Cities, Institutions, and Growth: The Emergence of Zipf's Law

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FIRST VERSION: VERY PRELIMINARY AND INCOMPLETE

Abstract

This paper examines Zipf's Law for city size distributions in historical perspective. It documents that the Zipf's Law regularity emerged in Europe between 1500 and 1800. It further takes Zipf's Law as a lens through which to examine city growth and structural change. It shows that convergence was associated with transformations in agriculture but was uneven in time and space, and that variations in convergence were associated with variations in economic institutions. In particular, institutions of the "second serfdom" in Eastern Europe were associated with a delay in convergence. These institutions were also associated with a retarded process of catch-up growth, but not – as sometimes believed – with either an absolute decline in city growth rates or with growth rates lower than in Western Europe.

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1 Introduction

Contemporary data on urban populations confronts us with what Krugman (1996b: 41) observes is "one of the most overwhelming empirical regularities in economics." Specifically, the size distribution of city populations is well described by a simple power law – the number of cities with population greater than T is proportionate to $1/T$. Put another way, there is a log-linear relation between city population and city size rank (in the contemporary USA, New York City is ranked 1, Los Angeles 2, and so on). This relationship is known as Zipf's Law and is apparent in **Figure 1**, which presents data on city populations in three contemporary economies, selected for purposes of illustration.[1] The regularity is so unusually exact and so "suspiciously like a universal law" that Krugman (1996a: 39) calls it "spooky." Gabaix (1999a: 129) observes that, "It appears to hold in virtually all countries and dates for which there are data, even the United States in 1790 and India in 1911." However, historical data on European city populations since 1300 reveals that Zipf's Law has emerged over time, and that convergence to the Zipf's Law dispensation has been uneven in time and space. This can be seen in **Figure 2**, which shows the evolution of city size distributions between 1300 and 1800 in Eastern, Western, and Ottoman Europe. The emergence of Zipf's Law in Figure 2 provides the key motivating fact for this paper, and an entry point into a set of larger debates.

Running back to at least Pirenne (1927), historians have framed cities as the seedbeds of the activities, institutions, behavioral norms, and social groups that transformed the European economy and launched modern economic growth. Postan (1975: 239) describes the cities of pre-modern Europe as "non-feudal islands in a feudal sea." Braudel (1973: 400) argues that, "Capitalism and towns were the same things in the West." De Vries (1984) suggests the development of urban systems in the early modern era provided a foundation for future economic development. On related ground, Bairoch (1988) styles the city "agent of civilization," and calls our attention to the fact that urban life opened the way for social contacts fostering the circulation of information and favoring innovation. Consonant ideas run through the economics literature. Lucas (2002: 59) em-

[1] Figures and tables appear at the end of the paper.

phasizes that the positive externalities associated with economic growth are what secure "the central role of cities in economic life." Contemporary work on urban economics suggests that cities are generally associated with increased sharing of information, superior matching between workers and employers, and significant technological spillovers.[2] However, city growth has also been tied to institutional dynamics. Bairoch (1988) and Acemoglu et al. (2005) have suggested that the Atlantic economies drove urbanization and city growth in the early modern era, that profits from the Atlantic trade empowered the urban groups that pressed for institutional reform along pro-growth lines. Other contributions in the historical literature suggest that while Western Europe experienced pro-capitalist institutional evolution, there was institutional retrogression in the East. This is illustrated schematically by **Figure 3**, which shows the evolution of the Polity-IV index of constraints on arbitrary executive authority in Eastern and Western Europe.[3] An examination of city growth, and the evolution of city sizes, can speak to these issues, shedding light on both the Zipf's Law regularity and questions concerning the institutional determinants of economic performance and the factors accounting for big divergences in European economic history.

This paper examines the emergence of Zipf's Law, and the ways changes in urban structure were related to changes in rural-urban relations and variations in economic institutions. The central arguments run as follows. First, Zipf's Law emerged over time in early modern Europe.[4] Convergence coincided with changes in agricultural productivity and increased long distance trade in grain. However, while Western Europe converged to a dispensation consistent with Zipf's Law by

[2]See Duranton and Puga (2004) for a review of the micro evidence and theories.

[3]Eastern Europe comprises Austria, the territory of former Czechoslovakia, Hungary, Poland, Romania, and a greater Russia that includes the Baltic states. The Balkan countries of Southeastern Europe are excluded. Western Europe comprises all remaining economies except Finland. The data is the historical coding of the Polity-IV index of constraint on executive authority. A value of 1 indicates "there are no regular limitations on the executives actions," a 3 indicates "there are some real but limited restraints on the executive," a 5 means "the executive has more effective authority than any accountability group, but is subject to substantial constraints by them," and 7 describes situations where "accountabilty groups have effective authority equal to or greater than the executive in most activity." Even numbers correspond to intermediate cases. See Acemoglu et al. (2005) for further details.

[4]I follow convention in referring to the period running from roughly 1500 to 1800 as "early modern". Readers can substitute their preferred tag for this period.

1700, a similar empirical regularity emerged in a more uneven, halting manner in Eastern Europe. Second, three macro-level regions emerged in early modern Europe – Europe West of the Elbe River, Europe East of the Elbe, and Ottoman Europe in the Southeast, below the Danube River. Third, variations in convergence are associated with institutional differences across regions. Historians describe the period running from roughly 1500 to 1800 in Eastern Europe as the "second serfdom." The institutional framework prevailing in Eastern Europe over this period was associated with the persistence of deviations from Zipf's Law and with an overall retardation of city growth. These historical facts facts help us discriminate between different explanations for Zipf's Law and set out some markers for an integrated theory of city growth. Fourth, a non-parametric regression estimator derived from work by Theil (1950) sheds light on these questions. This estimator can be employed to gauge the magnitudes of deviations from power law distributions, is superior to standard OLS estimators over small samples, and is competitive with rank-adjusted OLS estimators – even where the data generating process strictly follows a power law.

This paper sketches a simple model to put structure on the historical narrative. The model has two features that speak to the empirical evidence. First, land (or quasi-fixed land-intensive intermediates) may enter the city production function. Second, there may be politically-determined distortions that reduce the returns to young labor – thus damping city growth rates through some combination of birth rate and migration effects.

2 Review of Zipf's Law and Existing Literature

2.1 Zipf's Law

Zipf's Law for cities can be characterized in two ways. The first is in terms of the probability distribution of city populations in the upper tail. An economy in which cities follow a Zipf's Law is one in which cities are distributed according to a power law such that the probability of drawing one with population size S greater than some threshold T is:

$$\mathsf{Pr}(S > T) = \alpha T^{-\beta} \tag{1}$$

Here α is a constant and β is the Zipf coefficient. Equation (1) is consistent with a Pareto distribution where the size ranking of a city (denoted R) is inversely proportional to its population size:

$$R = \alpha (S)^{-\beta}$$

Thus the log-linear relation between city rank and city size is a tidy, second characterization of Zipf's Law:

$$\mathsf{log}(R) = \mathsf{log}(\alpha) - \beta \mathsf{log}(S) \tag{2}$$

In some cases, the literature assimilates Zipf's Law to the case where $\beta = 1$ or sits exceedingly close to 1. However, as observed by Guérin-Pace (1995), Soo (2003), Eeckhout (2004), and Gabaix and Ioannides (2004), estimates of β vary across time, across economies, and – within economies – with the population cut-off that defines the set of agglomerations to be classed and studied as cities. With these considerations in mind, this paper focuses on the log-linear relationship but takes a flexible position on the range of acceptable β's.[5]

2.2 Existing Literature

Economists have developed several theories to account for a world in which this rank-size relationship emerges spontaneously. The leading theories posit some form of random growth (e.g. Simon [1955], Krugman [1996a, 1996b], Gabaix [1999a, 1999b], Gabaix and Ioannides [2004], and Rossi-Hansberg and Wright [2004]). The

[5]As Gabaix and Iaonnides (2004: 2350) argue: "the debate on Zipf's Law should be cast in terms of how well, or poorly, it fits, rather than whether it can be rejected or not...if the empirical research establishes that the data are well described by a power law with exponent $\beta \in [0.8, 1.2]$, then this is a useful result." NB: For consistency, notation changed to β.

first contribution along these lines was Simon (1955), which posits a stochastic growth process and dynamics in which potential migrants move between cities (with some probability $1-\pi$) or found new cities (with probability π). As discussed in Krugman (1996a, 1996b), Simon's model delivers the rank-size relationship but does not cleanly generate a slope $\beta \approx 1$, requires that the number of cities grow faster than the populations of existing cities, exhibits a strange degeneracy with respect to its key probability parameter π, and converges infinitely slowly. More recently, Gabaix (1999b) has shown that Zipf's Law may arise as the limiting distribution of a process obeying Gibrat's Law – where cities draw growth rates from a common distribution and hence growth rates are independent of city size. Beyond random growth, the key assumption in Gabaix (1999b) is that there is a mechanism preventing small cities from getting "too small." In particular, Gabaix (1999b) assumes a growth process that is a random walk with an arbitrarily small lower (or reflecting) barrier.[6] Rossi-Hansberg and Wright (2004) develop a related model that combines increasing returns at the local level with constant returns in the aggregate and delivers Zipf's Law under special circumstances.

In addition to theories that center on random growth, Krugman (1996b) has suggested a geographic explanation. Krugman (1996b) observes that the landscape is not homogeneous and that its non-homogeneity may account for the size distribution of cities via some corresponding inhomogeneity of propitious locations. Suggestively, he observes that the distribution of river volumes in the USA follows, at a rough first approximation, something like a power law.

In recent empirical work, Ioannides and Overman (2004) have shown that Gibrat's Law appears to hold in contemporary data for the USA. But Soo (2003) has examined cross-country data and found that the data is inconsistent with a pure ($\beta = 1$) Zipf's Law in a substantial fraction of economies.

The economic history literature has examined Zipf's Law in a number of

[6]Absent this assumption, random growth delivers a lognormal distribution. Indeed, working with new US Census data on all population locations, Eekhout (2004) argues that in the USA today the complete, untruncated distribution is lognormal – not Pareto. Given the nature of the historical data, this paper is confined to an analysis of the upper tail of European city size distributions and remains agnostic on the true distribution function.

settings, but to my knowledge has not examined its differential emergence across Eastern and Western Europe in the early modern era. Guérin-Pace (1995) examines rank-size regularities in France from the 1800 to the present, and in particular the forces that may have led to departures from random growth in French history. Zipf's Law (or variants thereof) has been used in de Vries (1984) and Bairoch (1988) to derive imputed populations for small agglomerations on which historical population data is not readily available, and de Vries (1990) provides a review of the way the "rank-size rule" has been employed in the historical and development literatures. Noting that rank-size rules have been used to gauge the "maturity" or "balance" of urban systems, de Vries (1990) observes that estimated rank-size rules may be sensitive to the choice of estimator; that the choice of economies or regions matters; and that the relevant regions and their boundaries may be dynamic – indeed that they may acquire coherence through the emergence of urban systems themselves. Broadly, de Vries (1990) cautions that there may be more than one mode of urban growth, and that we ought to guard against over-simple reliance on the rank-size rule. This paper attempts to address these concerns, while also applying de Vries' (1990: 52) argument that rank-size distributions "can summarize effectively the process of urbanization and identify gross differences in the design of urban systems over time [and] in different societies."

3 Source Data and Methods

3.1 Source Data

Bairoch et al. (1988) collects population data on European cities over the period from 800 to 1850. The methodological approach in Bairoch et al. (1988) is to identify the set of cities ever reaching 5,000 inhabitants at some point between 1000 and 1800, and then to seach for population data for these cities in all relevant periods – including those when they did not have 5,000 inhabitants. The data is designed to record the populations of urban agglomerations, not simply populations living in politically or administratively defined boundaries. Thus Bairoch et al.

(1988: 289 – translation mine) make a special effort to include in their figures the inhabitants of "the 'fauborgs', the 'suburbs', 'communes', 'hamlets', 'quarters', etc. that are directly adjacent" to cities. This data is recorded every 100 years up to 1700, and then every 50 years to 1850. The data in Bairoch et al. (1988) – henceforth the "Bairoch data" – is not strictly continuous: city populations are given in thousands.

This paper skirts selection questions the Bairoch et al. (1988) methodology might raise for observations below 5,000 by only examining cities with population of at least 5,000. This paper further restricts its analysis to the period from 1300 forwards, when data on a relatively large set of cities is available. **Table 1** summarizes the Bairoch data, grouping cities by region (for further details see Appendix). Additional historical data are described as introduced. Finally, the empirical work below uses an unbalanced panel of cities, however a balanced panel yields similar results.[7]

3.2 Methods: A Small-Sample Estimator of Zipf Coefficients

Classically, Zipf's coefficients have been estimated with standard OLS regressions of the form:

$$\ln(R_i) = \alpha - \beta \ln(S_i) + \epsilon_i \tag{3}$$

More recently, Soo (2003), Newman (2005), and Clauset et al. (2007) have all discussed the Hill maximum likelihood estimator as an alternative to OLS. However, as Gabaix and Ioannides (2004) have argued, the small sample biases associated with the Hill estimator can be quite high and very worrisome.[8] For this reason, and because in this context using the Hill estimator does not change the qualitative nature of the key arguments, this paper does not present estimates using the Hill

[7] Acemoglu et al. (2005) also use the Bairoch data and find, in their empirical work, that results are similarly insensitive to the choice between a balanced panel with fewer observations and an unbalanced panel with more.

[8] For a sample of n cities with sizes S_i ordered so that $S_{(1)} \geq \ldots \geq S_{(n)}$, the Hill estimator is: $\hat{\beta}_H = (n-1)/\sum_{i=1}^{n}\left[\ln(S_{(i)}) - \ln(S_{(i+1)})\right]$.

estimator.

There are two problems with a standard OLS estimator. The first is that it may be biased by gross errors. The second is that even without outliers, even if the data generating process conforms strictly to a power law, the estimated coefficient $\hat{\beta}$ will be biased down in small samples. This point has been made by Gabaix and Ibragimov (2007) and can be illustrated in a simulation using data generated by a stochastic power law process. **Figure 4** uses simulated data to show how the estimates of $\hat{\beta}$ from equation (3) are typically biased over small samples.[9]

Gabaix and Ibragimov (2007) have proposed an elegant remedy that reduces the bias in OLS coefficients to a leading order: namely adding a shift of -1/2 to the city rank data. For many practical applications, this approach eliminates the small sample error in OLS estimates. However, any OLS estimator may be subject to gross errors in contexts marked by significant outliers. Given the shape of the rank-size relation for European cities in the early modern era, this is a particular concern here.

