains a leading explanation of the Great Divergence but it has come under criticism from revisionist economic historians who downplay many institutional differences between Europe and China (e.g. Bin Wong, 1997; Pomeranz, 2000).

In this paper, we provide an alternative mechanism to explain this puzzle. Our theory suggests that as a consequence of its centralization, China was more vulnerable to nomadic invasion and, as such, was more likely to experience periodic negative shocks to its population. We draw on a model developed by Aiyar et al. (2008) who that show that temporary negative population shocks can render some technologies unprofitable and therefore led to technological regress. Hence two equally sized populations $N_1 = N_2$ can generate different levels of A if they have different second moments, i.e. if $\sigma_1^2 > \sigma_2^2$, then $A_2 > A_1$. Hence, if two continents experience different frequency of shocks, the level of technology will tend to be higher in the continent with fewer shocks. Our paper shows why China was more vulnerable to negative population shocks and by drawing on Aiyar et al. (2008) we are able to suggest how our framework can provide an alternative explanation of the Great Divergence.

Relationship to the literature First and foremost our argument helps to clarify the emergence and stability of the European state system and its significance for the onset of sustained economic development. Numerous economists, historians, and sociologists have argued that political fragmentation in Europe led to the growth of economic and political freedom (Montesquieu, 1748, 1989), helped preserve the existence of independent city states and permitted the rise of a merchant class (Pirenne, 1925; Hicks, 1969; Hall, 1985; Rosenberg and L.E. Birdzell, 1986); encouraged experiments in political structures and investments in state capacity (Baechler, 1975; Cowen, 1990; Gennaioli and Voth, 2011);[1] and fostered innovation and scientific development (Diamond, 1997; Mokyr, 2007; Lagerlof, 2013).[2]

However, the argument that centralizing political authority is antithetical to economic development is far from clearcut. According to Epstein (2000), the fragmentation of sovereignty that characterized late medieval Europe raised transaction costs and impeded market activity. Shiue and Keller (2007) demonstrate that during the eighteenth century grain markets were more efficient in China than in much of Europe. Furthermore, tax rates were higher in Europe than in China (Rosenthal and Wong, 2011; Sng, 2011).

Our argument is closely related to Rosenthal and Wong (2011) who examine the costs and benefits of political centralization and fragmentation in China and Europe. They argue that political fragmentation led to more frequent warfare in medieval and early modern Europe. Continuous warfare imposed high costs. But political fragmentation also set in motion processes that would give Europe an advantage in

[1] Baechler observed that 'political anarchy' in Europe gave rise to experimentation in different state forms (Baechler, 1975, 74). Cowen (1990) argued that interstate competition in Europe provided an incentive for early modern states to develop capital markets and pro-market policies. Gennaioli and Voth (2011) show the military revolution induced investments in state capacity in some but not all European states.

[2] Diamond argued that 'Europe's geographic balkanization resulted in dozens or hundreds of independent, competing statelets and centers of innovation' whereas in China 'a decision by one despot could and repeatedly did halt innovation' (Diamond, 1997, 414-415). Mokyr notes that 'many of the most influential and innovative intellectuals took advantage of what Jones has called the competitive 'States system'. In different ways, Paracelsus, Comenius, Descartes, Hobbes, and Bayle, to name but a few, survived through strategic moves across national boundaries. They were able to flee persecutors, and while this imposed no-doubt considerable hardship, they survived and prospered' (Mokyr, 2007, 24). Lagerlof (2013) develops a growth model that emphasizes the benefits to scale in innovation under political unification and a greater incentive to innovate under political fragmentation. He calibrates the model to the initial conditions of China and Europe and shows that there are parameter values in which political fragmentation can give rise to the emergence of sustained growth Europe.

producing an industrial revolution; in particular, it lent an urban bias to the development of manufacturing which led to more capital intensive forms of production.

Like Rosenthal and Wong, we stress that political fragmentation was costly, but we depart from their view that the advantages of political fragmentation only accrued after 1750 (Rosenthal and Wong, 2011, 33).[3] We develop a different line of argument based on the observation that the costs of political collapse and external invasion were particularly high in China. That is, we argue that the Chinese empire could indeed have been more conducive to Smithian economic growth during stable periods as Rosenthal and Wong claim, but note that it was also less robust to external shocks. We argue that this greater volatility of economic development, output, and population was a major barrier that impeded the transition from stagnation to growth in China before 1800.

Our work complements research that emphasizes other aspects of the Great Divergence such as the higher age of first marriage in Europe relative to China (Voigtländer and Voth, 2013*a*), the differential impact of the Black Death (Voigtländer and Voth, 2013*b*), reliance on clans versus the public provision of poor relief (Greif and Tabellini, 2012), greater human capital in western Europe in general, or in England, specifically (Clark, 2007; van Zanden, 2009; Leunig et al., 2011; Kelly et al., 2013), or higher social status for entrepreneurs (McCloskey, 2010). Finally, our model is related to the literature on the optimal size of nations and to the literature on the rise of state capacity in Europe.[4]

The structure of the paper. Section 2 provides historical evidence that characterizes (1) the extent to which China was politically unified and Europe fragmented throughout their respective histories and (2) the extent to which both China and Europe were threatened by external invasion. In Section 3 we introduce a formal model of political centralization and decentralization. We explore the implications in Section 4 by presenting evidence on wars, population fluctuations and economic growth in both ends of Eurasia. Section 5 discusses how our argument relates to existing models of long-run economic growth and the Great Divergence. Section 6 concludes.

2 Two Puzzles: The Great Divergence and Political Fragmentation

The origins and causes of the Great Divergence between China and Europe pose a puzzle from the perspective of growth theory. Unified growth models that study the preindustrial period predict that in the Malthusian era economic growth will be driven by the size of the population (Kremer, 1993; Galor and Moav, 2002; Galor, 2011). In these models the stock of overall knowledge is initially slim, then

[3] Furthermore, it is tied to a specific argument that sees the industrial revolution as the product of a specific ratio of factor prices (a claim championed by Allen, 2009).

[4] The theory of the size of nations originates with Friedman (1977); more recent contributions include Alesina and Spolaore (1997); Wittman (2000). For work on the rise of state capacity in Europe see Dincecco (2009); Johnson and Koyama (2013, 2014*a*).

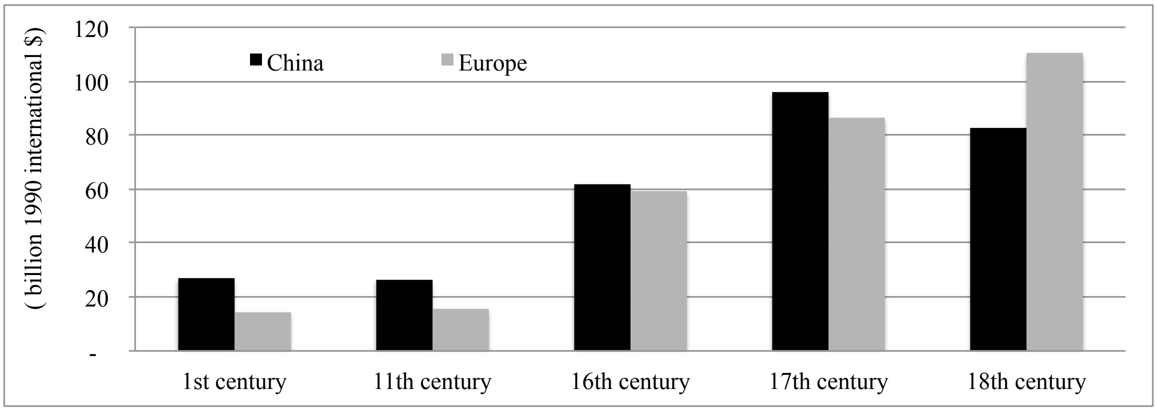


Figure 1: The size of the Chinese and European economies. Source: Maddison (2003).

as the population rises, the stock of overall knowledge gradually grows and, the returns to innovation increase until the level of technological knowledge in society reaches a critical point and the transition from stagnation to growth is triggered. However, as economic historians have noted that this framework does not tell us why economic growth began in Europe rather than in Asia, as China was the largest economy throughout most of the preindustrial period (see for instance Mokyr and Voth, 2010). Figure 1 illustrates this puzzle using Maddison's historical estimates of the relative size of Chinese and European economies (Maddison, 2003).[5]

We argue that the answer to this question lies in another puzzling observation: why was China politically unified for much of its history whereas Europe has been politically fragmented since the end of the Roman empire? Chinese historical records indicate that less than 80 states ruled over parts or all of China between AD 0 and 1800 (Wilkinson, 2012). Nussli (2011) provides data on all the states and statelets in existence at hundred year intervals in Europe. Figure 2 plots the number of sovereign states in Europe and in China for the preindustrial period. Despite data limitations, it is incontrovertible that there have always been more states in Europe than in China; in fact since the Middle Ages there have been an order of magnitude more states in Europe than in China.[6]

At the beginning of the period, Europe was dominated by the Roman empire. Consequently, there were three recorded sovereign states in Europe. With the breakup of the Roman empire, the number of states in Europe increased from 37 in 600 A.D. to 61 in 900 and by 1300 there were 114 independent political entities in Europe. This level of political fragmentation remained high during the Early Modern period.[7]

[5]Maddison's estimates of Chinese GDP have been criticized (see Broadberry, 2013). But, as they are typically criticized as representing an excessively pessimistic view of the Chinese economy in the preindustrial period, these criticisms work in our favor as they imply that these estimates provide a lower-bound for the size of the Chinese economy before 1800.

[6]The Nussli (2011) data does not capture all political entities in Europe since that number is unknown—there may have been as many as 1000 sovereign states within the Holy Roman empire alone—but it does record the majority of large and small political entities. By contrast, the Chinese dynastic tables are well known and the potential for disagreement is immaterial for our purpose. We count only sovereign states. Including vassal states would further strengthen the argument.

[7]This is consistent with Abramson (2013) who uses the Nussli data in conjunction with other sources to argue that contrary to Tilly (1990) the military revolution did not lead to state consolidation during the early modern period.

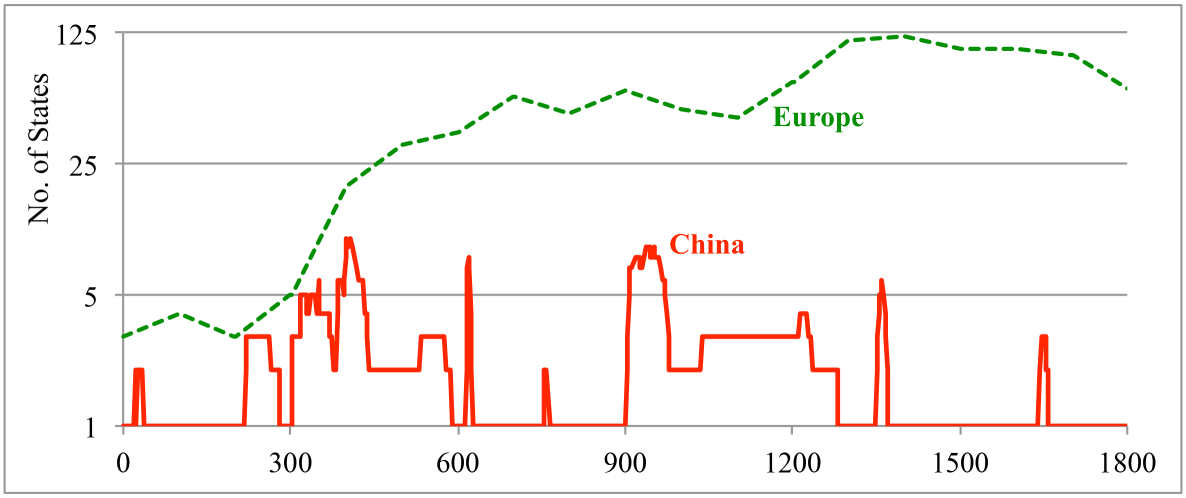


Figure 2: The number of sovereign states in China and Europe, 1-1800. Sources: Nussli (2011); Wilkinson (2012).

There were fewer states in China than in Europe throughout the past two millennia. China's first unification preceded Rome's dominance of the Mediterranean. The Chinese built a unitary state as early as the third century BC under the Qin dynasty. Moreover, the Chinese empire was longer-lasting than Rome. Although dynasties rose and fell after the Qin unification, China as an empire survived until the early twentieth century. Between AD 1 and 1800 the landmass between the Mongol steppe and the South China Sea was ruled by one single authority for 1007 years.[8]

The nomadic threat. We argue that in order to understand why China has typically been unified for much of its history whereas Europe has been fragmented, we need to assess the threats and challenges that they faced given their geography. Throughout most of history agrarian communities were threatened by nomadic invasion. In the words of William McNeil:

> 'between the eighth-seventh centuries B.C., when men first fully mastered the arts of steppe nomadry, and the sixteenth-seventeenth centuries A.D., . . . a pastoral conqueror was likely to celebrate his victories by brutal harassment of any pre-existing human inhabitants who were so imprudent as to await his coming. Most of whatever agricultural populations might have crept out into the plains under an earlier regime was thereby uprooted' (McNeil, 1964, 7).

Europe was threatened by Goths, Sarmatians, Vandals, Huns, Avars, Magyars, Vikings, Mongols and Tatars. Similarly, settled populations in China contended with a range of steppe nomads and semi-nomadic people: Xiongnu, Juanjuan, the Uygurs, Khitan, Jurchen, the Mongols, and the Manchus.

[8]If we consider vassal states as independent regimes, between 221 BC and 1911 China was politically unified for 935 years (Ge, 2008; Ma, 2012).

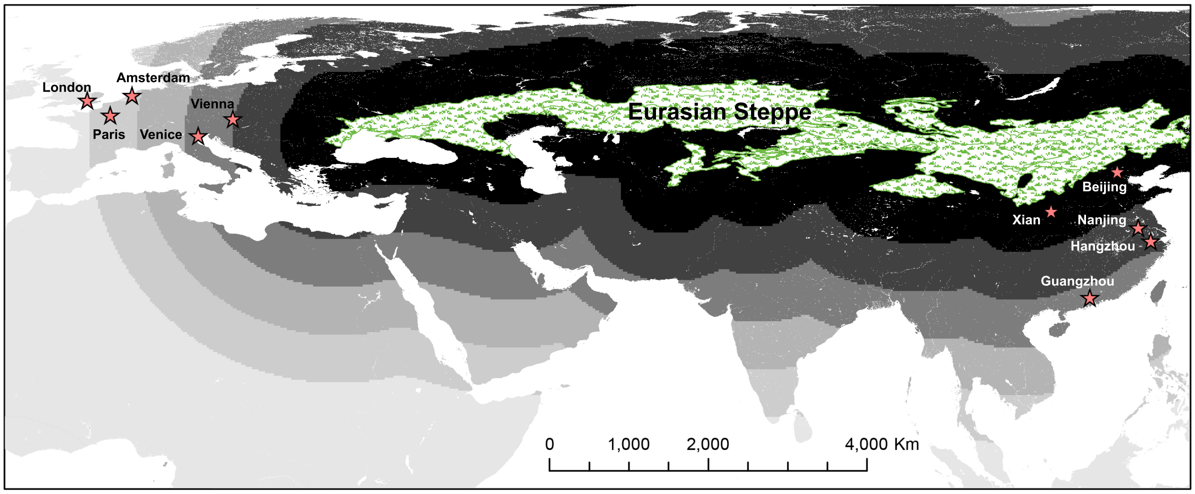


Figure 3: The Eurasian Steppe and Major Cities in China and Europe. Each shade represents approximately 600 kilometers from the steppe.

The threat of steppe nomads played a decisive role in Chinese history.[9] Despite the advantages that the Chinese enjoyed in terms of population and economic resources, before the development of effective gunpowder the steppe nomads often held the upper hand in military conflicts as their expertise in horses facilitated rapid mobilization and movement over long distances (Barfield, 1989). Furthermore, the Eurasian steppe constituted an undifferentiated 'highway of grass' (Frachetti, 2008) that allowed the nomads to move en masse from Mongolia to the Black Sea in a relatively short span of time. This gave the nomads an 'indefinite margin of retreat'. No matter how badly they were defeated in battle, they could never be conquered in war (Lattimore, 1940).

For largely geographical reasons, steppe nomads and semi-nomadic invaders posed as a more severe threat in China than in Europe. Central and Eastern Europe was vulnerable to incursions from the Eurasian steppe. But while western Europe was vulnerable to Viking invasions during the Early Middle Ages, Europe's forests and mountain ranges meant that many parts of western Europe were relatively free from the threat of nomadic invasions.[10] China's more compact geography meant that steppe invasions posed a more extensive threat to settled agricultural communities and urban centers. Figure 3 illustrates the distance of cities in China and Europe from the Eurasian steppe. As it makes clear, Guangzhou, the southernmost major Chinese city, was almost as close to the steppe as Vienna, the easternmost major western European city.

Scholars have long recognized the importance of the steppe nomads to state formation in ancient China (Lattimore, 1940; Huang, 1988; Lieberman, 2009; Turchin, 2009; Ma, 2012; Deng, 2012). We build on this literature by highlighting another important element in the nature of this threat that has

[9]Of the ten dynasties that ruled a unified China after 221 BC, three fell to nomadic invaders (Jin, Northern Song, and Ming) and two were set up by nomadic conquerors (Yuan and Qing). The steppe factor also featured prominently in the rise and fall of the other five dynasties (Qin, Former Han, Later Han, Sui, and Tang).

[10]The Mongol invasions of the thirteenth century pose a partial exception to this as it was understood that they had the ability to strike into western Europe had they desired to do so. As it was their invasion only reached as far as Hungary and Poland.

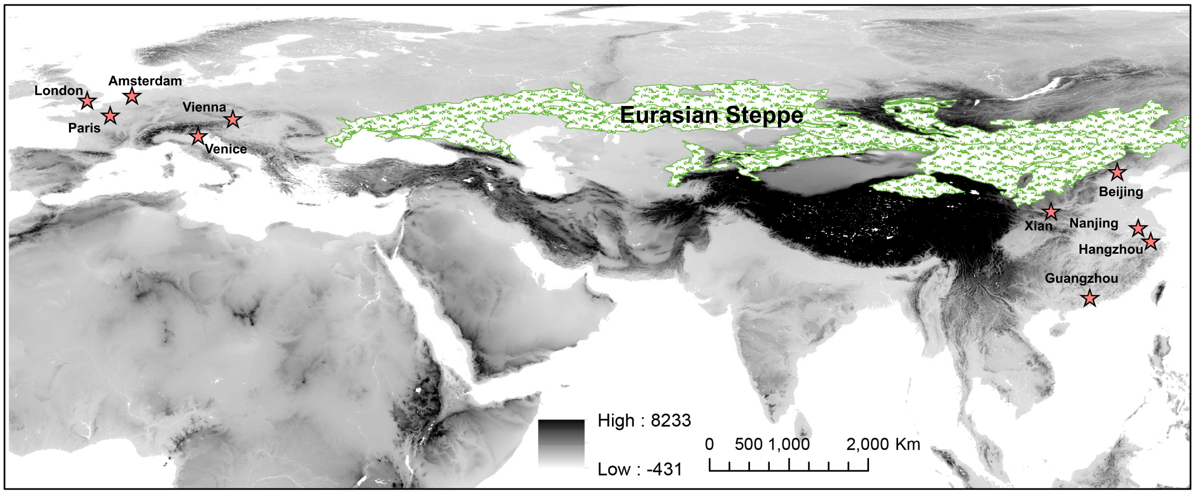


Figure 4: Although China was exposed to steppe invasion from its north, huge mountain ranges to its west, thick forests to its south, and the vast Pacific Ocean to its east meant that it was otherwise relatively isolated. By contrast, Europe was connected to the rest of Eurasia and Africa in multiple directions.

been overlooked so far: While—as the literature has pointed out—the severity of the nomadic problem provided the centripetal force that pushed the Chinese regions toward political centralization, it was also crucial that the external threats confronting China happened to be unidirectional and there were no major threats from other fronts that would have increased the appeal of an inherently more flexible politically decentralized system. Before 1800, all major invasions of China came from the north. We argue that this was geographically determined: as Figure 4 illustrates, China is shielded from from the south and west by the Himalayas and the Tibetan plateau. By contrast, prospective European empires typically faced enemies on multiple fronts. In the next section, we develop a theory that explains why a more severe but unidirectional threat gave rise to stable political centralization in China whereas political centralization in Europe was transitory and unstable.

3 Model

3.1 Setup

We model a continent as a line $[0,1] = \{x \in \mathbb{R} : 0 \leq x \leq 1\}$.[11] There is a unit mass of individuals uniformly distributed along this continent. An individual at x is endowed with income $\underline{y} + y$ where y is taxed. The continent is divided into s connected, mutually exclusive intervals each ruled by a separate political authority. For convenience, we restrict s to $s \in \{1, 2\}$. Of interest is the comparison between $s = 1$, which corresponds to political centralization or empire, and $s = 2$, which we will refer to as interstate competition or political fragmentation. We use e to label the single regime or empire when $s = 1$, and l and r to label the two regimes when $s = 2$. In the latter case, for convenience and because

[11]We will refer to both Europe and China as 'continents' or convenience.

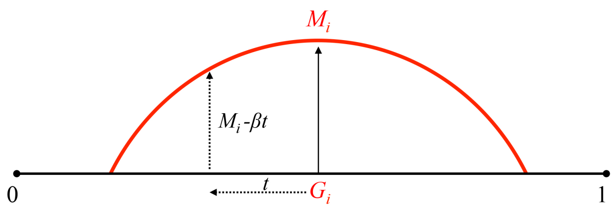


Figure 5: Regime i decides where to locate G_i and how much to spend on the military M_i.

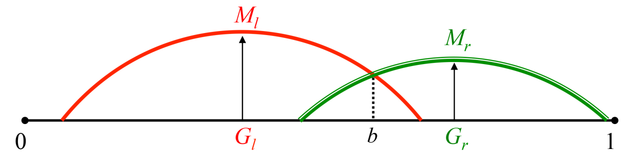


Figure 6: The border (b) between two regimes is determined by the locations of their capital cities (G_l and G_r) and their relative military spending (M_l and M_r).

we are primarily interested in analyzing two comparable regimes, we will treat l and r as identical and focus on the symmetric equilibrium when deriving the results.[12]

Regimes may invest in the military to compete against each other. However, the strength of the military deteriorates over distance due to the inefficiencies involved in the movement of troops and supplies. As such, the location of a regime's center of military deployment—referred to here as the capital city—is an important strategic variable.[13] For regime $i \in \{e, l, r\}$, $0 \leq G_i \leq 1$ denotes the location of its capital city and $M_i \geq 0$ the size of its military. For notational convenience, G_e and G_l are measured from 0 while G_r is measured from 1. As illustrated in Figure 5, for a location that is t distance away from G_i, regime i's level of military strength on that location is $M_i - \beta t^2$, where $\beta > 0$ captures the loss of military strength due to distance. The cost of providing M_i is θM_i^2.