However, there is another linear regression estimator that is intuitive, asymptotically unbiased, robust with small samples, and allows us to go some distance in addressing the problem posed by outliers. This is the nonparametric estimator derived from Theil (1950). This estimator has been largely overlooked in the Zipf's Law literature – perhaps because it is not available as a feature or add-in for the standard statistical software. The Theil slope parameter is calculated as the median of the set of slopes that connect the complete set of pairwise combinations of the observed data points. Given observations (Y_k, x_k) for $k = 1, \ldots, n$, one computes the $N = n(n-1)/2$ sample slopes $S_{ij} = (Y_j - Y_i)/(x_j - x_i), 1 \leq i < j \leq n$. The Theil slope estimator is then: $\beta_T =$ median$\{S_{ij}\}$. The corresponding constant term is: $\alpha_T =$ median$_k\{Y_k - \beta_T x_k\}$. That the Theil estimator is competitive with the Gabaix-Ibragimov estimator is evident in **Figure 5**, which uses simulated data to compare small sample biases in estimated β's across OLS, rank-adjusted OLS, and Theil estimators. It is also notable that the Theil estimator generates

[9]Data are constructed as follows. Sample n times from a uniform distribution on the unit interval to obtain x_i, $i = 1, \ldots, n$. Construct sizes $S_i = 1/x_i$ and rank the S_i's. Then compute logarithms of size and rank and apply OLS.

much more precise estimates than adjusted-OLS (i.e. relatively narrow confidence intervals around parameter estimates).

4 Historical Narrative

4.1 Overview

This narrative section motivates the empirical work and model introduced in the next two sections. It develops three arguments. First, in the pre-modern era cities were reliant on and constrained in their access to land in important, historically specific ways. Second, at a high level of generality, three macro regions developed in European economic history – one in the West, one in the East, and one in the Balkan penninsula. Third, economic institutions with significant family resemblances and significant consequences for city growth were installed in the East around 1500.

4.2 Cities and Land Before the Modern Era

Cities and countrysides were often subject to different legal rules in early modern Europe; cities often had substantial legal privileges and autonomy. Early modern cities were typically, though not always, walled cities. And yet historically rural and urban areas were not neatly separated. Urban population centers preserved substantial forms of land-intensive production. There were gardens, fields, and areas devoted to livestock within cities themselves. In addition, cities developed in conjunction with rural and semi-rural hinterlands that supplied cities with residents (labor), food, fuel, and demand for urban goods and services. Braudel (1979: 549, 555-557) notes:

> There is not a city, not a town that did not have its villages, its bits of annexed rural life, that did not impose on its "flat country" the commodities of its market, the use of its stores...In order to be, it was

> necessary for a city to dominate an empire, however small.
>
> In fact, cities and countrysides never separated like oil and water...Until the 18th century, even great cities conserved rural activities. They housed shepherds, village fêtes, laborers, and vineyards; they possessed within and beyond their walls a belt of gardens and orchards, and beyond these fields...The city dwellers of this time were often only half urbanized. At harvest time, artisans and [comfortable] "bonnes gens" left their trades and their homes to work in the fields.[10]

Pirenne (1958, vol. 1: 215) similarly observes that in the later middle ages and the Renaissance era, "Every city endeavoured to dominate the surrounding countryside, to subjugate it. The country had to provide it with a market, and, at the same time, to guarantee its supplies of foodstuffs." A classic example of this dynamic is found in Italy, where great cities – like Milan and Florence – conquered and dominated dependent territories that included smaller cities and agricultural hinterlands (see Chittolini 1994) . As Blockmans (1994: 226) notes, Northern Italian cities secured "unchallenged and undivided control over substantial hinterlands, measured in thousands of square kilometers. This territorial power secured the cities' absolutely vital supplies of food, water, and raw materials." In somewhat similar fashion, cities on the Istrian and Dalmatian coast controlled territories that stretched inland to the mountains (see Vilfan 1994). Elsewhere the balance of political and economic influence was different, but similar struggles emerged: "The counts of Oldenburg and Schleswig-Holstein and the related kings of Denmark had a long series of conflicts with Lübeck and Hamburg as a consequence of their rival claims on the control of land, waterways, and resources." (Blockmans 1994: 240) In Poland cities were – with few exceptions like Danzig – controlled and even owned by feudal lords. In Poland and parts of Northeast Germany, landlords instituted institutional arrangements that assisted them in transforming their domains into agricultural hinterlands for distant (Northwest European) economies, and limiting the growth of local urban business class. Braudel (1979: 355 - emphasis added) summarizes: "we see, in effect, all the dominant cities struggling to

[10]All citations from non-English language work are my translations.

expand their territory and to spread *their agricultural and industrial activities*."[11]

These observations suggest that access to agricultural land was often a binding constraint on city growth, and that political-economic and military considerations were important. However, transportation costs were another central constraint. Historically transportation costs – especially for heavier products and overland transport – were exceedingly high. The early modern period saw major developments in the international trade in grain; and yet as Braudel (1979: 133) observes, most cities remained heavily reliant on the provision of foodstuffs from a within, "a narrow circle of 20 to 30 kilometers which avoided onerous transport costs and the risks of reliance on foreign supplies." In a similar vein, Max Weber (1958: 71) notes that, "Normally the larger the city the less the opportunity for urban residents to dispose of acreage in relation to their food needs at the same time without controlling a self-sufficient pasture and wood lots in the manner of the village." Evidently, city production embodied land. The working hypothesis here is that transport costs, and the need to hedge against risks associated with reliance on distant food supplies, drove cities to rely on "near" land and imparted a fixedness to urban land endowments.

If we consider land – or a land-intensive intermediate – to be a quasi-fixed factor in urban production, it is natural to wonder how this is reflected in price data and how changes in agricultural productivity impacted city growth.

This paper defers a full treatment of the price data. For the moment it bears noting that we would expect rents to be increasing in population density other things equal. Anecdotal evidence suggests this was the case (e.g. Young 1760, 1790). We would also expect the prices of land intensive goods to increase in city size, after accounting for the effects of arbitrage. The data series on consumer prices in 18 European cities collected in Allen (2001) suggests this was the case. It is difficult to entirely account for differences in product quality, but

[11] One of the starkest cases was that of Novgorod, a Russian merchant city with commercial relations with the cities of the Hanseatic league and one of the largest cities of the East. Novgorod first lost its close hinterland to rising Moscow, then – at force of arms – had its municipal autonomy revoked in 1478. Its merchants were deported, their estates seized, and a royal governor appointed. Novgorod's population declined by 70 percent between 1500 and 1600.

Allen collects data on a basket of basic wage goods that were arguably reasonably undifferentiated. The expenditure share devoted to food in the consumption basket Allen (2001) examines is 60 percent (bread alone is 30 percent). Accounting for fuel as well, but not for wine or beer, basic land-intensive products account for roughly two-thirds of spending in this index – whose price is consistently correlated with city size. Moreover, a regression (not reported here) finds that when one pools the data and controls for period and city effects, there is a strong and significant correlation between prices and city size.

The historical evidence on agricultural productivity is limited and available with very irregular local coverage. However, Allen (2003) provides estimates of agricultural TFP in nine economies. **Figure 6** presents the estimates. It shows that the Netherlands and England enjoyed extraordinary improvements in agricultural productivity between 1600 and 1800. It also shows that TFP stagnated in Italy and Spain, and that Poland – an economy often taken as the classical case of the second serfdom – saw marked increases in agricultural TFP over the same period. These estimates should be treated with some caution, but a number of sources suggest great productivity gains in Northwest Europe and stagnation in Iberia and Italy. Moreover, local data in Maddalena (1977) suggests that on equivalent soils productivity in Eastern economies was not markedly below levels in mid-ranking Western economies. These points merit further research, but provisionally this paper assumes Allen's agricultural TFP estimates capture the big picture with reasonable accuracy.

Figure 7 describes the strong positive relationship between urbanization and agricultural productivity, but special interest attaches to the outliers. Figure 7 shows that agricultural TFP was nearly stagnant in Italy and Spain. It also suggests that Poland went from having the lowest TFP to having TFP higher than Germany, France, Italy, Spain, and greater Austria – without any increase in urbanization. The combination of impressive TFP growth in agriculture and stagnant urbanization suggests that effective land was not the central constraint on city growth in Poland. In keeping with this observation, the historical literature suggests important differences in institutions across economies.

4.3 Three Macro Regions: East, West, and Ottoman Balkans

There have been many – sometimes overlapping – regions in European economic history. This paper follows the historical literature in arguing that regional boundaries changed over time and that, despite these shifts and the salience of various micro-regions, three macro regions emerged in European history. (For reference, a map of Europe's political geography in 1500 is located at the end of the paper, after the Tables and Figures.)

Blum (1957), Hobsbawm (1965), Kahan (1973), Anderson (1974a, 1974b), Brenner (1974), Berend (1986), Bairoch (1988), Blockmans (1994), and Stoianovich (1994) have all argued that there are distinct, macro-regional trajectories in early modern European history. This historical literature suggests the Balkan economies below the Danube in Southeastern Europe followed a distinct trajectory marked by their incorporation into the Ottoman Empire. It further suggests that, some time around 1500, Europe West of the Elbe River diverged from Europe East of the Elbe.

There is a consensus that Balkan cities developed in a distinct institutional environment. Anderson (1974b: 361) argues that the Balkans were a "distinct geo-political sub-region." Bairoch (1988: 158-159) argues that, "the Balkans between the end of the fourteenth and the beginning of the nineteenth centuries did not really participate in the main currents of European culture" and, "even before that time...the urban life of the Balkan countries had already taken a different turn." A similar argument is suggested in de Vries (1984: 19). Where urban systems are concerned, Anderson (1974b: 375-376) observes that the "basically inimical relationship of the Ottoman state to [provincial] cities" was a feature of a regime in which "towns had no corporate or municipal autonomy: indeed, they had no legal existence at all." On similar ground, Stoianovich (1994) contends that Ottoman Europe was organized within a largely "command-economic" system in which economic allocations were determined to a relatively high degree by administrative and political decisions. Notably, Stoianovich (1994: 68) observes that into the 19th century the cities of the Balkans do not exhibit the rank-size regularities we find in contemporary data: "If rank-size regularities among cities are a necessary criterion of an urban system, one must conclude that no all-Ottoman, Eurasian-Ottoman, or Balkan-Ottoman urban system has ever existed."[12] The key point here is that urban systems can develop in various modes and that city systems may be integrated in significant ways without exhibiting Zipf's Law.

The division between Eastern Europe and Western Europe has been dynamic. In the period from the 11th to the 13th century, Eastern Germany, the Baltic plain, Poland, Silesia, Bohemia, and Hungary experienced a mass inflow of German (and to a lesser degree Dutch) peasants. As Wright (1975) and Blum (1957) document, landlords in these regions employed professional labor recruitors and so-called locators who organized and planned the colonization of new towns and villages under "German" (and occasionally "Flemish") law on a for-profit basis.[13] Contemporary Austria was Germanized between 900 and 1100 AD. Between 1100 and 1300, German immigrants moved into Bohemia, Silesia, Hungary, Poland, and the Baltic plain. The colonization process drew large numbers of migrants long-distances. Aubin (1966: 485) cites evidence suggesting that some 1,400 villages with a population of 150,000 were founded in East Prussia, and Blum (1957: 816) suggests that a further 150,000 settlers moved to Silesia. Our best estimates put total German population around 6 million in 1200 and 9 million in 1300 – suggesting that over 2 percent of the German population was involved. The key rights extended to tenant farmers living under German law were: hereditary tenancy agreements; fixed obligations to landlords; the ability to form village communes with their own mayors and courts; and the right to move.

However, the relative scarcity of labor created a situation in which German Law became broadly ascendant in Eastern Europe. The scarcity of labor created a context in which non-German, Slavic peasants were able to found "German" villages and towns of their own. This led to a more broad-based transformation. Increasingly, non-German villages reorganized their field layouts along lines pio-

[12] An exception – noted by Stoianovich – is Bosnia-Herzogovina, which exhibited a Zipf-like distribution of cities and towns by 1800.

[13] See especially Aubin (1966) for detailed discussion of the highly organized nature of colonization and the "regular body of entrepreneurs" who financed the migrations and assembled the new combinations of capital, labor, and land.

neered by German farmers, an "economic Germanization" that was "frequently followed by the linguistic" (Aubin 1966: 457). In this manner, the institutional framework of more Western economies came to prevail in Central Eastern Europe. Wright (1975: 240) observes that German Law spread "far beyond the area of German immigrant settlement and was adopted in much of Czech agrarian society as well." Blum (1957: 816-817) confirms that, "From the thirteenth century on, the authochthons in Eastern Germany, Poland, Bohemia, Silesia, and Northern Hungary began the enjoy...privileges that had at first been extended only to German newcomers. The serfdom that had held so many of the native peasantry...all but disappeared."[14] Aubin (1966: 481) similarly describes the "absorbtion of [East central Europe] into the complex economic conditions of the West." As Berend (1986: 331) observes, "By the 11th to 13th centuries...the frontiers of Western Europe had shifted considerably to the East, as far as the lower Danube, the Eastern Carpathians, and the forest belt that separated Polish from Russian territory."

Over this period, East and Central Eastern Europe enjoyed catch-up growth associated with institutional convergence; the clearing, draining, and exploitation of new agricultural lands; and the settlement of previously unexploited town locations. Berend (1986: 331-332) describes an "extraordinarily concentrated and rapid period of development" and "trends practically identical to those in the West." Aubin (1966: 485) writes of "extraordinary growth." Wright (1975: 241) observes that "At the beginning of the fifteenth century the course of peasant serfdom in Bohemia approximately paralleled that in Western Europe." Blum (1957: 819) notes that, "The peasants of Eastern Europe, like those of the West, seemed headed toward continued improvement in their condition."

Over the period running roughly 1450 to 1550 the situation changed. The frontier of Western Europe – and Western institutions – shifted back, and the "East" came to be defined as the ensemble of territories East of the Elbe River. From around 1500, different institutional regimes were adopted in Eastern and Western Europe. Subsequently, Eastern and Western Europe experienced different growth trajectories – trajectories closely related to the development of their city

[14] Blum (1957) documents the manner in which German law came to prevail throughout Bohemia and – following the Polish-Lithuanian union of 1387 – in the Baltics.

systems. Roberts (1996: 235) argues that "modernization" appears in Europe in this period – "for the most part, west of the Elbe." In his survey of the economic history of rural Europe over the period from 1500 to 1750, De Maddalena (1977: 287) argues for dividing Europe "into two parts, taking the Elbe as the line of demarcation." Berend (1986: 333-334) observes that, "The sharp line of demarcation between the economic and social structures that divided Europe in two after approximately the year 1500...ran with astonishing precision along the Elbe-Leitha frontier...historians see an incontestable change at about the turn of the 15th to the 16th century, a serious decline in the development of Eastern Europe." The Elbe boundary between Eastern and Western Europe is further suggested by authors ranging from de Vries (1976) and Moore (1966) to Brenner (1974) and Anderson (1974a, 1974b).