When $s = 1$, the empire taxes the whole continent, so its **net revenue**, defined as tax revenue net of military expense, is $V_e = y - \theta M_e^2$. When $s = 2$, y is shared between the two regimes. Let b represent the border of the two regimes. Without loss of generality, we restrict the locations of capitals to $G_l + G_r \leq 1$, that is, the capital city of regime l is always to the left of regime r's capital city. The border b is determined by the condition $M_l - \beta (b - G_l)^2 = M_r - \beta ((1-b) - G_r)^2$. In other words, b is the location where the military strengths of both regimes are equal, as described in Figure 6.[14] The net revenues for regimes l and r are $V_l = by - \theta M_l^2$ and $V_r = (1-b)\, y - \theta M_r^2$, respectively.

Investing in the military also helps a regime to defend itself against threats from outside the continent. We model these external threats as emanating either from both frontiers of the continent (at $x = 0$ and $x = 1$) or just from one frontier of the continent (at $x = 0$ only without loss of generality). Whether the threat is one-sided or multi-sided depends on the continent's geographical environment which is exogenously determined. An external threat, if realized, causes gross damage $\Lambda > 0$ at the frontier(s) of the continent. The damage can spread further into the continent: if a point is t distance away from the frontier, the gross damage at that point is $\Lambda - \alpha t$ where α captures the spillover strength of the threat.

[12] If one of the two regimes rules a much larger interval than the other one, it may be more appropriate to use "empire" instead of "interstate competition" to describe the political reality of the continent.

[13] The capital city was known as *jing-shi* in Chinese, or literally the peak (*jing*) and the military (*shi*).

[14] We have implicitly assumed $M_l - \beta (b - G_l)^2 \geq 0$ and $M_r - \beta ((1-b) - G_r)^2 \geq 0$. If these inequalities are not satisfied then the borders of the two regimes do not intersect and the remaining intervening territory is split between them evenly (this will never occur in equilibrium).

However, the presence of a military mitigates the damage caused by the threat and may even stop the threat from spreading into the rest of the continent. Under a one-sided threat (initiated at $x = 0$), if regime i's military strength at x is no less than the gross damage of the external threat at that location, then x and any location to its right is said to be **adequately protected**, that is, individuals at these locations suffers zero damage from the threat. Formally, a location x is adequately protected by regime i if there exists $0 \leq x' \leq x$ such that $M_i - \beta(G_i - x')^2 - (\Lambda - \alpha x') \geq 0$. Let $\mathbb{P}_i$ be the set of locations that is adequately protected by regime i, or $\mathbb{P}_i \equiv \{x \in [0,1] : x \text{ is adequately protected by regime } i\}$. If x is not adequately protected by regime i, or $x \notin \mathbb{P}_i$, then the **net damage** at x is the gross damage caused by the threat minus the strength of regime i's military at x, i.e., $\kappa_i(x) \equiv \Lambda - \alpha x - [M_i - \beta(G_i - x)^2]$. For threats initiated at $x = 1$, we define adequate protection, the set $\mathbb{P}_i$ and the net damage κ_i in a similar fashion.

If a regime fails to provide adequate protection to $\delta > 0$ fraction of its population, then a revolution occurs. The regime receives a payoff of negative infinity if a revolution occurs.

3.2 Equilibrium

Consider the optimization problem facing a single regime or empire (e). Regime e first decides the location of capital $G_e \in [0,1]$ and then decides military investment $M_e \geq 0$ to maximize the net tax revenue $V_e = y - \theta M_e^2$. Since this is a two-stage decision process, our first proposition employs backward induction to find the optimal solution. Proofs of each proposition are provided in Appendix A.

Proposition 1 (**Empire**)**.** *When the threat is multi-sided:*

1. *If* $\Lambda \leq \frac{\alpha(1-\delta)}{2}$*, the equilibrium military investment is zero;*
2. *If* $\frac{\alpha(1-\delta)}{2} < \Lambda \leq \frac{1}{8}\beta\delta^2 + \frac{1}{4}\alpha(3-\delta)$*, the regime spends a non-zero amount on the military to confront the threat emanating from one frontier while ignoring the threat from the other frontier;*
3. *If* $\Lambda > \frac{1}{8}\beta\delta^2 + \frac{1}{4}\alpha(3-\delta)$*, the regime locates the capital city at the center of the continent and spends a non-zero amount on the military to confront the threat emanating from both frontiers;*

When the threat is one-sided:

4. *If* $\Lambda \leq \alpha(1-\delta)$*, the equilibrium military investment is zero;*
5. *If* $\Lambda > \alpha(1-\delta)$*, the regime spends a non-zero amount on the military to confront the threat emanating from* $x = 0$*.*

Now consider the two-stage game with interstate competition ($s = 2$). Regimes l and r first simultaneously choose the location of their capital cities $G_l \in [0,1]$ and $G_r \in [0,1]$. After knowing locations of each other, two regimes simultaneously make military investments $M_l \geq 0$ and $M_r \geq 0$. This is a complete information game and we employ the subgame-perfect equilibrium as the solution concept.

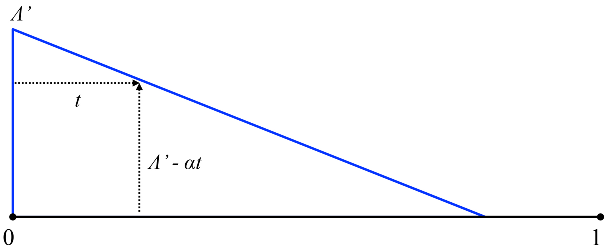


Figure 7: A severe, one-sided threat.

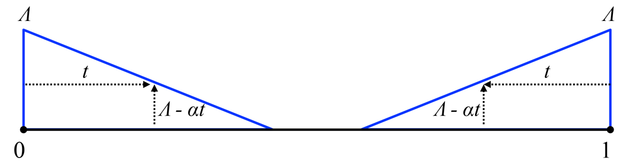


Figure 8: A moderate, multi-sided threat.

Proposition 2 (Political Fragmentation). *When the threat is multi-sided:*

1. *If $\Lambda \leq \frac{\alpha(1-\delta)}{2} - \frac{1}{4}\beta\delta^2 + \frac{\beta\delta}{2}(\frac{y}{4\theta\beta^2})^{1/3} + \frac{3}{4}(\frac{y^2}{4^2\theta^2\beta})^{1/3}$, the interval that is adequately protected is no less than δ so that the equilibrium outcome is the same as the case without any external threat ($\Lambda = 0$).*

2. *Otherwise, the revolution constraints are binding so that the interval that is adequately protected is exactly δ.*

3.3 Implications for Political Centralization or Fragmentation

We now use this simple setup to show that whether or not a continent is politically centralized or fragmented is shaped by its geographical characteristics and hence the nature of external threats that it faces.

Since there are many permutations of the external threat based on its strength (the value of Λ) and origins (one-sided or multi-sided), we will only focus on two particular scenarios that are directly relevant to this paper: (1) the case of a **severe** $\big(\Lambda > \alpha(1-\delta)\big)$ and one-sided threat; and (2) the case of a **moderate** $\big(\frac{1}{8}\beta\delta^2 + \frac{1}{4}\alpha(3-\delta) < \Lambda \leq \frac{\alpha(1-\delta)}{2} - \frac{1}{4}\beta\delta^2 + \frac{\beta\delta}{2}(\frac{y}{4\theta\beta^2})^{1/3} + \frac{3}{4}(\frac{y^2}{4^2\theta^2\beta})^{1/3}\big)$ but multi-sided threat. They are analogous to the Chinese case and the European case respectively. Figures 7 and 8 illustrate them graphically.

By Propositions 1 and 2, while an empire invests in the military only to protect itself against external threats, in a competitive state system regimes will invest in the military even in the absence of external threats so as to gain and maintain territorial control. Hence:

Implication 1. *In the absence of external threats, interstate competition is wasteful.*

Propositions 1 and 2 also imply that if the external threat is significant enough for an empire to spend a non-zero amount on the military, it will only provide adequate protection to a fraction δ of the population, so as to satisfy the revolution constraint, but no more than that (Figure 9). By contrast, in a competitive state system ($s = 2$), the competition-induced over-investment in the military may result in a larger-than-δ fraction of the continent being defended from external threats (Figure 10) Hence:

Implication 2. *When external threats are significant, interstate competition adequately protects a weakly bigger interval of the continent than an empire does.*

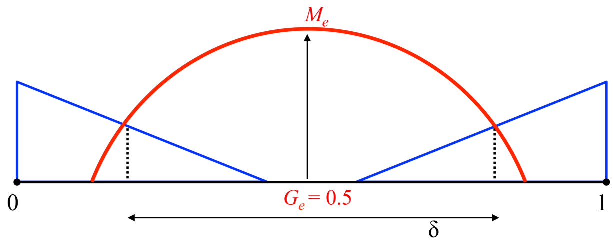


Figure 9: The optimal amount of military investment under political centralization.

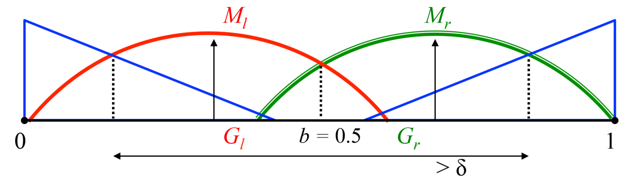


Figure 10: The optimal amount of military investment under political decentralization.

A regime is not **viable** if its equilibrium net tax revenue is negative. When $s = 1$ and regime e is not viable, then political centralization or empire cannot be a viable option for the continent, that is, even if an empire emerges, it is not sustainable in the long run. Likewise, when $s = 2$ and if either one or both regimes are not viable, political fragmentation is not a viable option for the continent.

Proposition 3 (Viability). *Under a one-sided threat, the net tax revenue of regime e is always larger than the sum of net tax revenues of regimes l and r. If the threat is sufficiently large, regime e is viable but regimes l and r are not. Under a moderate and multi-sided threat, the net tax revenue of regime e is decreasing in θ and β but the sum of net tax revenues for regimes l and r are increasing in θ and β.*

Proposition 3 gives rise to Implications 3 and 4 below:

Implication 3. *When the external threat is one-sided and severe, political centralization is more likely to be viable than political fragmentation.*

Implication 4. *When the external threat is moderate and multi-sided, political centralization is less likely to be viable than political fragmentation if θ or β is high.*

3.4 Taxation and Public Goods Provision

Now let us endogenize taxation. Previously, the amount of taxes paid in the continent was always equal to per capita income y. Suppose regime i has the option of reducing the tax burden of its people by $R_i \geq 0$. Lowering taxes (which is equivalent to providing a non-military public good that has a constant unit cost) eases the revolution constraint (as it helps keep the population happy) so that an individual at x does not engage in revolution if:

$$\underbrace{R_i}_{\text{tax reimbursement}} + \underbrace{M_i - \beta(G_i - x)^2}_{\text{military protection received}} - \underbrace{(\Lambda - \alpha x)}_{\text{expected damage from threat}} \geq 0 \qquad (1)$$

When $s = 1$, as long as the threat level is not insignificant, the revolution constraint will always bind in equilibrium regardless of whether the threats are one-sided or multi-sided. We show in Appendix A that if θ is sufficiently high, that is, if building a military is costly, the empire will opt to provide some tax reimbursement instead of relying solely on building the military to satisfy the revolution constraint.

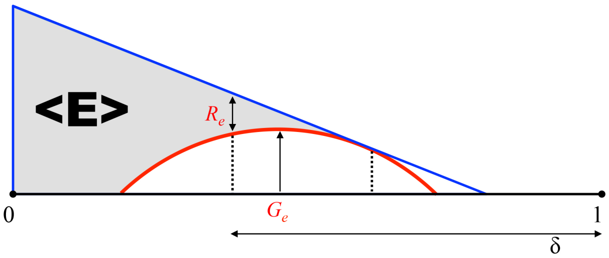


Figure 11: Under political centralization there is a positive level of tax reduction, i.e. $R_e^* > 0$. Under political decentralization tax reduction is zero.

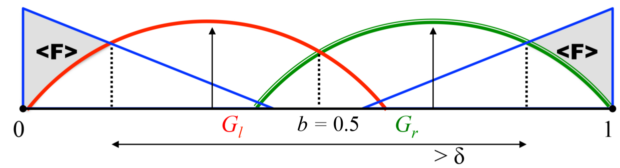


Figure 12: Fraction of the population are protected from invasion when the shock is one-sided compared to fraction of the population protected when the threat is multi-sided.

By contrast, when $s = 2$, the revolution constraint will not bind in equilibrium if the threat is not severe. Consequently, regimes l and r will set $R_l = R_r = 0$.

Consider the two scenarios that we are examining: in the case of a severe and one-sided threat, if an empire emerges the effective level of taxation will be $y - R_e$, where $R_e \geq 0$. In the case of a moderate and multi-sided threat, if interstate competition prevails, the level of taxation will remain at y. More generally we can state:

Implication 5. *Taxation is weakly lower and/or non-military public good provision weakly higher under political centralization than under political fragmentation.*

3.5 Population Dynamics and Long-run Growth

Until now, we have assumed that external threats are always present. Consider a dynamic model where in each period, the external threat is realized with some positive probability. Each individual lives for one period and inelastically supply labor to generate $\underline{y} + y$, where $\underline{y}$ is not taxable. For individual x under regime i, the disposable income is $\bar{y} = \underline{y} + R_i - \kappa_i(x)$ where y is the tax collected by the regime, R_i is the tax reimbursed by the regime, and $\kappa_i(x)$ is the net damage caused by the stochastic shock. Each individual chooses between private consumption c and producing n offspring to maximize her utility $c^{1-\gamma} n^{\gamma}$ subject to the budget constraint $\rho n + c \leq \bar{y}$, where ρ represents cost of rising a child. Standard optimization implies that the optimal number of children is

$$n = \frac{\gamma}{\rho} \cdot \bar{y} \, .$$

For simplicity, we assume that individuals redistribute themselves uniformly over the continent at the beginning of each period. Population growth is therefore given by:

$$N = \int_0^1 n dx = \int_0^1 \frac{\gamma}{\rho} \cdot \bar{y} \; dx \, .$$

Let N_E and N_F denote population growths in continent E and continent F respectively. The two continents are identical except that continent E is ruled by an empire ($s = 1$) and faces a severe one-sided threat of size Λ_E, which continent F is politically fragmented ($s = 2$) and faces a moderate multi-sided threat of size Λ_F.

When the external threat is not realized, the populations in the two continents grow to $N_E = \frac{\gamma}{\rho} \cdot (\underline{y} + R_e)$ and $N_F = \frac{\gamma}{\rho} \cdot (\underline{y})$ respectively. Since $N_E > N_F$, population grows faster under the empire.

However, the converse may be true if the external threat is realized. In this case, the realized population growths are given by:

$$N_E = \frac{\gamma}{\rho} \cdot \left\{ (\underline{y} + R_e) - \underbrace{\int_{x \notin \mathbb{P}_e} \Lambda_E - \alpha x - [M_e - \beta(G_e - x)^2] dx}_{\text{Area}\langle E \rangle} \right\};$$

$$N_F = \frac{\gamma}{\rho} \cdot \left\{ \underline{y} - \underbrace{2 \cdot \int_{x<b, x \notin \mathbb{P}_l} \Lambda_F - \alpha x - [M_l - \beta(G_l - x)^2] dx}_{\text{Area}\langle F \rangle} \right\},$$

where Area $\langle E \rangle$ and Area $\langle F \rangle$ are illustrated in Figures 11 and 12.

Given the nature of the threats and the political configurations in the two continents, Area $\langle E \rangle$ is likely to be larger than Area $\langle F \rangle$ for two reasons: First, $\Lambda_E > \Lambda_F$; Second, as we have shown in Implication 2, the empire offers adequate protection to only δ fraction of continent E (and less than δ if tax reduction is offered), while the fraction of continent F that is adequately protected is always weakly larger than δ due to the presence of interstate competition. If Area $\langle F \rangle <$ Area $\langle E \rangle - R_E$, it follows that $N_E < N_F$:

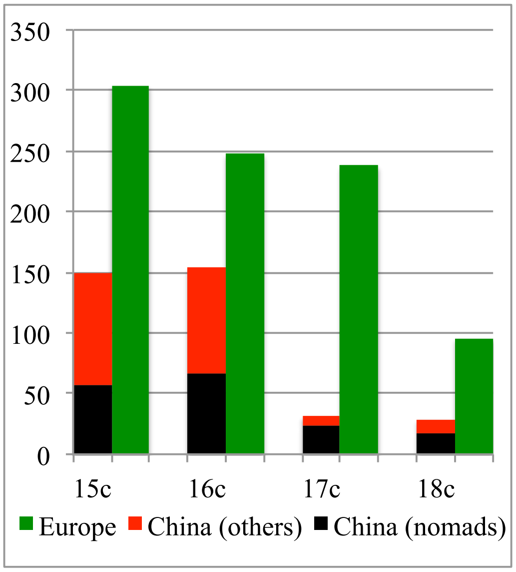
Implication 6. *If the external threat is not realized, population grows faster under political centralization. If the external threat is realized, a population contraction is more likely under political centralization than under political fragmentation.*

Implication 6 suggests that population growth is usually faster under an empire. However, in the event of an exogenous shock, the fall in population may be less severe under political fragmentation. In other words, population growth is likely to be more volatile under political centralization relative to political fragmentation.[15] As we discuss in Section 5, this has important consequences for the likelihood for modern economic growth to emerge either China or Europe.

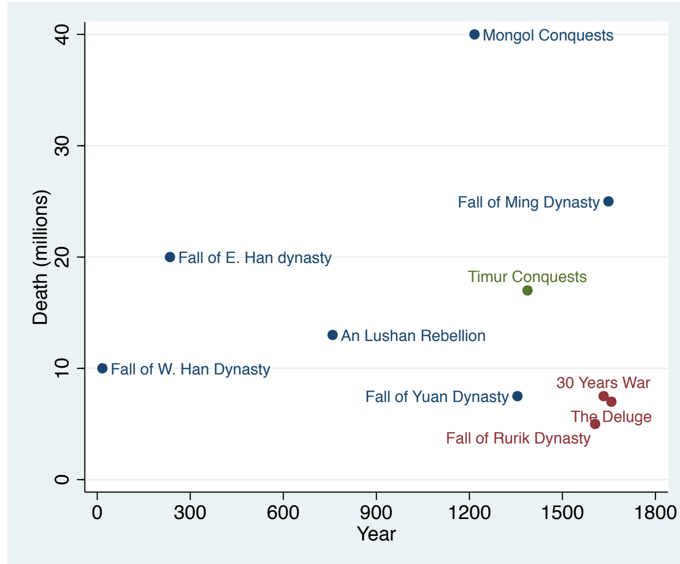
4 Predictions and Historical Evidence

We are now in a position to apply our theory to explain the historical evolution of political institutions in China and Europe. In particular, our framework yields several testable implications.

[15] In the Appendix we provide a numerical example of Implication 6. The example illustrates that even if the threat severity (Λ) is the same in continents E and F, in the event of an external shock the population may decline more under political centralization than under interstate competition because the latter offers adequate protection to a larger fraction of its population.



(a) Number of Violent Conflicts



(b) Largest Wars By No. of Deaths

Figure 13: The Frequency and Intensity of Warfare in China and Europe. For details on the data see main text and Appendix.

First, interstate competition is costly and our model predicts that this political fragmentation will lead to over investment in military power (Implication 1). While we do not explicitly model interstate warfare, this implication suggests that we should witness a greater frequency of interstate conflict in Europe relative to China, We document that this was in fact the case by presenting evidence on the frequency of interstate wars.

Second, the model predicts that Europe was more robust than China to external invasions (Implication 2). We show that this was indeed the case and that external invasions (and dynastic collapses) were extremely costly in China. Third, political centralization will be more likely when there is a large external threat and if that threat comes from a single direction (Implications 3 and 4). Thus our framework provides an analytical mechanism that can account for why political centralization was more persistent in China than in Europe. Furthermore, the model predicts that taxation is higher in Europe relative to China (Implication 5).

Finally, our framework suggests that population growth should be faster in China in the absence of external threats but outside invasions should be associated with a greater decline in population in China in comparison to Europe (Implication 6). This implies a greater volatility in population in China than in Europe, which is indeed what we observe in the data. More specifically, downturns in the Chinese population are closely connected to external invasions or the fall of a dynasty.

The frequency and intensity of warfare in China and Europe Figure 13a plots the number of armed conflicts in Europe and China between 1400 and 1800 derived from Peter Brecke's Conflict Catalog Dataset (Brecke, 1999). Armed conflicts including interstate and civil wars were much more common in

Europe. Additionally the vast majority of European wars were between other European states whereas a significant share of China's military conflicts between 1500 and 1800 were with nomads. However, when major wars did occur in China they were more likely to be extraordinarily violent. Figure 13b plots the ten most costly wars prior to 1800 over time. It is clear that the most violent wars of the preindustrial period occurred in Asia and particularly in China. In particular, the An Lushan Rebellion, the Ming-Manchu transition and the Mongol invasions were extraordinarily costly conflicts. Warfare in Europe was endemic but the war rarely resulted in large scale socio-economic collapse. As Paul Kennedy noted political fragmentation in Europe 'minimized the possibility that the continent could be overrun by an external force like the Mongol hordes' (Kennedy, 1987, 17).

External threats, the origins of centralization in China and the failure of European Empires Implications 3 and 4 are consistent with a history of fragmentation in Europe and centralization in China. China was first unified in 221 BC. In keeping with our theory, Lattimore (1940) attributed China's precocity in state-building to the relative proximity of the Eurasian steppes and the large river basins of China. His thesis, built upon in recent years by an increasing body of scholarship,[16] highlights the existence of a natural and unbridgeable geographical divide between the component regions of China and the steppes to their north and west. In China, sufficient rainfall and favorable soil conditions made possible the early development of agriculture, especially along the major river basins. In the steppe, pastoralism prevailed given the limitations imposed by the arid climate. Persistent tensions between the steppe nomads and the sedentary farmers, especially during prolonged periods of cold temperature, provided the impetus that pushed the Chinese regions toward unification (Bai and Kung, 2011; Chen, 2012).

Europe has historically been politically fragmented; the closest Europe came to be ruled by unified political system was under the Roman empire. The rise of Rome parallels the rise of the first empire in China (Scheidel, 2007). In terms of the model, one advantage Rome had over its rivals in the Hellenistic world was a lower θ. Rome's ability to project power and increase its resources of manpower was unequalled among European states in antiquity (Eckstein, 2011). Thus Rome was able to impose centralized rule upon much of Europe. Our model suggests that two factors can account for the decline of Rome: (1) over time, Rome's military advantage (θ_{Rome}) declined relative to the military capacities of its rivals such as the Sassanian empire or the Germanic confederacies; and (2) it faced threats from multiple directions.[17] Like episodes of dynastic and imperial collapse in China, the fall of the western Empire was associated with political disintegration and economic collapse across Europe (Ward-Perkins, 2005). However, unlike in China, all subsequent attempts to rebuild the Roman empire failed.