4.4 Institutions of the "Second Serfdom" and the Cities of Eastern Europe

The debate and terminology surrounding the "second serfdom" in Eastern Europe goes back to at least the observation in Marx (1882) that a "second edition" serfdom emerged in the Germany East of the Elbe after the 15th century. Kahan (1973: 96) observes that there was a "spectacular expansion of serfdom in the sixteenth and seventeenth century in Eastern Europe." Similar arguments are found in Moore (1966), Anderson (1974a, 1974b), Wright (1975), Blum (1957, 1978), Makkai (1975), Backus (1962), Carsten (1954), Brenner (1974), and Topolski (1974). De Vries (1976: 57, 56) observes that, "The distribution of political power is fundamental to understanding the course of agricultural development [East of the Elbe]" and that in the East the institutional and policy framework was one of "peasant oppression."[15] The argument here is that the institutions were also anti-urban.

There are stylized facts around which a reasonable consensus exists. These

[15]In another context, Robert Bates (1995: 47) has given us a remark that that is especially apposite here: "behind every Pareto-optimal outcome, then, arrived at by marginal adjustments among maximizing agents...lies a previous act of coercion."

facts locate the second serdom as an institutional regime existing – with local variations – from roughly 1500 to 1800 in East Central and Eastern Europe. There were several key aspects of this institutional framework. Peasants faced new labor obligations – in particular the number of days they were required to work on their landlords' domains was increased substantially. Landlords established new legal claims to land previously outside their domains (demesnes). Eastern European polities instituted new legal restrictions on peasant mobility and restrictions on competition for agricultural labor amongst purchasers. In addition, statutes and enforcement mechanisms were put into place to compel cities to respect the tenancy contracts in the agricultural sector and to reduce the economic privileges and legal autonomy of towns.

These broad developments were composed of a complex of innovations. In 1437, Bohemia legalized the (armed) pursuit of fugitive tenants. In 1497 and 1500, Bohemia instituted laws legalizing adscription (i.e. peasant farmers were to be legally transferred along with the estate to which they hereditarily pertained). In 1496, Poland banned seasonal migration by non-land-owning peasant farmers. In 1497, restrictions were placed on the right of debt-free peasants to leave their estates in Russia. The Prussian legal ordinances of 1494 stipulated that:

> A runaway peasant had to be handed over to his master who could have him hanged; a runaway servant was to be nailed to the pillory by one ear and to be given a knife to cut himself off; no servant was to go idle for more than a fortnight after the end of his employment, but was to accept new service: all this without any trial or arbitrament. (Carsten 1954: 106)

In Prussia, Pomerania, Livonia, Poland, Bohemia, Lithuania, and Russia laws were passed against the practice of lords "luring" peasants from each other's domains (i.e. laws restricting competition among purchasers in the labor market). In Prussia, Brandenburg, Bohemia, Silesia, and Poland, laws were passed requiring peasant renters to furnish landlords a replacement tenant before leaving their estates. By the seventeenth century, there were reciprocity agreements among Länder and sovereign states providing for the return of fugitive serfs. Austria, for instance, had legal agreements with Saxony, Brandenburg, and Poland.

Table 2 summarizes the timing of the key legal intiatives along three dimensions: (i) legal restrictions limiting the mobility of tenant farmers and tying them to the land, (ii) restrictions on the rights in land enjoyed by tenant farmers – including restrictions on access to commons and on the heritability of legal claims, and (iii) restrictions on the free disposal of tenant farmer labor – including increased *robot* and/or servant labor obligations.[16] I use this data to code an index of the timing and intensity of serfdom (the index takes values from 0 to 3). **[Table 2 is incomplete. Panels B and C will be added.]**

The legal institutions of the second serfdom impacted the growth of towns and cities in several ways. In the first instance, laws limited rural-to-urban migration by raising the risk and lowering the return to migration. In Prussia, Pomerania, and Bohemia, legal codes even stipulated that tenant farmers could not move to cities without proof of their lord's permission. Such laws could not be enforced perfectly. But they were instituted in economies where migrants entered walled cities through gates tended by watchmen. Thus Mols (1955: 347-348) reports that in 1608 an ordinance was passed requiring the presence of two guards charged with "interrogating immigrants on their nationality" at each of Vienna's gates. These were imperfect measures to be sure, but in seventeenth and early eighteenth century Austro-Hungary they were backed up with urban censuses specially designed to detect "undesirable strangers." In some respects, then, regulation reached deep into quotidian economic life. In 1743, one daily entry in the Berlin gatekeeper's log reads: "Today there passed six oxen, seven swine, and a Jew."[17]

These restrictions on labor mobility impacted city growth in specific demographic setting. A considerable literature examines the relationship between natality rates, mortality rates, and migration in the demography of early modern cities. Contributions include Süßmilch (1741), Mols (1955, 1956), Wrigley (1978), Sharlin (1978, 1981), Finlay (1979), Braudel (1979), de Vries (1984), Bairoch (1988),

[16]Robot labor obligations comprised the number of days (and the nature of draft animals) tenant farmers would have to devote to labor on the portion of their landlord's domain set aside for his production.

[17]Quoted in Craig (1982: 34).

McIntosh (2001), Reher (2001), and Woods (2003a). The central stylized fact in this literature is that urban death rates exceeded rural death rates and typically urban birth rates as well. The consensus has been that cities were relatively unhealthy places, required in-flows of migrants to grow, and attracted repeated waves from the relatively healthy rural sector. Mols (1955: 333) observes that cities were characterized by "endemic excess mortality" and that, "if, despite this, the population was to maintain itself, let alone grow, the unique cause was immigration from rural areas to the city. This immigration was for cities of the past a vital necessity. No city of any importance could do without its rural reservoir." As Braudel (1979: 559-561) puts it: "A city would stop living if she could no longer assure herself of supplies of new men...If she grew, she could not do so alone." Against this consensus view, Sharlin (1978, 1981) has suggested that the relatively high mortality rates in cities were largely accounted for by deaths among new migrants who – for economic and socio-cultural reasons – were relatively unlikely to marry and reproduce in their destination cities. However, as observed in de Vries (1984) and Woods (2003a), Sharlin's argument is undercut by evidence that in many European cities migrants were no less likely to marry and reproduce than others of similar class backgrounds.

Recent research has added nuance to the old view that cities were demographic graveyards, but typically finds that cities were relatively unhealthy places marked by high rates of mortality (see for instance Feher [2001], McIntosh [2001], and Woods [2003b]). Woods (2003a) provides a recent review of the literature, and finds that while, "mortality was directly related to population size." Thus Woods (2003a: 41) observes that "although it is convenient to categorize environments as either urban or rural, in reality there was in the past, at least in Europe, a mortality continuum." But where mortality rose in city size, data in Mols (1955) suggests that birth rates did not rise so quickly (if at all) in city size. Bairoch (1988: 181) confirms the "lack of any fundamental difference between urban and rural birth rates." In this world, restrictions on migration depressed city growth rates.

In addition, legal institutions reduced city growth was by distorting relative prices. In Poland, Prussia, and Bohemia price maximums were placed on urban goods for the express purpose of tilting the terms of trade towards asset owners in the agricultural sector, thus lowering city incomes and the incentive to migration (see Blum [1957], Carsten [1954], and Kula [1962]). In Prussia and Poland-Lithuania, land owners also won the right to export their produce directly, circumventing local cities and merchants, and to export without paying the previously required export taxes. Because the share of economic activity devoted to longer distance trade and its financing typically increased in city size, institutional changes lowering the returns to such activities would have operated as higher effective taxes on larger cities – although this point merits further research. Broadly, on several fronts, urban centers saw their legal rights and privileges eroded. Instead of land owners remaining dependent on communications and co-ordination activities of local urban merchants, they achieved a greater economic autonomy. These measures effectively reduced the agricultural hinterland (and potential labor reserve) centered around Eastern cities. As noted above, large parts of Northeast Europe came to sell grain directly to Dutch merchants and were transformed into hinterlands effectively producing for the rising Dutch cities.

4.5 Review

A classical argument locates the originality of European cities in their "unequaled liberty." In summary, "they dominated their countrysides, which were for these cities true colonial worlds," and "pursued their own economic policy, often capable of breaking down obstacles and always of producing and reproducing their [legal] privileges." (Braudel 1979: 580-581) However, arguments along these lines apply to the cities of Western Europe. Carsten (1954: 115) writes that in Prussia, "Above all, it was the long-lasting decline and the subjugation of the eastern towns which eliminated all resistance to the rise of the nobility." Blum (1957: 834) notes that the intensification of servile relations in agriculture was associated with "anti-urban policies followed by East German, Livonian, Polish, and Bohemian nobility." Anderson (1974a: 253) observes that, "The existence of urban municipal independence and power of attraction, even in reduced form, was a manifest obstacle to the coercive imposition of a generalized serfdom on the peasantry...the precondition of the ruthless regressive conversion of the countryside that ensued in the East was thus the annihilation of the autonomy and vitality of the towns."

This paper examines European cities in three regions: Europe West of the Elbe; Europe East of the Elbe; and formerly Ottoman Southeastern Europe. The Eastern cities are those located in Austria, Bohemia, Silesia, Hungary, Livonia, Poland, Lithuania, Russia, and Germany East of the Elbe or its tributary the Saale.[18] (Further details on the precise regional break-down are in the appendix.) The cities of the East existed in a variety of political and economic contexts. With an eye to this heterogeneity, the paper will sometimes focus on a subset of East Central European cities (by excluding the Russian cities). However, despite the differences in cultural, geographic, and economic contexts across the East, the argument here is that the East retains coherence as an analytical unit. There were local variations. But there is a broad resemblance in the institutional frameworks in which rural and urban development occured in the East. On this point Blum (1957: 835) argues, "The decline of the cities...is of fundamental importance in explaining why Eastern Europe remained a backward agrarian society in which institutions such as serfdom, which were rejected in the West, were able to flourish." This paper uses quantitative evidence to shed light on how, where, and whether Eastern cities in fact declined.

5 Empirics

5.1 Looking at the Data

European cities have existed in a set of complex urban systems. Considering the distribution of city sizes within these systems, we run up against the challenge of determining what are the appropriate, and most telling, definitions of urban systems. Is it cities in a given polity? Cities in some more or less unified linguistic and cultural space? Cities in a particular economic region? Given the limited nature of historical data on trade, factor, and information flows – and the dynamic

[18]See the discussion in Blum (1957: 807).

nature of political borders in European history – these questions do not have tidy answers. The tack taken here is to examine both regional aggregates and national (or, more properly, proto-national) city systems.

Figure 8 plots the rank-size distributions of Eastern and Western cities between 1300 and 1800. In addition to the raw data on city sizes, Figure 8 shows – for each period – the size-rank pair predicted from the Theil regression parameter estimates. It bears noting that in these graphs many observations overlap, so that there are not as many visibly distinct data points as there are underlying observations. For instance, in Eastern Europe there are 8 cities with 6 thousand inhabitants in 1500, but in Figure 8 the markers for these cities are indistinguishable.

Figure 8 shows that between 1500 and 1700 Western European cities evolved to conform with Zipf's Law, but that Eastern cities did not. From 1300 to 1400, cities were more numerous and larger in Western Europe; and yet the rank-size relations in Western and Eastern Europe diverge from Zipf's law and take quite similar shapes in these first centuries. In the East, there is relatively low growth at the upper end of the size distribution between 1500 and 1700. Further, we can see that between 1600 and 1700, the number of Eastern cities with population greater than 5,000 fell, that several large Eastern cities declined in population, and altogether the curvature in the rank-size relation increased.

Figure 8 raises questions about what Gabaix (1999b: 742) calls the "archaelogy of growth processes." If random growth is *the* explanation for the rank-size regularity, the fact that the rank-size regularity emerged relatively recently implies that there was likely persistent non-randomness in urban growth in the pre-modern era. The fact that the size distribution of European cities has been radically transformed over the course of several centuries also suggests that narrowly geographic theories will be insufficient – without closing the door on theories in which transformations in economic structure make geography operate differently over time.

It bears noting in this connection that power laws are preserved under addition, as well as multiplication and polynomial combination (see Gabaix [2008] and Jessen and Mikosch [2006]). However, as Zipf (1949: 418) observes, if the population of a given territory is organized into two or more independent distributions that individually obey Zipf's Law, the population as a whole may not exhibit the Zipf's Law regularity and *may* instead exhibit "conspicuous bends."

However, the curvature in Figure 8 is not a figment of the aggregation. At lower levels of aggregation – at the local, regional level or the level of contemporary political boundaries – city systems in Russia, Poland, Austria, the Baltics, and the Czech and Slovak lands do not exhibit a log-linear relation between rank and size between 1300 and 1750.[19] Instead these systems are marked by non-linear relations with – in three instances – exceptionally large cities. (The outliers are Prague, Vienna and – in Russia – St. Petersburg and Moscow. By 1800, Berlin joins the great cities of Eastern Europe.)

5.2 Evaluating the Bairoch Data

Historical data is often noisy. This paper examines the Bairoch data, and possibilities for measurement error, in several ways. First, it compares the Bairoch data to independently collected population data on the same cities. Second, it uses a simulation to consider the potential impact of classical measurement error. Third, it introduces a regression analysis to consider the extent of deviations from a hypothetical Zipf's Law and potential non-classical measurement error.

We can begin gauging possible measurement error by comparing the data in Bairoch data to the data in de Vries (1984). The coverage in these datasets is not the same. The Bairoch data covers European cities that reached 5,000 inhabitants by or before 1800, extends to all of Europe, and has rich data from 1300 to 1850. It contains observations on 2,202 cities. The data in de Vries (1984) covers cities that reached a population threshold of 10,000 sometime between 1500 and 1800, and is confined to West and Central Eastern Europe (it does not include cities in Russia, the Baltic states, Hungary, Romania or the Balkans). The de Vries (1984) data is collected for 379 cities. **Table 3** shows a comparison of cities contained

[19] In Russia, detailed provincial data suggests that regional city distributions did not approximate a Zipf's Law until deep into the 19th century.

in both databases. Panel A compares city population data from 1500 to 1800, for the 20 cities at the top of the size distribution in 1500. Panel B compares city population data for 10 randomly selected Eastern European cities. In keeping with the notion that measurement error may increase the farther back we reach in the historical record, it appears that the differences between the de Vries and Bairoch data decline over time. However, with rare (early) exceptions the Bairoch and De Vries data are quite consistent. The de Vries data is typically well within ± 20 percent of Bairoch data. Table 3 shows that on average populations are within a few percentage points.[20]

To simulate classical measurement error, we can add some 'noise' to 'pure' data that adheres perfectly to Zipf's Law. For instance, we can simulate noise with a multiplicative normal shock x_i distributed $N(1, \sigma^2)$ and compare the mean of noisy simulations to pure data over a large number of simulations. **Figure 9** presents the results of this exercise for $\sigma^2 \in \{0.25, 0.5\}$, and shows that this sort of error cannot account for the deviations from Zipf's Law that we find in the Bairoch data.