The most successful subsequent attempt to claim the mantle of Rome was the creation of a Frankish empire by the Carolingians. At its height under Charlemagne (768-814), the Carolingian empire controlled France, the Low Countries, Italy, Germany and central Europe. That Charlemagne was able to create and

[16]See, for example, Huang (1988); Perdue (2005); Lieberman (2009); Turchin (2009); Ma (2012); Deng (2012).
[17]These claims are consistent with the vast historical scholarship on this topic (see Heather, 2006).

administer such a large territorial expanse at all successfully was a testament to his personal ability and the ability of his immediate entourage. Apart from the king's officials (the *missi dominci*), the Frankish empire had no bureaucrats and was dependent on aristocrats with provincial loyalties and interests (see McKitterick, 2008; Costambeys et al., 2011).

Different external enemies threatened different parts of the empire (Vikings from the north, Saracens from the south, and Magyars from the east). As a result, the successors of Charlemagne struggled to defend their empire from external threats (Morrissey, 1997).[18] The division of the empire in 843 marks the end of point of Carolingian empire, although Carolingian rulers continued to rule in West Francia (France) for another century. Later attempts to rule the continent similarly failed. The Thirty Years Wars (1618-1648) ended in a stalemate that prevented the Habsburgs from dominating Europe. A coalition between the Austrians, Dutch and English prevented Louis XIV from likewise creating an Europe-wide dominion centered on France. Napoleon was briefly able to rule most of Europe under his authority but his empire proved extremely fragile and rapidly collapsed.

Taxation and public goods provision in China and Europe Scholarship in European economic history has shown that taxes were high in early modern European; furthermore, these sates did not in general provide non-military public goods. Tax revenues increased over time and were especially high in the Dutch Republic after 1600 and England after 1689 (Hoffman and Norberg, 1994; Bonney, 1995). Tax revenue increased in France as well (Johnson and Koyama, 2014*a*).[19] In contrast, taxes were comparatively low in China. Whereas European states relied heavily on indirect taxes includes exercise taxes, customs, and internal and external tariffs, the main tax in China was a land tax, 'there were few, if any, transit taxes or other tariffs within China' and the tax on land was comparatively light (Rosenthal and Wong, 2011, 174). Karaman and Pamuk (2013) provide data on taxes revenues as a share of GDP for a range of European countries. Table 1 depicts this data in conjunction with estimates of per capita tax revenue from China from Sng (2011). The per capita level of taxation as measured in silver was roughly five times higher compared to China. As China was a net importer of silver, the value of silver in China might have been higher than in Europe. To take this into account we use the bare-bones subsistence basket constructed in Allen et al. (2011) to estimate the tax burden in Europe and China and obtain similar results. Clearly, as Implication 5 suggests taxation was lighter under political centralized China than it was in fragmented Europe.

By and large, the taxes raised by European states were spent on warfare. In war years, over 75 percent of French revenue was spent on the military in the seventeenth century (Félix and Tallett, 2009, 155); in eighteenth century Britain, this figure varied between 61 and 74 per cent (Brewer, 1988, 32); while the peacetime military budget of Prussia during the eighteenth century accounted for 80 per cent of central

[18] Charles Oman in surveying the decline the Carolingian empire notes that 'three or four compact national kingdoms would be better able to cope with the Vikings than the vast but somewhat unwieldy empire of Charles the Great' (Oman, 1924, 95).

[19] Johnson and Koyama (2014*b*) document the increase in tax revenues at regional level in France throughout the seventeenth century.

	Per Capita Tax Revenue in silver (grams)		
	1700	1750	1780
England	91.9	109.1	172.3
France	43.5	48.7	77.6
Dutch Republic	210.6	189.4	228.2
Spain	28.6	46.2	59.0
European average	52.1	58.0 (27%)	77.3
China	10.4	11.8 (6%)	10.2

Table 1: Per capita tax revenue in grams of silver. European average tax revenue includes Venice, Austria, Russia, Prussia, and Poland-Lithuania in addition to England, France, Dutch Republic and Spain. Sources: Karaman and Pamuk (2013) and Sng (2011). In parentheses we include a comparison of per capita tax revenue as a proportion of 'bare-bones' subsistence in 1750 as measured by Allen et al. (2011). For further details on the calculations see Appendix A.6.

government expenditure (Wilson, 2009, 119). The major source of non-military social spending in early modern England was poor relief and other European states were at least as focused on war.

What about China? There is evidence that during the mid-eighteenth century, the Chinese state attempted to provide some non-military public goods such as granaries. Nevertheless, in China as in Europe, the majority of government revenue was spent on the military (Vries, 2012). The main difference was that China's total military spending was much lower:

> 'with roughly twenty times as many inhabitants, China, in real terms, per year on average only spent roughly 1.8 times as much on the military as Britain did during the period from the 1760s to the 1820s. Per capita in real terms Britain thus spent more than ten times as much on its army and navy than China' (Vries, 2012, 12).

This provides strong evidence in favor of Implication 5.

Population cycles in China and Europe. Implication 6 predicts that population growth should be more variable under political centralization because political centralization is associated with lower taxes during peacetime but also greater vulnerability to external shocks. We provide evidence in support of this proposition by drawing on population data from China and Europe. Figure 14 presents population estimates for Europe from McEvedy and Jones (1978) and from Cao (2000) for China. In general, the population of China was greater than that of Europe through the preindustrial period (a mean of 110.2 compared to 61.5 million) but the variance of the Chinese population was also much higher, more than five times greater than in Europe (7955 compared to 1638.82) between 0 and 1800. The only visible decline in European population visible in the McEvedy and Jones (1978) series is associated with the Black Death in the mid-fourteenth century.

Historians associate the sharps declines in Chinese population visible in the data with external invasions, political collapse and the fall of a dynasty: Mongol Invasions, the An Lushan Rebellion, and

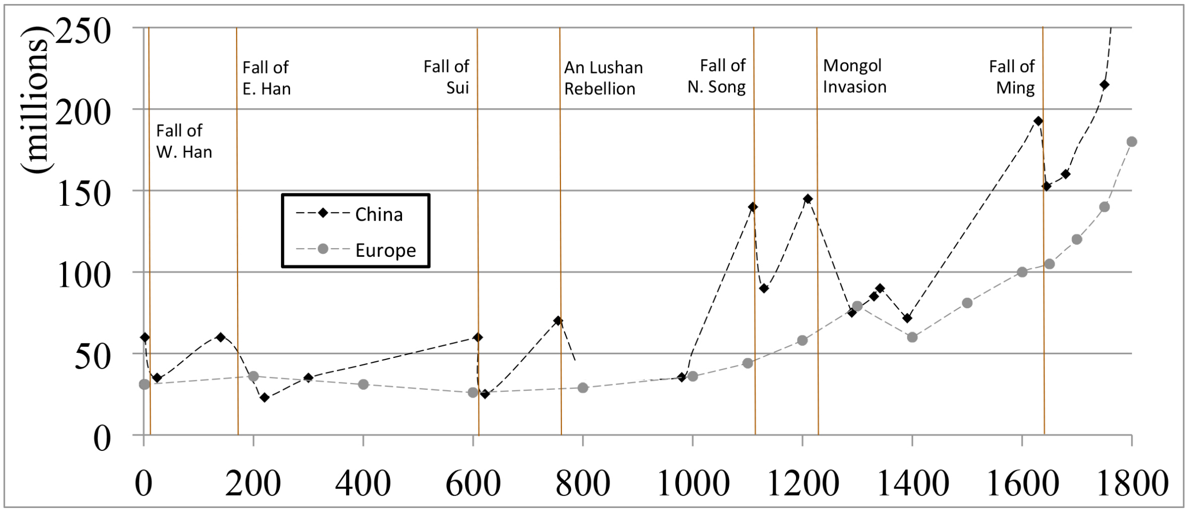


Figure 14: Estimated Population Levels in China and Europe and Major Political Crises in China. Sources: McEvedy and Jones (1978), Cao (2000). For more details, see footnote 20.

the fall of the Early and Later Han, Sui, Northern Song, Yuan, and Ming dynasties are all visible in in Figure 14.[20] For example, Kuhn observes that '[p]opulation figures took another dramatic turn downward between 1223 and 1264, and by 1292 in the whole of China the population had decreased by roughly 30 million, or one third of the population, to 75 million. This was probably due to a combination of factors—warfare in north China, the Mongol invasions, and the bubonic plague or other epidemics. Whatever the causes, this was a decline in human population on a magnitude that the world has seldom seen' (Kuhn, 2009, 75).

5 Implications for Long-Run Economic Growth

We can now study the implications our model has for our understanding of the onset of sustained economic growth. Since ideas are non-rival, a larger population should, all else equal, imply a higher rate of innovation (for an extended discussion see Kremer, 1993; Jones, 2001*a*).[21] Hence, all else equal, growth theory implies that sustained economic growth should have begun in the world's largest economy, in China, rather than in western Europe.

To understand the mechanisms responsible for the link between population size and economic development in the preindustrial period, we can focus on the canonical unified growth model developed by Galor and Weil (2000) in which the size of the population, together with the stock of technological

[20]We use the population estimates provided in Cao (2000) because of its coverage. The plunges in China's population depicted in Figure 14 would appear even more severe if we had used official statistics drawn from Chinese historical records instead. For example, official historical records suggest that China's population fell to 7 million in the third century after the collapse of the Han dynasty. A substantial amount of this population "loss" likely reflects the state's inability to keep accurate records during times of crises instead of actual deaths. By contrast, the corresponding population estimate is 23 million in Cao (2000).

[21]There are large number of models that rely on such a scale effect to explain the onset of modern economic growth. See Jones (2001*b*); Hansen and Prescott (2002); Galor and Weil (2000); Galor (2005).

knowledge, is a crucial state variable that has to reach a certain value in order to trigger the transition to modern economic growth. There are three growth regimes: a Malthusian growth regime in which technological progress translates into a higher population but not higher per capita incomes; a post-Malthusian growth regime characterized by faster population growth and technological progress and investment in human capital; and a modern growth regime in which technological progress outstrips population growth and there is sustained growth in per capita incomes.

Population growth in the Malthusian era was associated with economic growth through its effect on (a) the supply of innovative ideas, (b) the demand for new technologies, (c) the rate of technological diffusion, (d) the division of labor, and (e) the scope for trade (Galor, 2005, 239). Once the stock of technological knowledge becomes large enough, however, there is an incentive for parents to invest in human capital for their children. As a result parents switch from investing in a large number of children with no or low amounts of human capital to investing in a small-number of higher quality children thereby generating a demographic transition and a shift to a modern growth regime in which a sustained increase in per capita income can take place. This scale effect is deterministic; it predicts that the transition to sustained economic growth is inevitable and it does not say anything directly about where economic growth will occur.

This framework predicts that economic growth should be most likely to occur in the largest economy as that is where factors such as learning-by-doing, technological diffusion, and the supply of innovative ideas should be largest, all else equal. Nor is this prediction inconsistent with much of history; until around 1500 China was the most innovative part of the world economy (Mokyr, 1990).

However, sustained economic growth did not begin in China. This is a puzzle that unified growth theory can only account for by appealing to differences in how political or economic institutions shape the incentive to innovate. In this paper we provide a specific mechanism that can explain why sustained economic growth did not first take place in China. As a unified empire China was more vulnerable to collapsing as a direct or indirect consequence of the threat of external invasion. As a result China's population fluctuated widely during the preindustrial period and this undermined the gradual accumulation of technological knowledge that plays such an important role in generating the transition to sustained growth in the theoretical growth literature.

There are several channels through which we argue negative population shocks in China could have impeded technological innovation. First, technological knowledge was embodied in individuals therefore the large-scale collapses in China's population were associated with a fall in the stock of technology. Thus a more volatile population will be associated with a lower level of technological knowledge than an equally size but more stable population.

Alternatively, a complementary mechanism is present in the framework Aiyar et al. (2008) develop to explain episodes of technological regress. Aiyar et al. (2008) argue that many technologies require a minimum efficient scale. Therefore negative shocks that cause the extent of the market to contract, including a fall in the population, can bring about technological regress. Both of these explanations are consistent with our argument; if these mechanisms were operative then political centralization did not only make China more vulnerable to negative economic shocks, it also reduced the possibility of modern economic growth emerging in East Asia.

6 Conclusion

The idea that Europe's political and economic success is related to its political fragmentation goes back to the Enlightenment. Montesquieu noted that in contrast to Asia where strong nations are able to conquer and subdue their neighbors, in 'Europe on the contrary, strong nations are opposed to the strong; and those who join each other have nearly the same courage. This is the reason of the weakness of Asia and of the strength of Europe; of the liberty of Europe, and of the slavery of Asia' (Montesquieu, 1748, 1989, 266).

In this paper we have proposed a novel theory of the origins, persistence, and consequences of political centralization and fragmentation in both China and Europe. We build on the argument that the threat of nomadic invasion was a powerful force for political unification in China, but less of a factor in Europe. Our theory suggests that political centralization should indeed be stable in China, but not in Europe, and that this centralization was beneficial from a static perspective as it minimized costly interstate competition. However, we show that in the event of an external invasion a decentralized state system was more robust than a centralized empire. By extending this political economy model to allow for population growth, we show that a political centralized state, such as China, will tend to experience more volatile population growth than will a set of independent states. We draw on insights from growth theory to argue that this volatility can help to account for China's failure to achieve modern economic growth in the period before 1800.

Other scholars have argued that decentralization gave Europe an edge in the Great Divergence because it led to greater innovation (Mokyr, 1990; Diamond, 1997; Mokyr and Voth, 2010); support for merchants (Rosenberg and L.E. Birdzell, 1986) or political freedoms and representation (Hall, 1985). Our theory complements these existing arguments but emphasizes two additional and previously neglected parts of the puzzle. We show that geographical factors made political fragmentation more viable in Europe than in China and we emphasize the significance of one previously neglected consequence of political centralization in China. There were periods of economic expansion, innovation, and population growth in China, but these were brought to a halt by external invasions and political crises. It was these population crises, we suggest, that help to explain why China did not enter a period of sustained economic growth in the preindustrial period. In contrast, Europe's polycentric system of states gave it the institutional robustness that was one of the preconditions for modern economic growth to occur.

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A Online Appendix

A.1 Proposition 1

We restate the Proposition 1 with technical details.

Proposition 1. *When the threat is multi-sided:*

1. *If* $\Lambda \leq \frac{\alpha(1-\delta)}{2}$*, we have* $M_e = 0$.
2. *If* $\frac{\alpha(1-\delta)}{2} < \Lambda \leq \frac{1}{8}\beta\delta^2 + \frac{1}{4}\alpha(3-\delta)$*, the regime spends a non-zero amount (*$M_e = \beta(\frac{\delta}{2})^2 + 2\Lambda - \alpha > 0$*) on the military to confront the threat emanating from one frontier (*$G_e^* = 1 - \left(\delta - \left(1 - 2\frac{\Lambda}{\alpha}\right)\right)$ *or* $\delta - \left(1 - 2\frac{\Lambda}{\alpha}\right)$*) while ignoring the threat from the other frontier;*
3. *If* $\Lambda > \frac{1}{8}\beta\delta^2 + \frac{1}{4}\alpha(3-\delta)$*, the regime locates the capital city at the center of the continent (*$G_e^* = \frac{1}{2}$*)and spends a non-zero amount (*$M_e = \beta\left(\frac{\delta}{2}\right)^2 + \Lambda - \frac{\alpha}{2}(1-\delta)$*)on the military to confront the threat emanating from both frontiers;*

When the threat is one-sided:

4. *If* $\Lambda \leq \alpha(1-\delta)$*, the equilibrium military investment is zero;*
5. *If* $\Lambda > \alpha(1-\delta)$*, the regime spends a non-zero amount (*$M_e = \Lambda - \alpha(1-\delta)$*) on the military to confront the threat emanating from* $x = 0$.

Proof. First, it is clear that if $\Lambda < \alpha(1-\delta)/2$, then the optimal military investment is zero if location of capital is at the middle. Since the payoff is decreasing with military investment, then it is optimal to only invest zero.

Second if threat sufficiently high such that $\Lambda > \alpha$, then every location on the continent faces the same threat $2\Lambda - \alpha$ so that the optimal investment is $M_e = \beta(\frac{\delta}{2})^2 + 2\Lambda - \alpha$ and optimal location can be anywhere in $[\delta/2, 1-\delta/2]$, so that the center of continent is still an optimal location.

Now consider the intermediate case when $\alpha(1-\delta)/2 < \Lambda < \alpha$. We will compare two cases: (i) two sides are protected, and (ii) only one side is protected. Case (i): Suppose the regime is protecting both sides of the continent under threat. Let $G_e - x$ be leftmost location of the regime where the net threat is zero. Hence, x is the further distance from the left of the capital to have zero net threat. Since military investment is costly, the optimal solution implies that revolutionary constraint is binding so that only δ fraction of people have zero net threat. Therefore, we have the following system of equations:

$$M = \beta(\gamma - x)^2 + \Lambda - \alpha x\ ,$$
$$M = \beta(1 - \gamma - (1-\delta-x))^2 + \Lambda - \alpha(1-\delta-x)\ .$$

Hence,

$$x = \frac{1}{2\alpha + 2\beta\delta}\left(\alpha - \alpha\delta - \beta\delta^2 + 2\beta G\delta\right) \ .$$

Note that

$$\frac{dx}{dG} = \frac{2\beta\delta}{2\alpha + 2\beta\delta} \ .$$

The centralized regime's objective function is to choice the location of capital to minimize military expense:

$$\min_G M = \beta\left(G - x\right)^2 + \Lambda - \alpha x \ ,$$

such that

$$x = \frac{1}{2\alpha + 2\beta\delta}\left(\alpha - \alpha\delta - \beta\delta^2 + 2\beta\gamma\delta\right) \ .$$

We have the following FOC

$$\begin{aligned}
\frac{dM}{dG} &= 2\beta\left(G - x\right)\left(1 - \frac{dx}{dG}\right) - \alpha\left(\frac{dx}{dG}\right) \\
&= 2\beta\left(\gamma - \frac{1}{2\alpha + 2\beta\delta}\left(\alpha - \alpha\delta - \beta\delta^2 + 2\beta\gamma\delta\right)\right)\left(\frac{2\alpha}{2\alpha + 2\beta\delta}\right) - \alpha\frac{2\beta\delta}{2\alpha + 2\beta\delta} \\
&= \alpha^2\frac{\beta}{\left(\alpha + \beta\delta\right)^2}\left(2\gamma - 1\right)
\end{aligned}$$

The SOC is

$$\frac{d^2M}{dG^2} = \frac{2\beta\alpha^2}{\left(\alpha + \beta\delta\right)^2} > 0 \ .$$

Hence, we have

$$G^* = 1/2 \ .$$

This implies

$$\begin{aligned}
x &= \frac{1}{2\alpha + 2\beta\delta}\left(\alpha - \alpha\delta - \beta\delta^2 + 2\beta\left(\frac{1}{2}\right)\delta\right) \ , \\
&= \frac{1}{2}\left(1 - \delta\right) \ ,
\end{aligned}$$

and

$$\begin{aligned}
M^* &= \beta\left(G - x\right)^2 + \Lambda - \alpha\left(x\right) \\
&= \beta\left(\frac{\delta}{2}\right)^2 + \Lambda - \frac{\alpha}{2}\left(1 - \delta\right) \ .
\end{aligned}$$

Now consider case (ii) that the regime only protects one side. Then we have

$$
\begin{aligned}
G &= 1-\left(\delta-\left(1-2\frac{\Lambda}{\alpha}\right)\right)\\
&= 2-\delta-2\frac{\Lambda}{\alpha}\\
M &= \Lambda-\alpha\left(2-\delta-2\frac{\Lambda}{\alpha}\right)\\
&= \Lambda-2\alpha+\alpha\delta+2\Lambda\\
&= 3\Lambda-2\alpha+\alpha\delta
\end{aligned}
$$

Hence, the regime will be located at 1/2 if $3\Lambda-2\alpha+\alpha\delta>\beta\left(\frac{\delta}{2}\right)^2+\Lambda-\frac{\alpha}{2}\left(1-\delta\right)$ or

$$
\begin{aligned}
0 &< 3\Lambda-2\alpha+\alpha\delta-\left(\beta\left(\frac{\delta}{2}\right)^2+\Lambda-\frac{\alpha}{2}\left(1-\delta\right)\right)\\
&= 2\Lambda-\frac{1}{4}\beta\delta^2+\frac{1}{2}\alpha\delta-\frac{3}{2}\alpha\\
&= 2\Lambda-\frac{1}{4}\beta\delta^2+\frac{1}{2}\alpha\left(\delta-3\right)
\end{aligned}
$$

as desired. Finally consider a one-sided threat. It is clear that if $\Lambda\leq\alpha(1-\delta)$, then the optimal military investment is zero if location of capital is at the middle. Since the payoff is decreasing with military investment, then it is optimal to only invest zero. Now consider $\Lambda>\alpha\left(1-\delta\right)$, the regime need to have a positive investment. Since military investment is costly, the optimal solution implies that revolutionary constraint is binding so that only δ fraction of people have zero net threat. Therefore, we have the following

$$
\begin{aligned}
G &= 1-\delta\\
M &= \Lambda-\alpha\left(1-\delta\right)
\end{aligned}
$$

as desired. □

A.2 Proposition 2

Before proving Proposition 2, it is convenient to characterize the result of interstate competition in the absence of external threat. First, the border of two regimes b is defined by

$$
M_l-\left(b-G_l\right)^2\beta=M_r-\left(\left(1-G_r\right),-b\right)^2\beta
$$

subject to the constraints that

$$M_l - (b - G_l)^2 \beta \geq 0\,;$$
$$M_r - ((1-b) - G_r))^2 \beta \geq 0\,.$$

If the above inequalities are not satisfied, the land is split between two regime. (this cannot occur in equilibrium). Hence, we have border to be a function of M_l, M_r, G_l and G_r

$$b\left(M_l, M_r, G_l, G_r\right) = \frac{M_l - M_r}{2\beta\left(1 - \left(G_r + G_l\right)\right)} + \frac{\left(1 - G_r\right) + G_l}{2}\,.$$

We can now establish.

Lemma 1. *When there is no nomadic threat, the interstate competition between two states implies that equilibrium military expenses are the same for both regimes:*

$$M_l^* = M_r^* = \frac{y}{4\beta\theta\left(1 - \left(G_r + G_l\right)\right)}$$

and the distance of the two capitals is

$$1 - \left(G_r + G_l\right) = \left(\frac{y}{4\theta\beta^2}\right)^{1/3}$$

Proof. We will solve the model by backward induction. We solve first the military investment problem given locations of two capitals and then solve for location of two capitals.