However, it is possible that there is similar non-classical measurement error in both the Bairoch data and de Vries (1984). To gauge this possibility, and to clarify the evolution of urban systems, I estimate hypothetical Zipf's Laws and calculate deviations from these benchmarks. The exercise amounts to asking the question: How much larger (smaller) would outlier cities need to be to generate a pure log-linear relation? This exercise is implemented using the Theil regression predictions shown in Figure 8. **Table 4** uses these estimates and shows the ratio of actually observed population to what we might term "Zipf-consistent" population for the biggest cities in Eastern and Western Europe. Table 4 shows that between 1400 and 1700 the biggest Eastern cities were far smaller they they "needed to be" to satisfy a rank-size rule. For instance, on average the ten largest Eastern cities were approximately 1/2 the size of the counter-factual Zipf-consistent populations

[20]Despite this concordance, is notable that the Bairoch data seems to report population figures that are slightly, but systematically larger than in de Vries (1984). This may be because Bairoch et al. (1988: 289) make a special effort to include in their city population figures the inhabitants of suburbs, hamlets, communes, and other "directly adjacent" population areas.

in 1700. In early periods there are similarly stark deviations. It also shows that the Western cities converged to a rank-size rule relatively steadily and quickly. Broadly, the magnitudes of the big city population shortfalls are so big that non-classical measurement error driven by downwards biases in the historical data is not a plausible explanation for the curving patterns on display in Figure 8. This big-picture conclusion is not sensitive to the estimator used, the inclusion of Russian cities, or the precise delineation of East and West.

5.3 Regional Growth Processes – Was Growth Random? If So, Where and When?

The leading theories that account for Zipf's Law posit random growth. The data in Figure 8 (and similar analyses of lower-level aggregations) suggest that growth had been non-random over some considerable period through 1400. A key question for periods where relatively rich data exists is: Were growth rates independent of city size?

Following Ioannides and Overman (2003), the analysis here works with normalized city sizes and growth rates.[21] When one pools normalized data, there is no association between city size and subsequent growth across the whole sample. But when one cuts the data along regional and period lines, correlations emerge. **Table 5** shows these correlations for Western and Eastern Europe (excluding the Balkans). Table 5 shows that large cities grew slowly in both Western and Eastern Europe from 1400 to 1500, but that the negative association was much more pronounced in the East. Between 1500 to 1600 we have something like random growth in the West, but a pronounced departure from random growth in the East. Between 1600 and 1700, the big cities of the West grew relatively quickly, but in the East there was a small, negative correlation between size and growth. Broadly, between 1400 and 1750, the correlations between size and growth were much smaller (more negative) in the East. Subsequently, catch up growth resumed, with

[21] If the growth rate of city i is g_{it} and the mean and standard deviation across cities in this period are $\bar{g}_t$ and σ_t, then normalized growth is $\hat{g}_{it} = (g_{it} - \bar{g}_t)/\sigma_t$. A similar procedure gives normalized city size.

big Eastern cities growing relatively quickly.

We can further dissect regional growth by first grouping cities in size deciles by region, and then examining the distribution of growth rates within each decile. **Figure 10** presents box-plots of city growth by size decile. (The line within each box is the median relative growth rate, the box itself describes the interquartile range, and the "whiskers" capture the upper and lower adjacent values – i.e. the upper adjacent value is the 75th percentile value plus the interquartile range multiplied by 1.5.) From 1500 to 1800, growth in the West is essentially random. This is, in itself, a somewhat remarkable finding: over one hundred year periods there is no systematic relationship between size and growth – big cities did not have persistent advantages or disadvantages. In contrast, there are substantial growth short-falls in large Eastern cities, particularly between 1500 and 1600 and between 1700 and 1750. This finding is confirmed with a variety of other tests, including OLS and non-parametric smoothing regressions, and estimated bivariate kernel densities.

5.4 Factors Associated With Variations in Growth

As noted above, the historical literature suggests that the institutional framework established in Eastern Europe was detrimental to development in the urban sector. However this literature is largely non-quantitative. It raises the question: Were the institutions of the second serfdom associated with variations in overall city growth? And if so, is the association "big"?

Table 1 shows mean growth rates in the three macro-regions, pinning down the general magnitudes of growth rates in the early modern era. Table 1 shows a sharp demographic contraction in Western European cities between 1300 and 1400 (the era of the Black Death). It also shows growth West of the Elbe outstripping growth in the East between 1500 and 1600. But overall, the data reveals that Eastern cities were not at a general growth disadvantage. **Table 6** focuses on the very largest cities, showing that over the two hundred years from 1500 to 1700 big cities in the West grew far faster than their Eastern counterparts. This data also shows that large Eastern cities were growing relatively quickly both prior to and after the second second serfdom.

A regression analysis provides a closer analysis of these questions. This paper presents two regression analyses. The first analysis essentially looks at the association between a broad period indicator and growth. The second, preferred regression exploits time variation in local legal institutions within the East.

The first regression draws on Berend's (1986: 333-334) argument that "historians see an incontestable [institutional] change at about the turn of the 15th to the 16th century." In keeping with this claim, the first regression analysis examines the association between city growth and an indicator recording whether or not observations are for Eastern cities over the period between 1500 and the date of the first emancipation proclamation issued in their territory. (**Table 7** provides a complete list of emancipation decrees and their dates.) The model includes controls for initial population, any cross-period impact of regional location (i.e. East, West, or Ottoman), and period effects. The estimating equation is:

$$\text{log growth}_{i,t} = \alpha + \beta(\text{log size})_{i,t} + \sum_j \gamma_j \text{region}_j +$$

$$\sum_k \eta_k \text{year}_k + \theta(\text{second serfdom})_{i,t} + \epsilon_{i,t}$$

The second regression keeps this structure but examines the association between city growth and a serfdom index for cities to the East of the Elbe. The index records the presence of laws restricting peasant labor mobility and tying peasants to the land (it will be updated with the additional panels of Table 2 to include the other legal dimensions of serfdom). The index records the presence of these laws starting from the dates given in Table 2 until the date of the first emancipation decree issued in the relevant political territory. Unlike the simple first regression, this one has the capacity to capture local time variation in key institutions of Eastern serfdom.

Table 8 presents results for the first model (serfdom runs from 1500 to first emancipation decree) for several different specifications. In Table 8, columns (2) to (4) use the Elbe as the border between East and West. Columns (5) to (8) use the Elbe and its tributary the Saale as the border. Across the complete data, there is a negative association between "serfdom" and growth that is marginally significant. Interestingly, when Russia is dropped from the sample the association becomes significant at the conventional levels. This is arguably because of the idiosyncratic "pre-serfdom" period in Russian history. The era before serfdom was marked by military conflicts – notably invasions of the late 14th century – and their after-effects. These were followed by the depredations unleashed around the reign of Ivan the Terrible. Over this period towns like Novgorod, Kolomna and Mozhaisk lost up to 80 percent of their population. Langer (1976: 30) notes that, "Not until the late 1620s and 1630s did the towns again begin to recover and grow." Thus Russia's history was one in which, for peculiar and largely "exogenous" reasons, the period of high serfdom was an era of relatively robust urban growth.

Two parameter estimates stand out. First, there is a strong *positive* association between city growth and location in Eastern Europe. In particular, an Eastern location is associated with an increase of roughly 0.2 log points of growth every 100 years (equivalently, 19 extra percentage points). This flies in the face of the idea that the East was stagnant or in absolute decline. Second, there is a significant negative association between serfdom and growth: serfdom is associated with a decline in growth of roughly 0.09 log points. Over 100 years, a decline of 9 percentage points seems a very small number: It implies a decline of 0.0009 in the annual growth rate. But mean growth in the East from 1300 to 1850 was 0.0054. And as shown in Table 6, annual growth in the East was not more than 0.0027 before 1750. For illustration: $(0.0009)/(0.0009 + 0.0054) \approx 14$ percent, and $(0.0009)/(0.0009 + 0.0027) \approx 23$ percent. The fact that Eastern cities grew relatively quickly, but that serfdom was associated with slow growth suggests that the institutional framework may have prevented or delayed a catch-up process otherwise under way.

Table 9 presents results for the second, preferred model (serfdom is defined in terms of the presence of legal restrictions on peasant mobility that vary in their timing across Eastern Europe). Here again Russian data damps down the "serfdom effect" for the reasons described above. But when we exclude non-

Baltic Russian cities from the sample, the serfdom effect is substantially larger and overwhelmingly statistically significant. In particular, in a narrow central Europe of German, Hungarian, Czech, Slovak, Austrian, and Polish cities, Table 9 shows that the presence of laws restricting peasant labor mobility was associated with a 0.15 log point decline in growth (see columns 4 and 8). If we turn to cities in a broad central Europe that also includes French cities, the growth shortfall associated with the legal institutions of serfdom is 0.17 log points (see columns 5 and 9). Parameter estimates of this magnitude suggest that the imposition of laws restricting labor mobility may have cut Eastern city growth by two fifths (≈ 39 percent) – a figure that crosses the threshold of social and economic significance.

It is useful, however, to underline what this exercise identifies and what it does not. The regressions in Table 9 pick up the association between the presence of laws and city growth by exploiting the variation in laws over time and cross-regional variation in city growth. Future work to supplement the Bairoch data with data for 1900 and 2000 may provide grounds on which to implement a robust test of whether the association between legal restrictions and growth holds purely within the Eastern economies that experienced the second serfdom. As it is the results implicitly construct a counterfactual that relies, in the "narrow central Europe" specification, on growth rates of Western German cities (and in the "broad central Europe" specification on the growth rates of French cities as well). Future work can also be devoted to extending the index of the legal institutions of the second serfdom along additional dimensions.

5.5 Zipf's Law and Institutions

Zipf (1941, 1949) suggests that the rank-size regularity reflects an equilibrium state. Whether or not this is the case, it is also worth noting that convergence to Zipf's Law is associated with subsequent institutional change. One way to see this is the following. Group cities by country, using 20th century polities. For each country-year, estimate a Zipf's Law. Then compute an index of convergence at the tail by summing the absolute value of deviations among the largest cities. This index can be used as an explanatory variable in a regression examining subsequent institutional change. I implement this using the Polity-IV measure of constraints on executive authority, controlling for country i and year t effects and the urbanization rate.

$$\Delta \text{INST}_{it} = \alpha_0 + \delta_t + \gamma_i + \theta \text{URBAN}_{it} + \phi \text{ZIPF}_{it} + \epsilon_{it}$$

This allows us to run a race of sorts between urbanization and Zipf. Because ZIPF is itself estimated, and has a sampling distribution, it is sensible to use a bootstrap approach to gauge the signficance of ϕ. As shown in **Figure 11**, this exercise suggests Zipf's Law has explanatory power but urbanization does not. One hypothesis is that convergence to Zipf proxies for situations where business classes are thriving and economic and social power is likely to be distributed amongst multiple urban centers.

6 Modelling City Growth

6.1 Background and Overview

The leading theoretical explanations of Zipf's frame city size distributions as outcomes of random growth processes. In particular, Gabaix (1999b) has shown how a Zipf's Law regularity emerges spontaneously when cities "draw" growth rates randomly from a common distribution. Recently, Rossi-Hansberg and Wright (2005) have extended Gabaix's argument, showing that the slight curvature we observe in log rank-log size plots of contemporary city population data may reflect a slight negative correlation between city sizes and city growth rates. A similar, but much more pronounced curvature is visible in data on European city populations in the early modern era; and where this curvature persisted longest – in Eastern Europe – there is evidence that growth rates were negatively correlated with city size over long periods.

With these arguments as motivation, I sketch the beginnings of a model of city growth over the historical long-run. The model contains two features that may deliver non-random growth: a production function in which land may be an argument, and potential distortions. The distortions can be thought of as taxes on migration or distortions that hit productivity directly.

6.2 Economic Environment

The model has overlapping generations. At any time t, cities indexed with i have old residents N^o_{it} and young residents N^y_{it}, with old people dying at some rate δ. There are city-specific amenity shocks a_{it} due to some combination of policy and nature. In particular:

$$a_{it} = \epsilon_{it}(1 - \tau_{it}) \tag{4}$$

Here ϵ_{it} is a random, iid city-specific shock and $\tau_{it} \in (0, 1)$ is a city-specific distortion – in effect a tax on migration. The amenity shocks a_{it} enter utility multiplicatively:

$$u(c) = a_{it}c \tag{5}$$

Production is CRS, with Hicks neutral technology. The arguments in the production function are labor (young and old) and land. For simplicity, assume production is Cobb-Douglas:

$$Y_{it} = A_{it}(N^y_{it})^\alpha (N^o_{it})^\beta (L_{it})^{1-\alpha-\beta} \tag{6}$$

Assume that $\alpha, \beta \in (0, 1)$ and that $\alpha + \beta \leq 1$. Where $\alpha + \beta = 1$, production is CRS in labor. The wage is the marginal product of labor and is consumed in each period:

$$c_{it} = w_{it} = \frac{\partial Y_{it}}{\partial N^j_{it}} \quad j \in \{y, o\} \tag{7}$$

The overlapping generations structure has a first period in which agents are born and decide if and where to migrate. In subsequent periods agents live out their days without further migration. In each period, $N^y_t = \sum_i N^y_{it}$ and $N^o_t = \sum_i N^o_{it}$. The aggregate number of young potential migrants is determined by a "birth rate" n_t and the number of mature agents: $N^y_t = n_t N^o_t$.

The idea of the birth rate here is a stylized one, as n_t can equally be taken as a description of a migration rate from the non-urban sector. Imagine, in a Malthusian vein, that the birth rate responds to the opportunities available the coming generation – or assume in the spirit of Lewis (1954) that there is a rural sector with quantities of surplus labor that can be drawn to cities with relatively high wages. The model frames the number of young agents arriving in each city as an endogenous variable. This means n_t is also endogenous, varying with the returns to young labor.

6.3 Analysis of City Growth – The General Case

In this environment, the individual maximization problem reduces to:

$$\max_i a_{it} w_{it}$$

Potential migrants consider wages and taxes. In equilibrium with free mobility: $u_{it} = u_t$. It follows that:

$$w_{it} = \frac{u_t}{a_{it}} \tag{8}$$

Because young people earn wages equal to their marginal product, and wages equalize across age groups, we have that:

$$w_{it} = \alpha A_{it} (N_{it}^y)^{\alpha-1} (N_{it}^o)^{\beta} (L_{it})^{1-\alpha-\beta} \tag{9}$$

Combining (4), (8), and (9), we get an expression for the number of new-comers in the representative city:

$$N_{it}^y = (N_{it}^o)^{\frac{\beta}{1-\alpha}} (A_{it})^{\frac{1}{1-\alpha}} (L_{it})^{\frac{1-\alpha-\beta}{1-\alpha}} (1-\tau_{it})^{\frac{1}{1-\alpha}} \left(\frac{\alpha \epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} \tag{10}$$

The representative city growth rate is:

$$g_{it}^N \equiv \frac{\Delta N_{it}}{N_{it}} = \frac{N_{it}^y - \delta N_{it}^o}{N_{it}^o} \tag{11}$$

Substituting with equation (10) gives:

$$g_{it}^N = (N_{it}^o)^{\frac{\beta+\alpha-1}{1-\alpha}} (A_{it})^{\frac{1}{1-\alpha}} (L_{it})^{\frac{1-\alpha-\beta}{1-\alpha}} (1-\tau_{it})^{\frac{1}{1-\alpha}} \left(\frac{\alpha \epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} - \delta \tag{12}$$

The implications of this general case can be brought out by comparing it to situations where land is unimportant, distortions do not vary with city size, and technology represents a set of non-rival ideas. Note that a distortion hitting productivity (and not amenities) would have an identical growth rate impact.

6.4 Random Growth

The conventional argument in the Zipf's Law literature is that growth rates are independent of city size. This argument embodies three assumptions: fixed factors are not important in urban production; productivity does not vary with population across cities; and distortions are independent of city size. When these are facts $\alpha + \beta = 1$. The idea that productivity and migration costs do not vary with city size can be captured by assuming: $\tau_{it} = \tau_t$ and $A_{it} = A_t$. Making these assumptions and substituting into equation (12) gives:

$$g_{it}^N = (A_t)^{\frac{1}{1-\alpha}}(1-\tau_t)^{\frac{1}{1-\alpha}}\left(\frac{\alpha\epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} - \delta \tag{13}$$

The only city-specific argument on the right-hand side of (13) is the iid random shock ϵ_{it}. It follows that the rate of population growth is independent of city size. This is the model in Gabaix (1999b).

6.5 Non-Random Growth – When Fixed Land Enters the Production Function

Assume that migration costs are constant across cities, but fixed land has some positive income share. For simplicity, normalize $L_{it} = L_i = 1$. To focus on the impact of the fixed factor, assume that $A_{it} = A_t$. Under this fixed land dispensation, we have the following variant of equation (12):

$$g_{it}^N = (N_{it}^o)^{\frac{\beta+\alpha-1}{1-\alpha}}(A_t)^{\frac{1}{1-\alpha}}(1-\tau_t)^{\frac{1}{1-\alpha}}\left(\frac{\alpha\epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} - \delta \tag{14}$$

Here land has a positive income share because $\alpha + \beta < 1$. This fact simultaneously secures the key feature of (14): city growth rates decline in population when land is fixed. Broadly, one can imagine the long pre-modern era as one in which land entered production and land was more or less fixed. Under a fixed-land regime, growth rates are negatively correlated with city populations. These assumptions deliver a distribution of growth rates in keeping with the European city size distributions we see in 1300. (See below for a simple simulation.)

6.6 Non-Random Growth – Due to Politically-Determined Distortions

6.6.1 Distortions in Migration Costs

Consider first a simple heuristic: a world without migration. With no migration, the number of young in each location i is equal to the product of the mature population N_{it}^{o} and the city-specific gross birth rate n_{it}:

$$N_{i,t}^{y} = n_{it} N_{i,t}^{o}$$

In this case, the population growth rate is:

$$g_{i,t}^{N} = \frac{N_{it}^{y} - \delta N_{it}^{o}}{N_{it}^{o}} = n_{it} - \delta$$

As noted above, there was a mortality continuum in European history such that:

$$\delta = \delta_{it} = \delta(N_{it}), \quad \delta'(\cdot) > 0$$

Assuming natality rates do not rise in city size as fast as death rates, it follows that growth rates fall in city size under autarky:

$$g_{i,t}^{N} = g_{i,t}^{N}(N_{it}), \quad g_{i,t}^{N\prime}(\cdot) < 0$$

This stylized analysis suggests the mechanism through which restrictions on migration may have produced a distribution of growth rates that would generate the sort of curvature in city size distributions we observe in Eastern Europe before convergence to Zipf's Law.

In terms of the growth model presented here, prospective migrants face utilities that embody a tax τ_{it}. It is assumed in equations (4) and (5) that τ_{it} enters utility through the multiplicative amenity shock, but an additive structure would not change the story. The tax τ_{it} generates non-random growth when (and if) it falls hardest on larger cities. Imagine, then, that land is no longer the binding constraint on population growth, but that taxes on migration are. In the starkest case, where land is absent from production and all cities have the same level of productivity (normalized to unity), migration into the representative city is:

$$N_{it}^{y} = N_{it}^{o}(1-\tau_{it})^{\frac{1}{1-\alpha}}\left(\frac{\alpha\epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} \tag{15}$$

The associated growth rate is:

$$g_{it}^{N} = (1-\tau_{it})^{\frac{1}{1-\alpha}}\left(\frac{\alpha\epsilon_{it}}{u_t}\right)^{\frac{1}{1-\alpha}} - \delta \tag{16}$$

When τ_{it} is increasing in city size, growth rates in larger cities are relatively low.

It may be that the restrictions on migration fell harder on bigger cities – say, because the representative peasant migrant coming to a big city had to come from relatively far afield, thus raising the probability of capture and fearful punishment. But this is an open historical question. There certainly is evidence peasants were not able to safely travel great distances. In the later 1600s the Austrians sent an emissary to Krakow to press the Polish authorities to implement their agreement and to return fugitive Silesian serfs, leading Wright (1961) to observe observe that, while some escaped, for most Bohemian serfs Poland was "too distant to be an attainable asylum."

6.6.2 A Distortion Hitting Productivity

Historically, it appears that as cities grew merchants and capitalists – and in particular merchants and capitalists involved in the coordination and financing of longer-distance trade – tended to account for an increasing share of economic activity. If so, an institutional set-up biased against these activities can be modelled as higher effective taxes on big cities. A classical case of this situation in Eastern Europe is the institutional set-up in Poland, where price controls were placed on urban goods and landlords won the right to export grain free of previously existing export duties, and export directly on their own account via Dutch merchants, circumventing the indigenous merchants and entrepreneurs in Polish cities.

Imagine that there is no distortion in amenities, but that discriminatory institutions operate such that productivity is deflated by τ_{it}:

$$Y_{it} = (1 - \tau_{it})A_{it}(N^y_{it})^{\alpha}(N^o_{it})^{\beta}(L_{it})^{1-\alpha-\beta} \tag{17}$$

In this case, the city growth rate g^N_{it} suffers from a distortion identical to the one generated by a direct tax on migration. The extent to which some such productivity tax increasing in N_{it} could account for the pattern of growth in Eastern Europe is an open question.

6.7 Discussion and Future Directions

A simple simulation illustrates how this model can generate deviations from Zipf's Law. **Figure 12** shows the city-size distributions that result when one takes an arbitrary, fixed set of cities and runs them through the model assuming that the fixed factor L has a positive income share and that productivity is static and common across cities. The simulation is run over 250 periods. It is assumed that $\alpha = 0.6$, $\beta = 0.2$, $\delta = 0.1$. The scaling factor u is chosen to lend plausible final sizes, but has no impact on the shape of the distribution. With no technological change, this model tends to a steady state with no growth in population (or per capita income) aside from ephemeral variations induced by stochastic shocks. Simulating the model with $\tau_{it} > 0$ and increasing slightly in city size gives equivalent results. Allowing for new cities to form reduces the curvature at the lower end of the distribution but not at the top.

This model is sketched in reduced form. Individuals and social groups typically have economically-determined preferences over institutions. Further work should be directed towards endogenizing the key politically-determined distortion τ as a choice variable in a maximization problem. Similarly, the model as sketched has distinct regimes, but ideally should incorporate a transition that allows the share of income going to the fixed factor to decay. In other words, it makes sense to consider ways to make $\alpha = \alpha_t$ and $\beta = \beta_t$, with a process such that $\alpha + \beta \to 1$.

7 Conclusion

This paper has documented several significant facts. First, Zipf's Law emerged over the transition to modern economic growth as city production became less reliant on quasi-fixed local land endowments. Second, Zipf's Law emerged unevenly. In particular, Zipf's Law emerged relatively slowly in Eastern Europe. This paper ties the differences in convergence experiences to the divergence in the institutional frameworks prevailing in Eastern and Western Europe. In particular, this paper documents and emphasizes the fact that the emergence of a dynamic capitalism and Zipf-consistent urban order in the West was historically associated with institutional regression in the East. For their part, legal institutions of the second serfdom were associated with a substantial reduction in Eastern European growth rates – but not an absolute decline.

The heuristic model of city growth remains to be further developed. On the empirical front, further work could be directed towards developing and incorporating richer measures of agricultural productivity, exploiting data on variations in natural geography, and constructing a more detailed index of the institutions of serfdom.

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Fig. 1: Zipf's Law in Contemporary City Distributions
Urban Agglomerations in Italy, Germany, and the USA

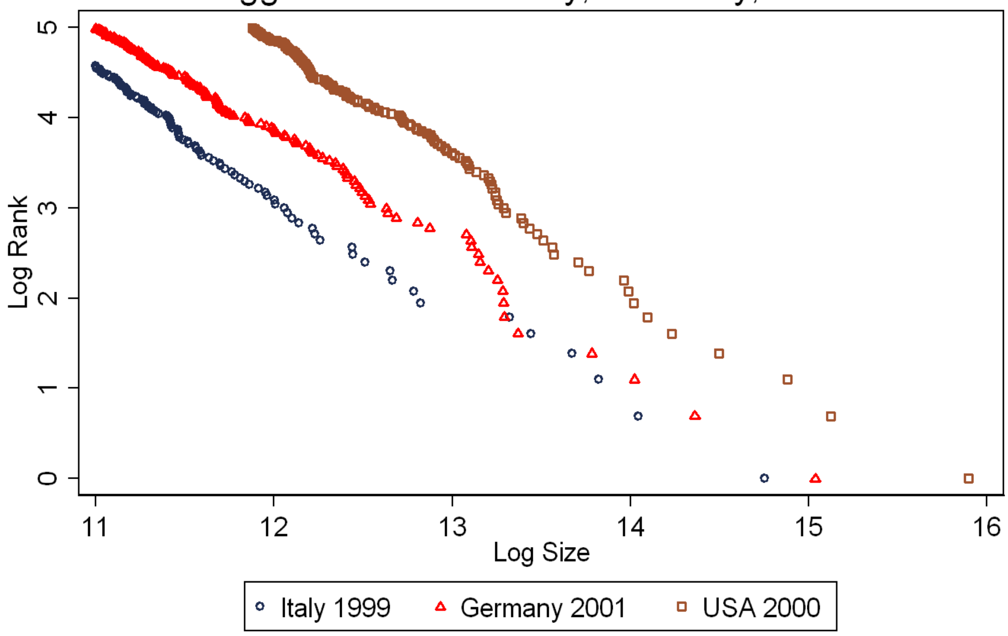


Fig. 2: City Distributions in Early Modern Europe
West of Elbe, East of Elbe, and Ottoman below Danube

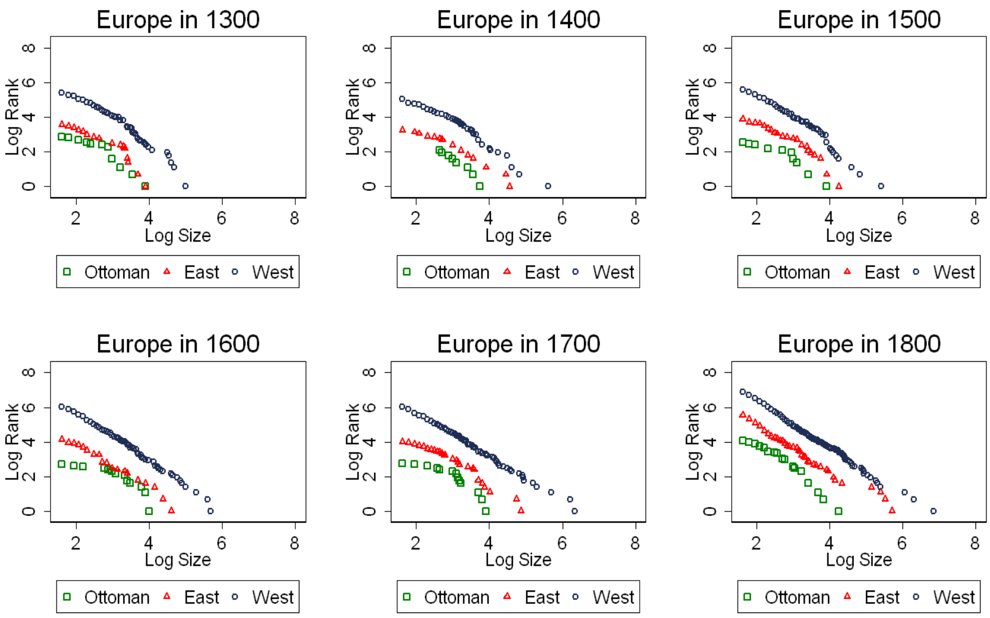
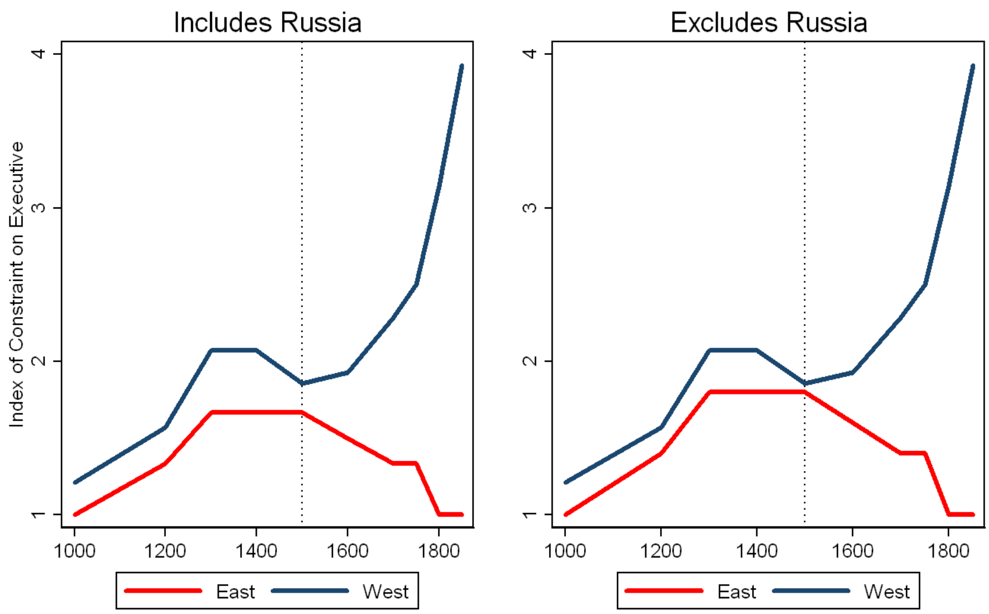


Fig. 3: Constraints on the Executive in European History
Average Level of Polity IV-Coded Index