Since regime 1 has surplus $V_l \equiv by - \theta M_l^2$, the optimization problem is

$$\begin{aligned}\max_{M_l} V_l &= by - \theta M_l^2 \\ &= \left(\frac{M_l - M_r}{2\beta\left(1 - \left(G_r + G_l\right)\right)} + \frac{\left(1 - G_r\right) + G_l}{2}\right)(y) - \theta M_l^2\end{aligned}$$

so that FOC is (SOC is ok)

$$\frac{y}{2\beta\left(1 - \left(G_r + G_l\right)\right)} - 2\theta M_l = 0$$

or

$$M_l^* = \frac{y}{4\beta\theta\left(1 - \left(G_r + G_l\right)\right)}$$

Similarly, we have similar optimization problem and equilibrium solution for regime 2. Hence, we have

$$M_r^* = \frac{y}{4\beta\theta\left(1 - \left(G_r + G_l\right)\right)}$$

By backward induction, for regime one is

$$\max_{G_l}\left(\frac{M_l^*-M_r^*}{2\beta\left(1-\left(G_r+G_l\right)\right)}+\frac{\left(1-G_r\right)+G_l}{2}\right)(y)-\theta\left(M_l^*\right)^2$$

so that we have

$$\max_{G_l}\left(\frac{1-G_r+G_l}{2}\right)y-\theta\left[\frac{y}{4\beta\theta\left(1-\left(G_r+G_l\right)\right)}\right]^2$$

so that FOC is (SOC is negative)

$$\frac{y}{2}+\frac{y^2}{16\beta^2 c}\frac{-2}{\left(1-\left(\gamma_2+\gamma_1\right)\right)^3}=0$$

Therefore, we have

$$1-\left(G_r+G_l\right)=\left(\frac{y}{4\theta\beta^2}\right)^{1/3}$$

It is easy to see that the same expression can be obtained from solving the optimization problem for regime 2. Finally, we need to check if the military provision at the border is positive at the border The military provision at the border is

$$\begin{aligned}
&M_l^*-\left(b^*-G_l\right)^2\beta\\
&=M_l^*-\left(\frac{M_l^*-M_r^*}{2\beta\left(1-\left(G_r+G_l\right)\right)}+\frac{1-G_r^*+G_l^*}{2}-G_l\right)^2\beta\\
&=\frac{y}{4\beta\theta\left(1-\left(G_r^*+G_l^*\right)\right)}-\left(\frac{\left(1-\left(G_r^*+G_l^*\right)\right)}{2}\right)^2\beta
\end{aligned}$$

This is positive if and only if

$$\left(1-\left(G_r^*+G_l^*\right)\right)^3\leq\frac{y}{\theta\beta^2}$$

Since $1-\left(G_r^*+G_l^*\right)=\left(\frac{y}{4\theta\beta^2}\right)^{1/3}$, this implies the non-negativity constraint is satisfied. □

To determine the exact location of the two regimes, we either use bargaining or Tullock competition. Or we can use dynamics moving. (assuming capital starts at symmetric location, say 0 and 1, allow capital to move, we then look for the stable steady state, there is a unique one in symmetric case). All above assumptions will imply the border is at 1/2. Hence, we have

$$\begin{aligned}
G_l^*&=G_r^*=\frac{1}{2}\left(1-\left(\frac{y}{4\theta\beta^2}\right)^{1/3}\right)\\
M_l^*&=M_r^*=\frac{y}{4\beta\theta\left(1-\left(G_r^*+G_l^*\right)\right)}=\frac{y}{4\beta\theta\left(\frac{y}{4\theta\beta^2}\right)^{1/3}}=\frac{y^{2/3}}{4^{2/3}\beta^{1/3}\theta^{2/3}}
\end{aligned}$$

Consider there is nomadic threat. Let x be the most left locations in regime 1 that receives zero net nomadic threat. The no-revolution constraint implies (each regime need to satisfy δ fraction of people)

$$M_l - (G_l - x)^2 = h - \alpha x$$
$$b - x \geq \delta b$$

so that we have

$$x = (1 - \delta)\, b$$

In a symmetric equilibrium where $b = 1/2$, we have $x = 0.5\,(1 - \delta)$. Hence, we have

$$M_l - \left(\gamma_1 - \frac{1}{2}(1-\delta)\right)^2 \beta - \left(\Lambda - \frac{\alpha}{2}(1-\delta)\right) = 0$$

This implies that in order for the interstate competition result to remain intact under no-revolution constraint, the level of military expense has to be at least as M_l^{**}:

$$\begin{aligned} M_l^{**} &= \Lambda - \frac{\alpha}{2}(1-\delta) + \beta\left(G_l^* - \frac{1}{2}(1-\delta)\right)^2 \\ &= \Lambda - \frac{\alpha}{2}(1-\delta) + \beta\left(\frac{1}{2}\left(1 - \left(\frac{y}{4\theta\beta^2}\right)^{1/3}\right) - \frac{1}{2}(1-\delta)\right)^2 \\ &= \Lambda - \frac{\alpha}{2}(1-\delta) + \frac{\beta}{4}\left(\left(\frac{y}{4\theta\beta^2}\right)^{1/3} - \delta\right)^2 \end{aligned}$$

Now let us restate Proposition 2.

Proposition 2 (Political Fragmentation). *When the threat is multi-sided:*

1. *If $\Lambda \leq \frac{\alpha(1-\delta)}{2} - \frac{1}{4}\beta\delta^2 + \frac{\beta\delta}{2}(\frac{y}{4\theta\beta^2})^{1/3} + \frac{3}{4}(\frac{y^2}{4^2\theta^2\beta})^{1/3}$, the interval that is adequately protected is no less than δ so that the equilibrium outcome is the same as the case without any external threat ($\Lambda = 0$).*

2. *Otherwise, the revolution constraints are binding so that the interval that is adequately protected is exactly δ.*

Proof. If $M_l^* = \frac{y^{2/3}}{4^{2/3}\beta^{1/3}\theta^{2/3}} > M_l^{**} = \Lambda - \frac{\alpha}{2}(1-\delta) + \frac{\beta}{4}\left(\left(\frac{y}{4\theta\beta^2}\right)^{1/3} - \delta\right)^2$, then no-revolution constraint is not binding. By rearranging the inequality, we obtain the desired condition 1. Given that payoff is negative infinity for revolution, the two regimes will make sure that exactly δ fraction of people are happy. □

A.3 Proposition 3

Proposition 3 (Viability). *Under a one-sided threat, the net tax revenue of regime e is always larger than the sum of net tax revenues of regimes l and r. If the threat is sufficiently large, regime e is viable* *but regimes l and r are not. Under a moderate and multi-sided threat, the net tax revenue of regime e is decreasing in θ and β but the sum of net tax revenues for regimes l and r are increasing in θ and β.*

Proof. First consider the case with one-sided threat. Suppose to the contrary that

$$V_e^* < V_l^* + V_r^* .$$

Then regime e can mimic the choices of regime l, set $G_e = G_l^*$ and $M_e = M_l$, and obtain a payoff that is greater than the sum of net tax revenues of regimes l and r, which is a contradiction. Hence, we have

$$V_e^* \geq V_l^* + V_r^* .$$

The inequality becomes strict since regime r non-zero military investment. To show implication 3, first notet that both V_e^* and $V_l^* + V_r^*$ are decreasing in Λ. As the threat increases steadily in severity (as Λ increases), beyond some value of Λ, $V_l^* + V_r^*$ will turn negative while V_e^* is still positive.

Consider the case with multi-sided threats. The surplus of the centralized regime under moderate threat is

$$V_e = y - \theta \left(\beta \left(\frac{\delta}{2} \right)^2 + \Lambda - \frac{\alpha}{2} (1 - \delta) \right)^2$$

and the surplus of regime l (or r) is $V_r = V_l = \frac{y^{4/3}}{4^{4/3} \beta^{2/3} \theta^{1/3}}$. Let $\Delta V \equiv V_e - (V_l + V_r)$ be the difference of surplus between centralized regime and two-regime. We have

$$\Delta V = -\theta \left(\beta \left(\frac{\delta}{2} \right)^2 + \Lambda - \frac{\alpha}{2} (1 - \delta) \right)^2 + 2 \frac{y^{4/3}}{4^{4/3} \beta^{2/3} \theta^{1/3}}$$

The comparative statics results is as follows:

$$\frac{\partial \Delta V}{\partial \Lambda} < 0; \frac{\partial \Delta V}{\partial \alpha} > 0$$
$$\frac{\partial \Delta V}{\partial \beta} < 0; \frac{\partial \Delta V}{\partial \theta} < 0$$
$$\frac{\partial \Delta V}{\partial \delta} < 0; \frac{\partial \Delta V}{\partial y} > 0$$

□

A.4 Tax Reimbursement

Claim. If $\Lambda - \alpha (1 - \delta) > \frac{1}{2\theta}$, the empire always provides a strictly positive amount of tax reimbursement ($R > 0$).

Proof. Consider the case of an empire facing one-sided threat. In the second stage, the optimization problem is

$$\max_{R,M} V_e = y - \left(R + \theta M^2\right)$$

such that

$$\begin{aligned} R + M - \beta \left(G - (1-\delta)\right)^2 - \left(\Lambda - \alpha\left(1-\delta\right)\right) &\geq 0 \\ R &\geq 0 \\ M - \beta\left(G - x\right)^2 &\geq \Lambda - \alpha x \text{ for some } x \leq \Lambda/\alpha \end{aligned}$$

where the last constraint ensures that there exists some location that suffers zero threat. Since the net revenue is decreasing in M and R, the first constraint must be binding in equilibrium. Returning to the last constraint, if $M - \beta\left(G - x\right)^2 \geq \Lambda - \alpha x$ for some $x \leq \Lambda/\alpha$, it must be the case that

$$\max_{x} M - \beta\left(G - x\right)^2 - \Lambda + \alpha x \geq 0$$

Therefore, we only need to consider x such that

$$2\beta\left(G - x\right) + \alpha = 0 \text{ or } x = G + \frac{\alpha}{2\beta}$$

We ignore the non-negativity constraint of R because we already know the solution when $R = 0$. Therefore, the problem becomes

$$\max_{R,M} y - \left(R + \theta M^2\right)$$

such that

$$\begin{aligned} R + M - \beta \left(G - (1-\delta)\right)^2 - \left(\Lambda - \alpha\left(1-\delta\right)\right) &= 0 \\ M - \beta\left(\frac{\alpha}{2\beta}\right)^2 &\geq \Lambda - \alpha\left(G + \frac{\alpha}{2\beta}\right) \end{aligned}$$

The corresponding Lagrangian is

$$\begin{aligned} L = {} & y - \left(R + \theta M^2\right) + \phi\left(R + M - \beta\left(G - (1-\delta)\right)^2 - \left(\Lambda - \alpha\left(1-\delta\right)\right)\right) \\ & + \lambda\left(M - \beta\left(\frac{\alpha}{2\beta}\right)^2 - \Lambda + \alpha\left(G + \frac{\alpha}{2\beta}\right)\right) \end{aligned}$$

then we have

$$
\begin{aligned}
(M) &: -2\theta M + \phi + \lambda = 0 \\
(R) &: -1 + \phi = 0 \\
(\phi) &: R + M - \beta \left(G - (1-\delta)\right)^2 - \left(\Lambda - \alpha \left(1-\delta\right)\right) = 0 \\
(\lambda) &: \lambda \left(M - \beta \left(\frac{\alpha}{2\beta}\right)^2 - \Lambda + \alpha \left(G + \frac{\alpha}{2\beta}\right)\right) \geq 0 \\
\lambda &= 0 \text{ or } M - \beta \left(\frac{\alpha}{2\beta}\right)^2 = \Lambda - \alpha \left(G + \frac{\alpha}{2\beta}\right)
\end{aligned}
$$

Case 1) Suppose $\lambda = 0$. Then we have

$$
\begin{aligned}
M &= \frac{1}{2\theta} \\
R &= \frac{-1}{2\theta} + \beta \left(G - (1-\delta)\right)^2 + \left(\Lambda - \alpha \left(1-\delta\right)\right)
\end{aligned}
$$

Case 2) Consider $\lambda \neq 0$, and we have

$$
\begin{aligned}
M &= \beta \left(\frac{\alpha}{2\beta}\right)^2 + \Lambda - \alpha \left(G + \frac{\alpha}{2\beta}\right) \\
R &= -M + \beta \left(G - (1-\delta)\right)^2 + \left(\Lambda - \alpha \left(1-\delta\right)\right) \\
&= \frac{1}{4\beta} \left(\alpha - 2\beta + 2G\beta + 2\beta\delta\right)^2 > 0
\end{aligned}
$$

Since the tax rebate is always positive in Case 2, we only need to consider the choice of the capital city in Case 1:

$$
\begin{aligned}
\max_G V_e &= y - \left(R + \theta M^2\right) \\
&= y - \left(-\frac{1}{2\theta} + \beta \left(G - (1-\delta)\right)^2 + \left(\Lambda - \alpha \left(1-\delta\right)\right) + \theta \left(\frac{1}{2\theta}\right)^2\right)
\end{aligned}
$$

The FOC is

$$
-2\beta \left(G - (1-\delta)\right) = 0
$$

where SOC is negative (hence this is a maximization problem). We have

$$
\begin{aligned}
G &= 1 - \delta \\
R &= -\frac{1}{2\theta} + \left(\Lambda - \alpha \left(1-\delta\right)\right) \\
M &= \frac{1}{2\theta}
\end{aligned}
$$

Note that

$$V_e = y - \left(-\frac{1}{2\theta} + (\Lambda - \alpha(1-\delta)) + \frac{1}{4\theta}\right)$$
$$= y - (\Lambda - \alpha(1-\delta)) + \frac{1}{4\theta}$$

Recall that if tax reimbursement is zero:

$$V_e(R=0) = y - \theta(\Lambda - \alpha(1-\delta))^2$$

We have

$$y - (\Lambda - \alpha(1-\delta)) + \frac{1}{4\theta} - \left(y - \theta(\Lambda - \alpha(1-\delta))^2\right)$$
$$= \theta\left((\Lambda - \alpha(1-\delta))^2 - \frac{1}{\theta}(\Lambda - \alpha(1-\delta)) + \frac{1}{4\theta^2}\right)$$
$$= \theta\left((\Lambda - \alpha(1-\delta)) - \frac{1}{2\theta}\right)^2 \geq 0$$

Since $(\Lambda - \alpha(1-\delta)) > \frac{1}{2\theta}$, net revenue is higher when R is positive, as desired. $\square$

B A Numerical Example

We illustrate Implication 6 using a simple numerical example. Let: $\Lambda = 20$, $\alpha = 35$, $\beta = 100$, $\delta = 0.45$, $y = 1500$, and $\theta = 1$. To show $N_F > N_E$, it suffices to demonstrate Area $\langle E\rangle + R_e <$ Area $\langle F\rangle$.

For continent E, the capital city is located at $1 - \delta = 0.55$, military investment is $M = 1/(2\theta) = 0.5$, and the tax rebate is $R_e = -\frac{1}{2\theta} + (\Lambda_E - \alpha(1-\delta)) = 0.25$. Subsequently, Area $\langle E\rangle + R_e = -5.432\,7$.

For continent F, the location of two capital cities are given by $G_l = G_r = \frac{1}{2} - \frac{1}{2}\left(\frac{y}{4\theta\beta^2}\right)^{1/3} = 0.33264$. Each regimes invests $M = \frac{y^{2/3}}{4^{2/3}\beta^{1/3}\theta^{2/3}} = 11.204$. Subsequently, Area $\langle F\rangle = 4.6374$.

Since Area $\langle E\rangle + R_e -$ Area $\langle F\rangle = -5.4327 + 4.6374 = -0.7953 < 0$, we show that in this case, the population falls more sharply under political centralization than under political fragmentation when the shock is realized.

C A Growth Model Adapted from Aiyar et al. (2008)

In this section we directly adapt the model developed by Aiyar, Dalgaard, Moav (2008). This framework enables us to demonstrate that an economy that suffers negative shocks to its population can experience technological regress.

Consider a Malthusian environment where land is a fixed factor of production and intermediate goods are employed to produce the final output. Production of each variety of intermediate good requires the use of labor and specific knowledge owned by some individuals. New ideas are discovered in each period and can be used to produce new variety; but only when market is large enough to support further division of labor. Technology progresses when new ideas are adopted and variety of intermediate good expands.

The technology to produce final good Z_t is given by

$$Z_t = K^{1-\alpha} \int_0^{N_t} x_t(j)^\alpha \, dj \ ,$$

where K is efficient unit of land, N_t is the number of intermediate good in period t, $x(j)$: intermediate good j where $j \in [0, N_t]$ and $\alpha \in (0, 1/2)$ by assumption.

Aggregate income is equal to:

$$Y_t = Z_t - \theta_t N_t = K^{1-\alpha} \int_0^{N_t} x_t(j)^\alpha \, dj - \theta_t N_t \ ,$$

where θ_t is a fixed cost of production of each intermediate good. Since the final good sector is competitive, by envelope theorem, factors prices are:

$$\begin{aligned} R_t &= \frac{\partial Y_t}{\partial K} = (1-\alpha) K^{-\alpha} \int_0^{N_t} x_t(j)^\alpha \, dj \\ p_t(j) &= \frac{\partial Y_t}{\partial x_t} = \alpha K^{1-\alpha} x_t(j)^{\alpha-1} \ , \end{aligned}$$

where R_t is rent of land and $p_t(j)$ is price of intermediate good j at period t. Hence demand for $x_t(j)$ is

$$x_t(j) = K \left(\frac{\alpha}{p_t(j)} \right)^{\frac{1}{1-\alpha}} \ .$$

Since any knowledgable individual can operate an intermediate good firm with following production function.

$$x_t(j) = l_t(j) \ ,$$

where $l_t(j)$ is the labor employed by firm j in period t. The profit of intermediate good firm in period t is

$$\pi_t = x_t(p_t - w_t) - \theta_t \ ,$$

where $\theta_t = \delta N_t$. Each monopolist will produce under marginal cost is marginal revenue

$$w_t = \frac{\partial}{\partial x_t(j)} p_t(j) \, x_t(j) = \alpha^2 K^{1-\alpha} x_t(j)^{\alpha-1} = \alpha p_t(j) \ \text{ or } p_t = \frac{w_t}{\alpha} \ ,$$

where w_t is the real wage of period t. This implies that optimal production is

$$x_t(j) = K\left(\frac{\alpha}{p_t(j)}\right)^{\frac{1}{1-\alpha}} = K\left(\frac{\alpha^2}{w_t}\right)^{\frac{1}{1-\alpha}} .$$

We can define

$$\begin{aligned}\pi(w_t, \theta_t; K) &\equiv K\left(\frac{\alpha^2}{w_t}\right)^{\frac{1}{1-\alpha}}\left(\frac{w_t}{\alpha} - w_t\right) - \theta_t \\ &= (1-\alpha)\,\alpha^{\frac{1+\alpha}{1-\alpha}} w_t^{\frac{\alpha}{\alpha-1}} K - \theta_t ,\end{aligned}$$

as the equilibrium profit function. Define N_t^* to be the number of variety when each intermediate firm earns zero profit $\pi(w_t, \delta N_t^*; K_t) = 0$.

We consider a symmetry equilibrium with free entry of immediate goods market. If $H_t > N^*(L_t; K)$, excessive competition implies zero profit so that $N_t = N_t^*$. Otherwise, individuals owning specific knowledge earns positive profit, or $N_t = H_t$. Hence we have

$$N_t = \begin{cases} H_t & \text{if } H_t < N^*(L_t; K) , \\ N_t^* & \text{if } H_t > N^*(L_t; K) ; \end{cases}$$

Labor market clearance imply

$$L_t = x_t N_t = \begin{cases} x_t H_t & \text{if } H_t < N^*(L_t; K) , \\ x_t N_t^* = \alpha^{\frac{2}{1-\alpha}} w_t^{\frac{1}{\alpha-1}} K N_t^* & \text{if } H_t > N^*(L_t; K) ; \end{cases}$$

Aggregate income is therefore

$$Y_t = \begin{cases} K^{1-\alpha} H_t^{1-\alpha} L_t^{\alpha} - \delta H_t^2 , & \text{if } H_t < N^*(L_t; K) , \\ \Omega\left(K^{1-\alpha} L_t^{\alpha}\right)^{\frac{2}{1+\alpha}} ; & \text{if } H_t > N^*(L_t; K) ; \end{cases}$$

where $\equiv \delta^{\frac{\alpha-1}{1+\alpha}}\left([(1-\alpha)\,\alpha]^{\frac{1-\alpha}{1+\alpha}} - [(1-\alpha)\,\alpha]^{\frac{2}{1+\alpha}}\right)$

Each individual lives two periods. First period is idle children and second period supplies one unit of labor and spends income between consumption and raising children. Homothetic preference and constant cost of raising child implies population of next period is a fixed fraction of current period income:

$$L_{t+1} = \mu Y_t = \begin{cases} \mu K^{1-\alpha} H_t^{1-\alpha} L_t^{\alpha} - \delta H_t^2 & \text{if } H_t < N^*(L_t; K) , \\ \mu\Omega\left(K^{1-\alpha} L_t^{\alpha}\right)^{\frac{2}{1+\alpha}} & \text{if } H_t > N^*(L_t; K) ; \end{cases}$$

Thus we have:

Proposition 4. *(Aiyar, Dalgaard, Moav 2008) If $H_t \geq N^*(L_t; K)$ for all t, then there exists a unique* *globally stable steady state of population*

$$\bar{L}(K) = \Lambda K^2 \text{ where } \Lambda = (\mu\Omega)^{\frac{1+\alpha}{1-\alpha}}$$

Otherwise, there exists a unique non-trivial conditional steady state level of population for any $H_t < \bar{N}(K)$*, denoted as* $\tilde{L}(H_t; K)$ *where* $\tilde{L}(H_t; K) < \bar{L}(K)$ *and* $N^*\left(\tilde{L}(H_t; K); K\right) > H_t$.

Using Proposition 4 and Implication **??** we can reconcile Figure 1 with unified growth theory. Proposition 4 implies that population is not a sufficient statistics for level of knowledge. And together with Implication **??** it suggests that a continent suffering from more shocks may have a lower level of knowledge than another continent suffering from fewer shocks even if the population in the first country is bigger.

C.1 Historical Data

Data for Figure 13 comes from Brecke (1999) and White (2013). Data on casualties in preindustrial warfare should be interpreted with caution. The figures we report are lower bound estimates. Per capita tax revenues come from Karaman and Pamuk (2013) and Sng (2011). In Table 1, We report tax revenue measured by silver grams to facilitate cross-country comparisons. However, since China was a net importer of silver it is a concern that the value of silver in China might have been higher than in Europe. To take this into account we use the bare-bones subsistence basket constructed in Allen et al. (2011) to estimate the tax burden in Europe and China as a proportion of the cost of living.