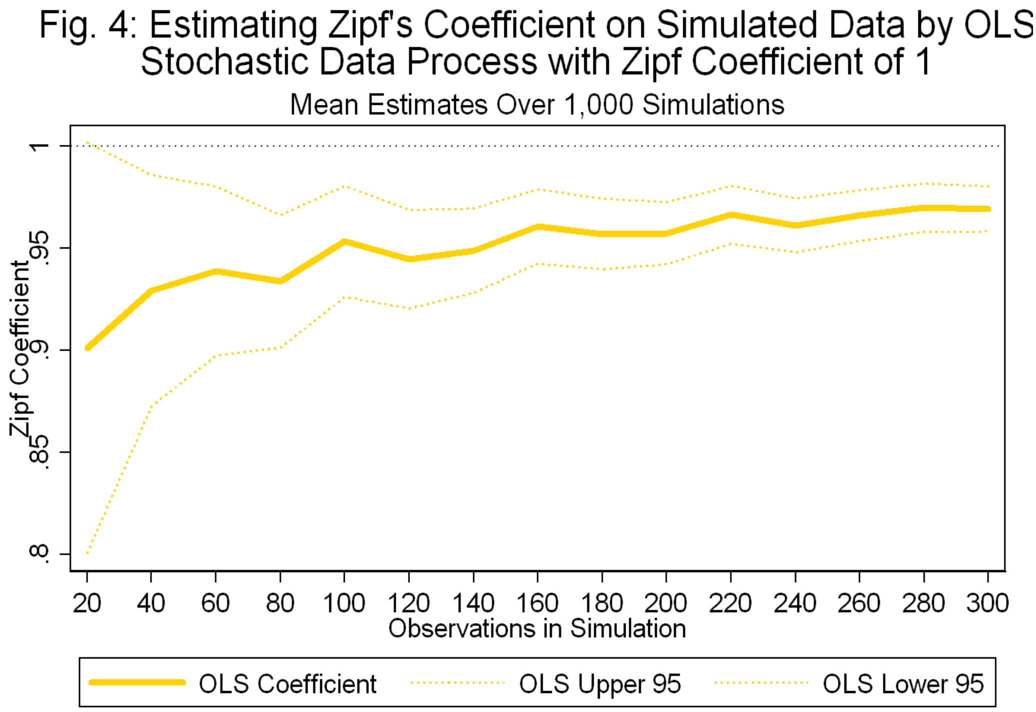


Fig. 4: Estimating Zipf's Coefficient on Simulated Data by OLS
Stochastic Data Process with Zipf Coefficient of 1
Mean Estimates Over 1,000 Simulations
Zipf Coefficient
.8
.85
.9
.95
1
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Observations in Simulation
OLS Coefficient
OLS Upper 95
OLS Lower 95

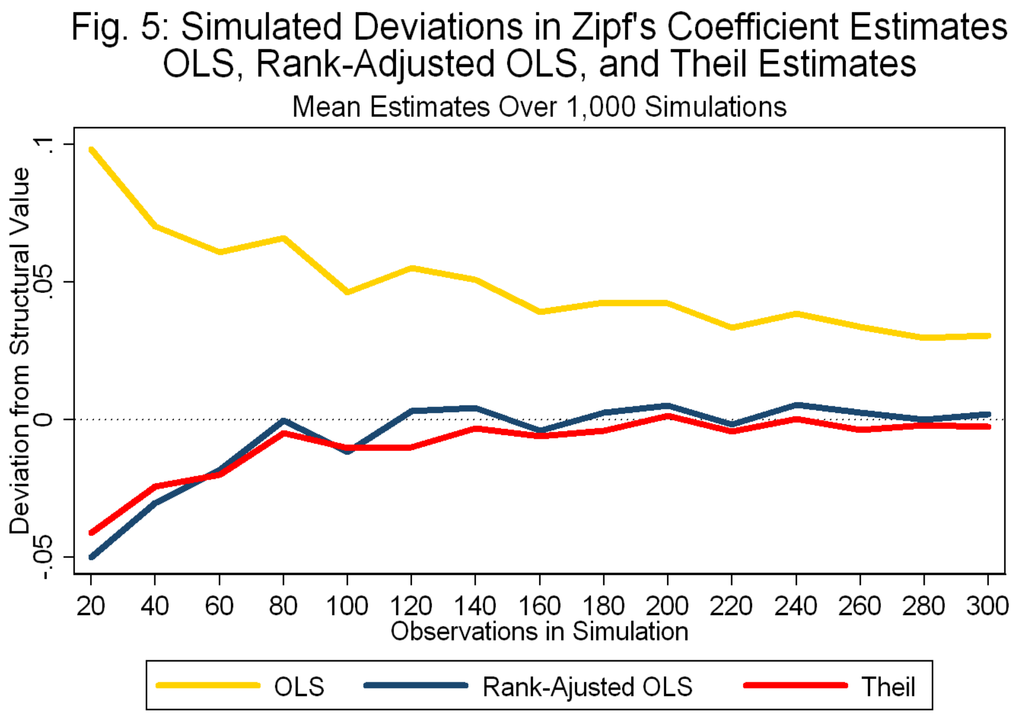


Fig. 5: Simulated Deviations in Zipf's Coefficient Estimates
OLS, Rank-Adjusted OLS, and Theil Estimates
Mean Estimates Over 1,000 Simulations
Deviation from Structural Value
-.05
0
.05
.1
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Observations in Simulation
OLS
Rank-Ajusted OLS
Theil

Fig. 6: Agricultural TFP in European History

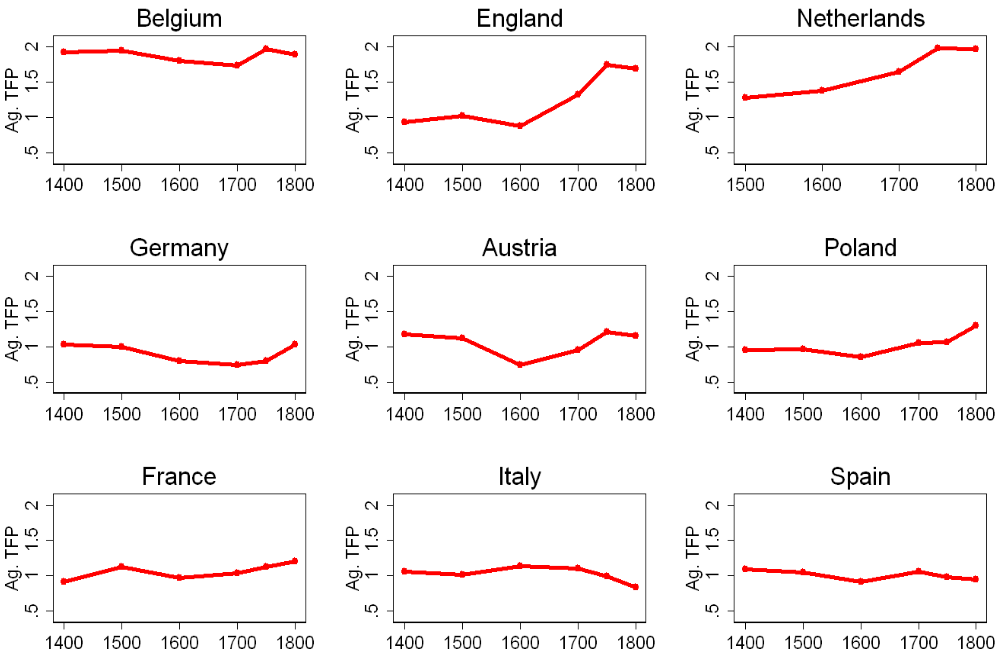


Fig. 7: Agricultural TFP and Urbanization in European History

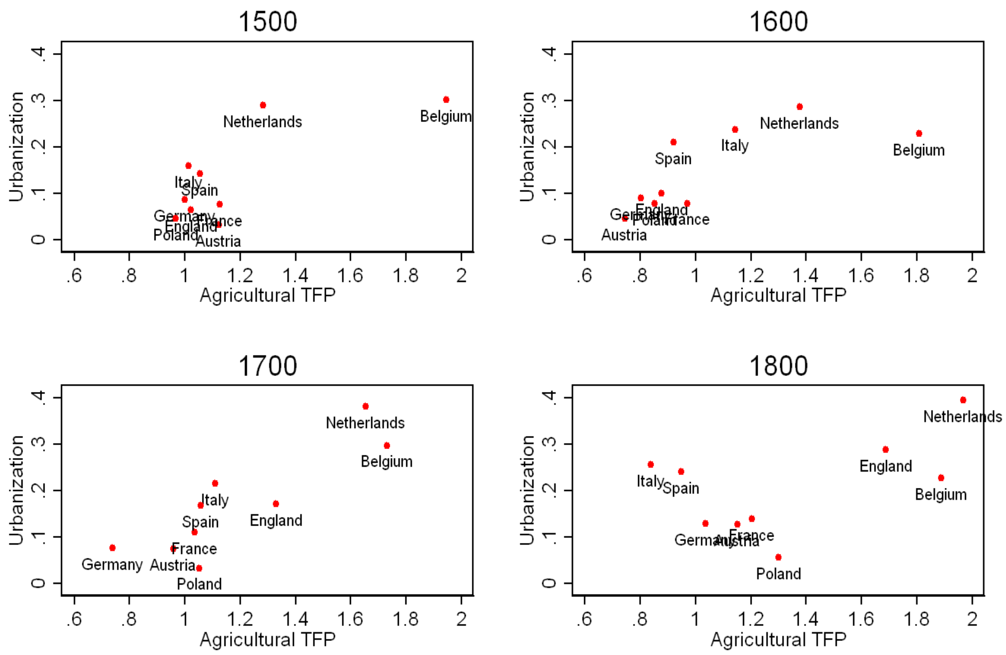


Fig. 8A: Zipf's Law in Eastern Europe
Non-Parametric Theil Regression Estimates

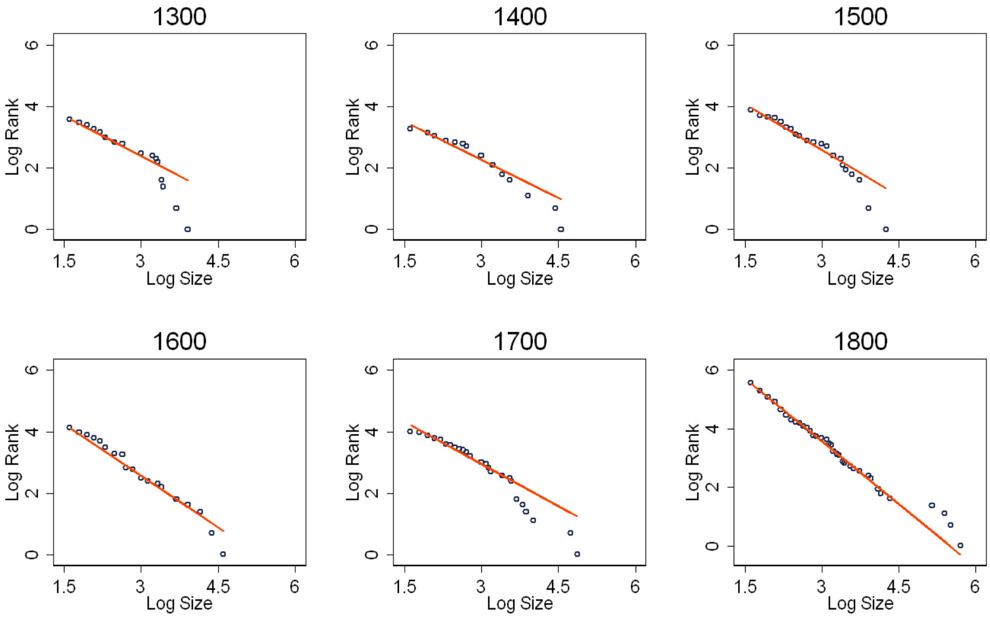


Fig: 8B: Zipf's Law in Western Europe
Non-Parametric Theil Regression Estimates

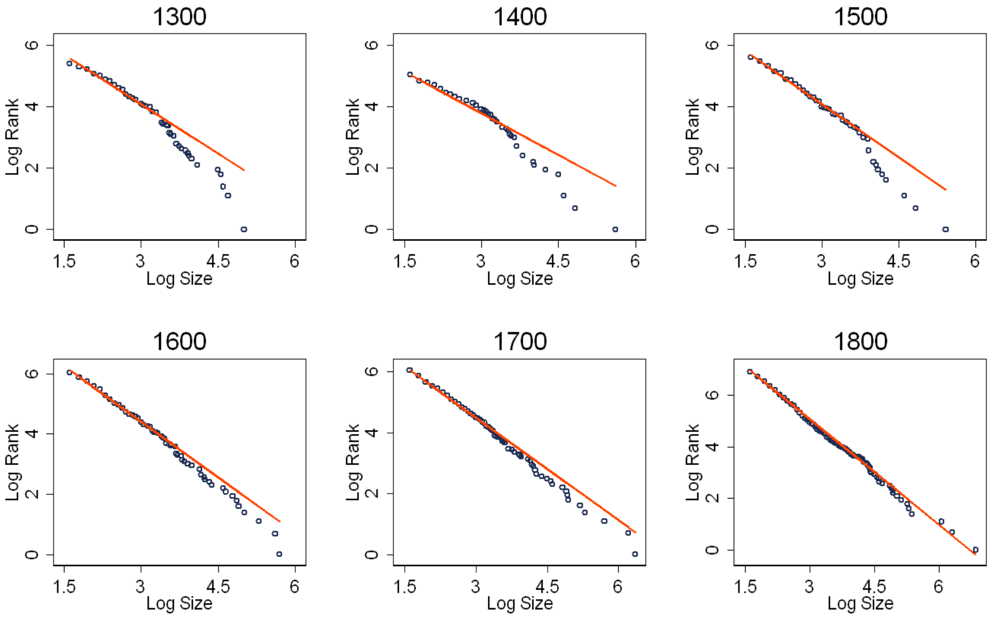


Fig. 9: 100 Simulations of Rank-Size Relationship
with Classical Measurement Error in City Size Data

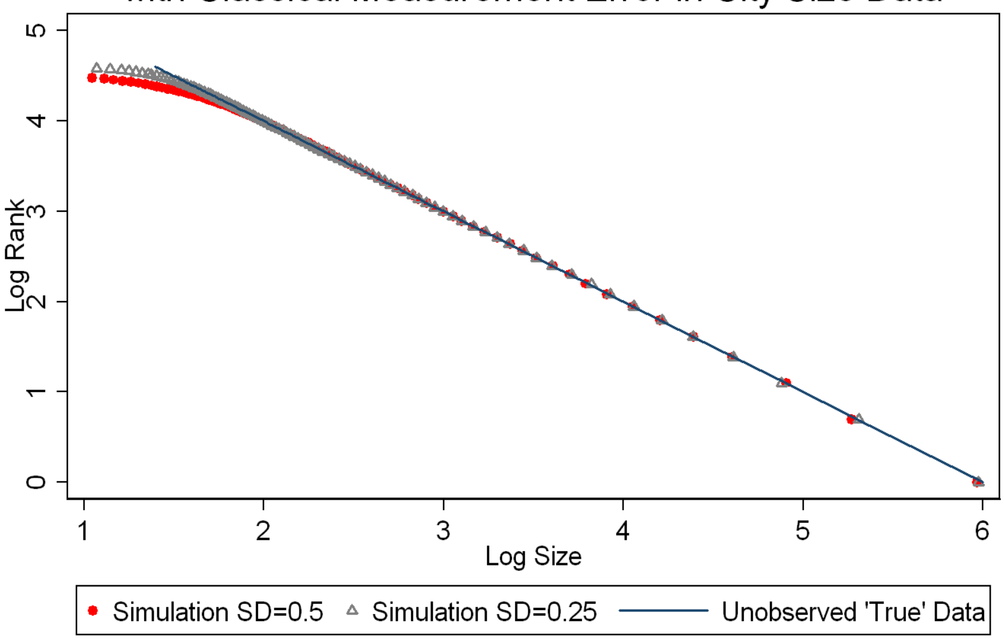


Fig. 10A: City Growth in Early Modern Europe
Cities Grouped in Deciles By Population Size

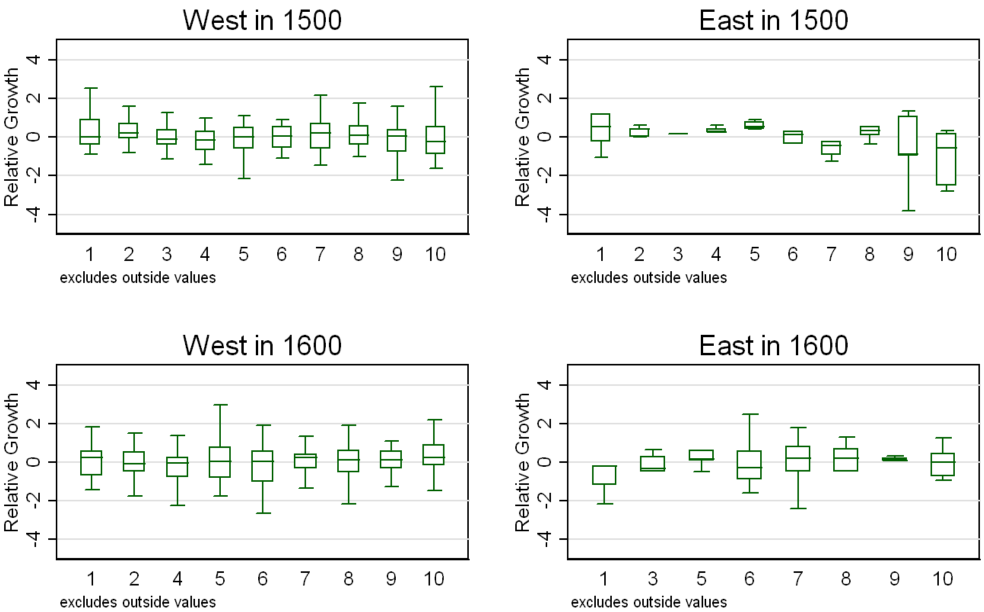


Fig. 10B: City Growth in Early Modern Europe
Cities Grouped in Deciles By Population Size

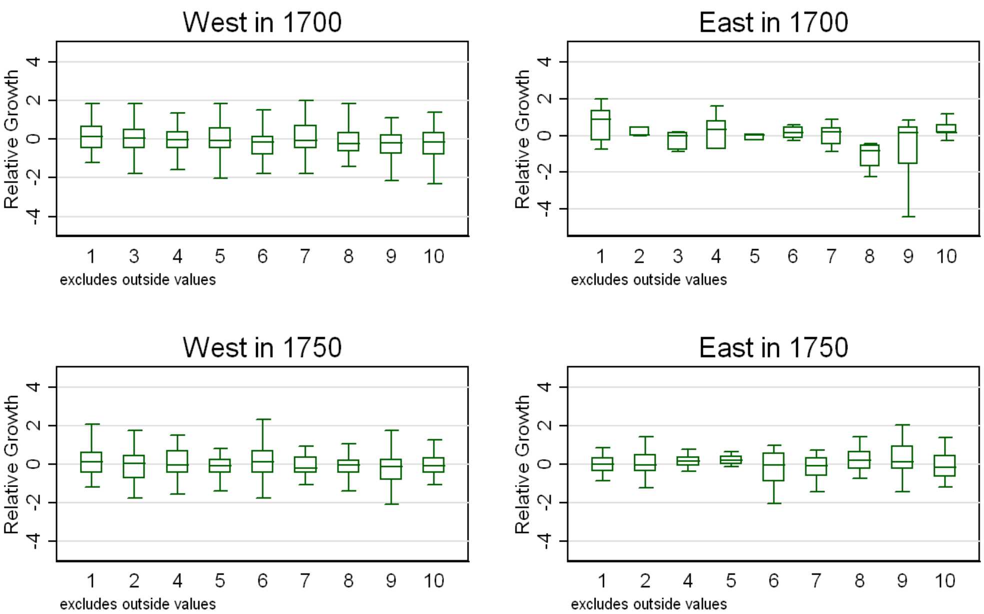


Fig. 11: Changes in Constraints on the Executive
Institutional Change, Urbanization, and Departures from Zipf
t Statistics from Regression Analysis

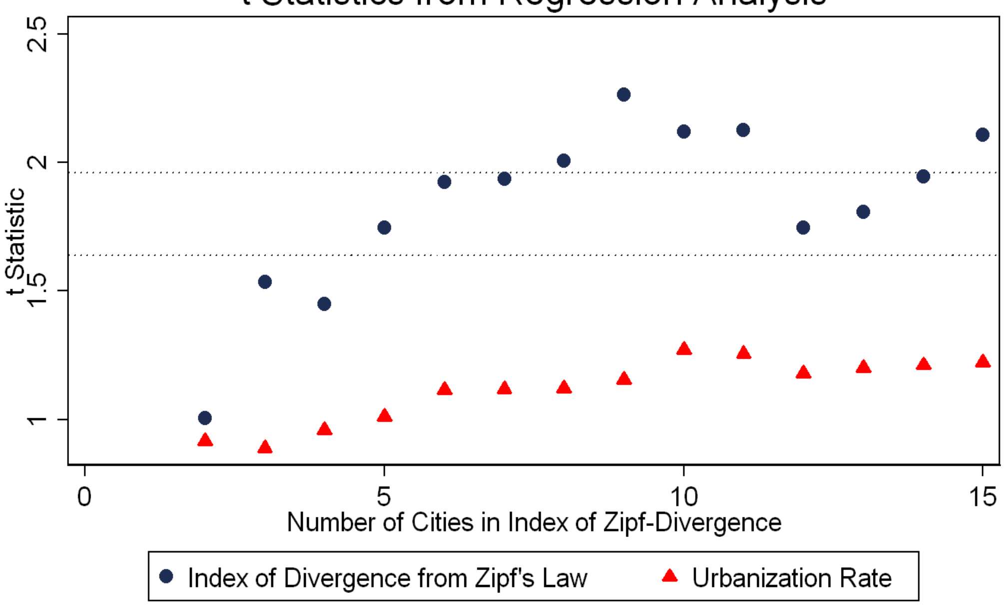


Fig. 12: City Sizes When Fixed Land Enters Production
Four Representative Simulations Based on City Growth Model

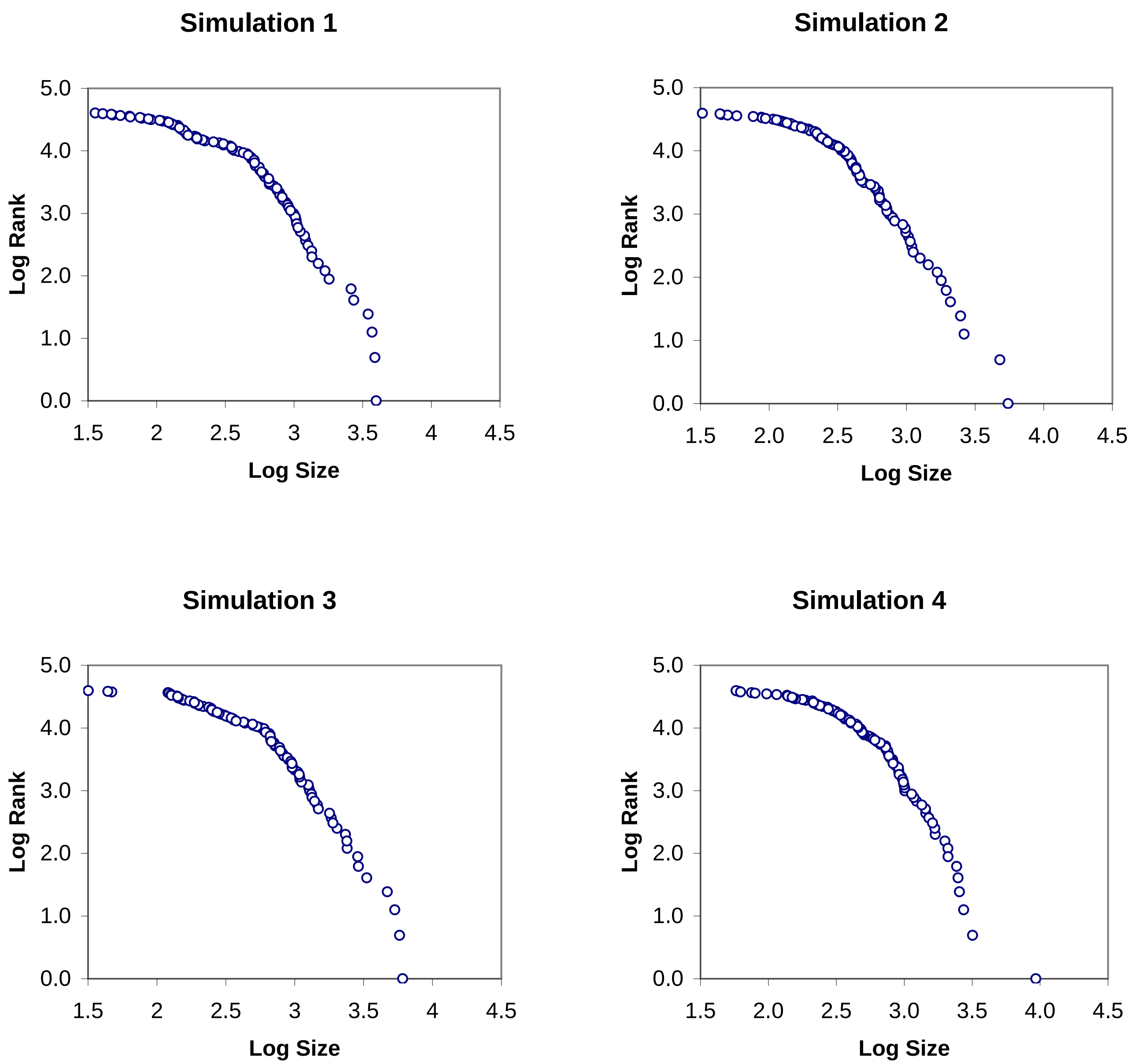


Table 1: Summary of City Data in Three European Regions
West of the Elbe River, East of the Elbe River, and Ottoman Below the Danube River

	West of the Elbe River			East of the Elbe River			Ottoman Below Danube River		
Period	Number of Cities	Mean Growth	Standard Deviation	Number of Cities	Mean Growth	Standard Deviation	Number of Cities	Mean Growth	Standard Deviation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1300 to 1400	256	-0.22%	0.58%	44	0.14%	0.48%	23	0.25%	0.40%
1400 to 1500	188	0.06%	0.52%	32	0.08%	0.46%	8	-0.05%	0.73%
1500 to 1600	322	0.18%	0.46%	55	0.14%	0.62%	13	0.53%	0.75%
1600 to 1700	518	-0.14%	0.55%	87	-0.06%	0.71%	15	-0.02%	0.66%
1700 to 1750	540	0.28%	0.60%	61	0.27%	0.99%	16	-0.06%	0.31%
1750 to 1800	691	0.29%	0.63%	161	0.36%	0.96%	19	0.30%	0.48%
1800 to 1850	1,318	0.68%	0.78%	354	0.92%	0.73%	72	0.22%	1.19%

Source: Bairoch et al. (1988). Mean growth is computed on an annualized basis. Standard deviations computed over similarly annualized growth rates.

Table 2: Three Dimensions of the "Second Serfdom" in the East
Restrictions on Migration, Inheritance, and Free Disposal of Peasant Labor

Panel A: Restrictions on Free Migration - Dates of Principal Laws

Historic Territory (1)	Contemporary Location (2)	Date (3)
Austria	Austria	1539
Bohemia	Czech Republic	1487
Brandenburg	Eastern Germany	1528
Hungary	Hungary	1514
Livonia	Estonia & Latvia	1561
Mecklenberg	Northeastern Germany	1654
Poland	Poland	1495
Pomerania	Northeastern Germany	1616
Prussia	Eastern Germany, Poland	1526
Romanian Wallachia	Romania	late 1500s
Russia	Russia	1640s/1700s
Saxony	Eastern Central Germany	--
Schleswig-Holstein	Northern Germany	1617
Silesia	Czech Rep., Poland, Eastern Germany	1528

See Appendix for sources.

Table 3A: Comparison of Bairoch and de Vries Data on City Populations
Data on the 20 Cities with the Largest Populations in 1500

City	1500			1600			1700			1800		
	Bairoch	De Vries	Ratio	Bairoch	De Vries	Ratio	Bairoch	De Vries	Ratio	Bairoch	De Vries	Ratio
(1)	(2)	(3)	(4) (2)/(3)	(5)	(6)	(7) (5)/(6)	(8)	(9)	(10) (8)/(9)	(11)	(12)	(13) (11)/(12)
Paris	225	100	2.25	300	220	1.36	500	510	0.98	550	581	0.95
Naples	125	150	0.83	275	281	0.98	300	216	1.39	430	427	1.01
Milan	100	100	1.00	120	120	1.00	125	124	1.01	135	135	1.00
Venice	100	100	1.00	151	158	0.96	138	138	1.00	138	138	1.00
Prague	70	--	--	100	--	--	48	39	1.23	76	77	0.99
Granada	70	70	1.00	69	69	1.00	70	--	--	70	55	1.27
Lisbon	65	30	2.17	130	100	1.30	180	165	1.09	195	180	1.08
Tours	60	--	--	65	--	--	21	30	0.70	13	23	0.57
Genoa	58	60	0.97	63	71	0.89	65	80	0.81	90	91	0.99
Rome	55	55	1.00	100	105	0.95	135	138	0.98	153	163	0.94
Florence	55	70	0.79	76	70	1.09	72	72	1.00	81	81	1.00
Gent	55	40	1.38	31	31	1.00	52	51	1.02	55	51	1.08
Palermo	55	55	1.00	105	105	1.00	100	100	1.00	139	139	1.00
Lyon	50	50	1.00	35	40	0.88	97	97	1.00	109	100	1.09
Bologna	50	55	0.91	63	63	1.00	63	63	1.00	68	71	0.96
Verona	50	38	1.32	45	49	0.92	35	41	0.85	51	41	1.24
Orleans	50	--	--	40	--	--	32	30	1.07	48	43	1.12
Bordeaux	50	20	2.50	40	40	1.00	45	50	0.90	96	88	1.09
London	50	40	1.25	200	200	1.00	575	575	1.00	948	865	1.10
Brescia	49	49	1.00	36	42	0.86	35	35	1.00	32	28	1.14
Mean Ratio Bairoch / De Vries:			1.26			1.01			1.00			1.03

Source: Bairoch et al. (1988) and de Vries (1984).

Table 3B: Comparison of Bairoch and de Vries Data on City Populations
Data on 10 Randomly Selected Eastern Cities

City	1500 Bairoch	1500 De Vries	1500 Ratio	1600 Bairoch	1600 De Vries	1600 Ratio	1700 Bairoch	1700 De Vries	1700 Ratio	1800 Bairoch	1800 De Vries	1800 Ratio
(1)	(2)	(3)	(4) (2)/(3)	(5)	(6)	(7) (5)/(6)	(8)	(9)	(10) (8)/(9)	(11)	(12)	(13) (11)/(12)
Danzig (Gdansk)	30	20	1.50	80	50	1.60	40	50	0.80	37	40	0.93
Chemnitz (K-Marx-St.)	--	0	--	5	5	1.00	--	4	--	14	11	1.27
Dresden	5	5	1.00	12	12	1.00	40	40	1.00	60	55	1.09
Frankfurt A O	11	11	1.00	13	13	1.00	9	9	1.00	13	12	1.08
Breslau (Wroclaw)	25	25	1.00	40	30	1.33	40	--	--	60	54	1.11
Warsaw	5	0	--	12	15	0.80	15	15	1.00	63	63	1.00
Prague	70	--	--	100	--	--	48	39	1.23	76	77	0.99
Leipzig	10	10	1.00	17	14	1.21	20	20	1.00	30	32	0.94
Lubeck	25	24	1.04	23	23	1.00	23	--	--	25	23	1.09
Potsdam	--	0	--	--	0	--	--	2	--	27	27	1.00
Mean Ratio Bairoch / De Vries:			1.09			1.12			1.01			1.05

Source: Bairoch et al. (1988) and de Vries (1984).

Table 4: Deviations from Linear Zipf's Law in Europe's Largest Cities
Ratio of Observed Population to Zipf-Consistent Population

The Fifteen Largest Cities in Rank Order	Deviation Ratio in 1500		Deviation Ratio in 1600		Deviation Ratio in 1700		Deviation Ratio in 1800	
	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	0.3	0.3	0.5	0.4	0.3	0.5	1.2	1.1
2	0.4	0.3	0.8	0.7	0.5	0.8	1.6	1.1
3	0.4	0.4	0.8	0.7	0.4	0.7	1.9	1.2
4	0.4	0.4	1.1	0.6	0.4	0.6	1.9	0.7
5	0.8	0.4	1.1	0.7	0.5	0.7	1.0	0.8
6	0.8	0.5	1.0	0.8	0.6	0.6	0.9	0.9
7	0.8	0.5	1.0	0.8	0.6	0.7	1.0	0.8
8	0.9	0.5	1.0	0.8	0.6	0.8	1.0	0.8
9	0.9	0.6	1.1	0.8	0.6	0.8	1.0	0.8
10	1.1	0.6	1.1	0.7	0.6	0.7	1.1	0.9
11	1.0	0.6	1.0	0.7	1.0	0.7	1.1	0.9
12	1.0	0.6	0.9	0.7	1.1	0.7	1.1	1.0
13	1.0	0.7	0.9	0.8	1.0	0.7	1.0	0.9
14	1.0	0.7	0.9	0.8	1.0	0.7	1.0	0.8
15	1.2	0.7	0.9	0.8	0.9	0.7	1.0	0.8

Note: the deviation ratio is equal to the observed population divided by the counterfactual population consistent with a Zipf's Law estimated with a Theil non-parametric regression for each region-period.

Table 5: Correlations Between City Size and City Growth
Correlation Between Normalized Size and Normalized Growth

Period (1)	East & West Europe (2)	Europe West of the Elbe River (3)	Europe East of the Elbe River (4)
A. All Data Pooled			
1300 to 1850	0.00	0.01	-0.02
B. Period By Period			
1300 to 1400	-0.01	-0.01	-0.03
1400 to 1500	-0.21 **	-0.19 **	-0.37 *
1500 to 1600	-0.07	-0.03	-0.33 **
1600 to 1700	0.09 *	0.10 **	-0.03
1700 to 1750	-0.05	-0.05	-0.11
1750 to 1800	0.00	-0.01	0.04
1800 to 1850	0.04 *	0.04	0.06

Significance at the 5 and 10 percent levels denoted by " ** " and " * ", respectively.

Table 6: Growth in Europe's Largest Cities
A Comparison of the 15 Biggest Cities in Eastern and Western Europe

Regional Growth Calculated as City Population Weighted Average

Period (1)	Europe West of the Elbe (2)	Europe East of the Elbe (3)	Western Advantage (4) (2) - (3)
1300 to 1400	-10%	34%	-45%
1400 to 1500	-11%	-3%	-9%
1500 to 1600	39%	9%	30%
1600 to 1700	29%	-8%	36%
1700 to 1750	12%	10%	2%
1750 to 1800	17%	42%	-25%
1800 to 1850	70%	83%	-13%

Table 7: The End of Serfdom
Emancipation Decrees in Central and Eastern Europe

Territory (1)	Year of Initial Emancipation Decree (2)
Poland (Grand Duchy of Warsaw)	1807
Prussia	1807
Estonia	1816
Courland	1817
Livonia	1819
Mecklenburg	1820
Saxe-Altenburg	1831
Saxony	1832
Schwarzburg-Sondershausen	1848
Reuss (older line)	1848
Saxe-Weimar	1848
Austria	1848
Saxe-Gotha	1848
Anhalt-Dessau-Köthen	1848
Schwarzburg-Rudolstadt	1849
Anhalt-Bernburg	1849
Saxe-Meiningen	1850
Reuss (younger line)	1852
Hungary	1853
Russia	1861
Romania (Danubian Principalities)	1864

Source: Blum (1978)

Table 8: Regression Analysis of City Growth From 1300 to 1850
Dependent Variable is Log City Growth
Serfdom Runs from 1500 to Emancipation

Independent Variable	Eastern Cities are Located East of the Elbe River			Eastern Cities are Located East of the Elbe and/or Saale		
	Complete Data	Europe Excluding Russia[1]	Only 'Central' Europe[2]	Complete Data	Europe Excluding Russia[1]	Only 'Central' Europe[2]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Size	-0.02	-0.01	0.01	-0.02	-0.01	0.01
	(1.63)	(1.15)	(0.65)	(1.62)	(1.14)	(0.65)
Year 1400	0.21	0.23	0.26	0.21	0.23	0.26
	(3.53)	(3.68)	(2.71)	(3.55)	(3.70)	(2.74)
Year 1500	0.34	0.37	0.36	0.34	0.37	0.36
	(6.80)	(7.18)	(4.55)	(6.78)	(7.17)	(4.51)
Year 1600	0.04	0.04	0.05	0.04	0.04	0.04
	(0.77)	(0.74)	(0.54)	(0.77)	(0.74)	(0.51)
Year 1700	0.30	0.31	0.31	0.30	0.31	0.31
	(6.73)	(6.82)	(4.17)	(6.72)	(6.82)	(4.15)
Year 1750	0.31	0.32	0.31	0.31	0.32	0.31
	(7.10)	(7.24)	(4.24)	(7.07)	(7.23)	(4.21)
Year 1800	0.51	0.50	0.49	0.51	0.50	0.49
	(11.84)	(11.52)	(6.77)	(11.82)	(11.52)	(6.76)
West	0.05	0.05	-0.17	0.05	0.05	-0.17
	(1.10)	(1.13)	(4.40)	(1.07)	(1.10)	(4.48)
East	0.20	0.23		0.20	0.22	
	(3.25)	(3.79)		(3.23)	(3.74)	
Second Serfdom[3]	-0.08	-0.10	-0.10	-0.08	-0.09	-0.09
	(1.79)	(2.11)	(2.20)	(1.69)	(1.99)	(1.97)
Observations	4,324	4,069	1,523	4,324	4,069	1,523
F Statistic	67.90	63.26	25.76	68.40	63.93	26.53
R Squared	0.14	0.15	0.15	0.14	0.15	0.15
SE Clustered	On City	On City	On City	On City	On City	On City

[1] Excludes only Russian, Belorussian, and Ukrainian cities. Lithuanian, Latvia, and Estonian cities included, as are cities found today in Russian Kaliningrad.

[2] Data restricted to cities located in contemporary Germany, Austria, Czech Republic, Slovakia, Hungary, and Poland.

[3] 'Second Serfdom' indicator is 1 for Eastern European cities from 1500 through date of first emancipation decree.

Table 9: Regression Analysis of City Growth From 1300 to 1850
Dependent Variable is Log City Growth
Serfdom Effect Captured by Index of Laws Restricting Peasant Mobility

	Eastern Cities are Located East of the Elbe River				Eastern Cities are East of the Elbe and/or Saale			
Independent Variable	Complete Data	Europe Excluding Russia[1]	A Narrow 'Central' Europe[2]	A Broad 'Central' Europe[3]	Complete Data	Europe Excluding Russia[1]	A Narrow 'Central' Europe[2]	A Broad 'Central' Europe[3]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Size	-0.02	-0.01	0.02	0.01	-0.02	-0.01	0.02	0.01
	(1.61)	(1.08)	(0.84)	(0.83)	(1.60)	(1.08)	(0.77)	(0.81)
Year 1400	0.21	0.23	0.10	0.26	0.21	0.23	0.10	0.26
	(3.55)	(3.70)	(0.87)	(2.72)	(3.56)	(3.72)	(0.90)	(2.74)
Year 1500	0.34	0.36	0.22	0.37	0.34	0.36	0.22	0.37
	(6.60)	(7.07)	(2.89)	(4.66)	(6.60)	(7.06)	(2.85)	(4.64)
Year 1600	0.03	0.04	-0.22	0.05	0.03	0.03	-0.23	0.05
	(0.67)	(0.71)	(2.24)	(0.63)	(0.67)	(0.70)	(2.27)	(0.59)
Year 1700	0.29	0.30	0.22	0.32	0.29	0.30	0.21	0.32
	(6.60)	(6.77)	(2.55)	(4.25)	(6.60)	(6.77)	(2.50)	(4.24)
Year 1750	0.30	0.31	0.20	0.31	0.30	0.31	0.20	0.31
	(6.95)	(7.15)	(2.62)	(4.23)	(6.95)	(7.15)	(2.59)	(4.23)
Year 1800	0.50	0.50	0.39	0.49	0.50	0.50	0.39	0.49
	(11.70)	(11.44)	(5.10)	(6.73)	(11.71)	(11.44)	(5.10)	(6.74)
West	0.05	0.05	-0.12	-0.17	0.05	0.05	-0.13	-0.17
	(1.11)	(1.13)	(3.74)	(5.80)	(1.08)	(1.11)	(4.11)	(6.34)
East	0.16	0.20			0.16	0.20		
	(2.92)	(3.78)			(3.02)	(3.76)		
Serfdom Laws[4]	-0.05	-0.11	-0.15	-0.18	-0.05	-0.11	-0.15	-0.17
	(1.36)	(2.57)	(2.89)	(3.46)	(1.46)	(2.52)	(2.88)	(3.41)
Observations	4,324	4,069	773	1,523	4,324	4,069	773	1,523
F Statistic	67.98	63.89	20.87	27.16	68.73	64.95	21.18	28.51
R Squared	0.14	0.15	0.23	0.16	0.14	0.15	0.23	0.16
SE Clustered	On City	On City	On City	On City	On City	On City	On City	On City

[1] Excludes only Russian, Belorussian, and Ukrainian cities. Lithuanian, Latvia, and Estonian cities included, as are cities found today in Russian Kaliningrad.

[2] Data restricted to cities located in contemporary Germany, Austria, Czech Republic, Slovakia, Hungary, and Poland.

[3] Data restricted to cities located in contemporary Germany, Austria, Czech Republic, Slovakia, Hungary, Poland, and France.

[4] 'Serfdom Laws' is 1 for Eastern cities in territories with restrictions on peasant mobiliity from the date of the passage of these laws through date of first emancipation decree.


KINGDOM OF NORWAY
KINGDOM OF SWEDEN
KINGDOM OF DENMARK
DUCHY OF FINLAND
KNIGHTS OF LIVONIA
PSKOV
GRAND PRINCIPALITY OF MUSCOVY OR RUSSIA
PRINCIPALITY OF RIAZAN
GOLDEN HORDE in decay
KHANATE OF ASTRAKHAN
KINGDOM OF SCOTLAND
NORTH SEA
BALTIC SEA
Tir Connail
Tir
Mayo
Sligo
Galway
Thomond
Or-mond
Desmond
K of MAN
Principality of Wales
KINGDOM OF ENGLAND
Teutonic Prussia
GRAND DUCHY OF LITHUANIA
Duchy of Pomerania
Meck-lenburg
Fries-land
small states
Brandenburg
Saxony
Hesse
small states
KINGDOM OF POLAND
CROWN OF BOHEMIA
BOHEMIA
and HUNGARY in personal union
Kingdom of Hungary
House of AUSTRIA
THE CHANNEL
KINGDOM OF FRANCE
Confederacy of the Swiss
Venice
SAVOY
MILAN
Este
Kingdom of Croatia
PRINCIPALITY OF MOLDAVIA
PRINCIPALITY OF WALLACHIA
KHANATE OF KRIMEA
WILD FIELDS
Bosnia
Monte-negro
Ragusa
Genoa
French prot.
Pisa
ST PETER
French occupation
Kingdom of NAPLES
BEYLERBEYLIK OF RUMELIA
OTTOMAN EMPIRE
BLACK SEA
Adighs or Circassians
Kabards
Ossetians
Abkhazia
Imereti
Kartli
Ka-kheti
Samt-skhe
BEYLERBEYLIK OF RUM
BEYLERBEYLIK OF ANATOLIA
DULKADIR
DOMINION OF SHAH ISMAIL
FEDERATION OF THE WHITE SHEEP
Na-varre
CROWN OF CASTILE
CROWN OF ARAGON
CATHOLIC MONARCHY
KINGDOM OF PORTUGAL
KINGDOM OF SICILY
MEDITERRANEAN SEA
Algiers
Kuko
Cons-tantine
Bizerta
K of Labbes
HAFSID KINGDOM
Spain
Oran
Tlemcen
Warsenis
KINGDOM OF FEZ
Kingdom of MOROCCO
IMAN OF SUS
OASIS OF FIGUIG
MZAB
TOUGGOURT
WARGLA
GHADAMES
TRIPOLI
Naxos
Saint John
Karpathos
MEDITERRANEAN SEA
SULTANATE OF EGYPT