EXTENDED ABSTRACT

The estimation of ancient urban population numbers accounting for different levels of accuracy, precision, and semantics of primary data sources:

A case study on Southern Mesopotamia

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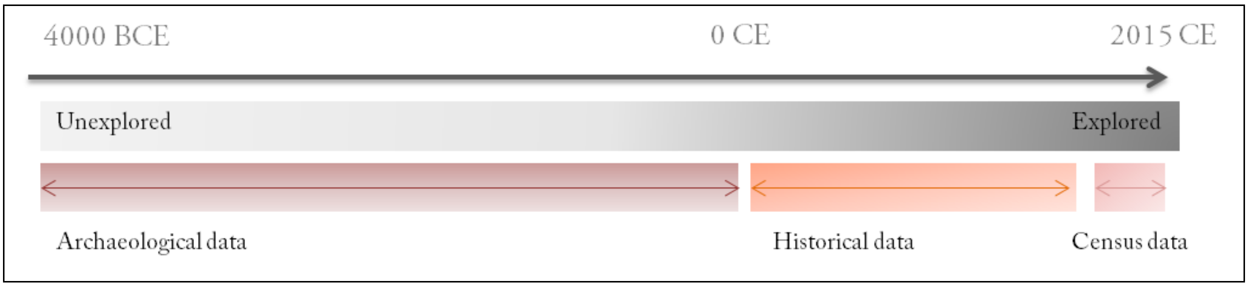
Abstract

Extensive bodies of research in the fields of economic geography, regional studies, and urban economics have underlined the importance of city formation, city growth and the development of city networks in relation to innovation, wealth creation, and thus to economic growth (Bettencourt et all., 2007; Clark, Feldman, Gertler, 2000; Marshall, 1890, 1920; McCann, 2013). The influential school known under the banner of 'New Economic Geography'(NEG) specifically focuses on the importance of explaining development trajectories of the spatial economy in relation to the evolution of city systems (Krugman, 2000; McCann, 2013). Since the evolution of city systems does not happen overnight, the analysis of economic growth in relation to cities is placed in a broader, timely perspective than regular models do.

Though making significant scientific contributions, the primary impact of NEG has been with respect to theory rather than empirical developments (Ascani, Crescenzi, Iammarino, 2012). An important factor inhibiting the knowledge production on city networks in relation to economic performance over more extensive time spans is that only census data and to a small extent historical data is easily, quantitatively accessible albeit archaeological data with quantitative potential on ancient cities and urban systems has expanded tremendously (Blumin, 1994; McShane, 2006; Nijman, 2007; Smith, 2009). As a result, approximately ninety percent of human economic experience in urban networks since the first state formations is still excluded from analyses (figure 1).

Figure 1: Overview of type of data availability



This would not be a problem per see if there is no evidence of significant economic and spatial change in pre-historical times. However, especially the periods for which only or mainly archaeological data is available appear to be promising for delivering insights into the nature of economic performance and its relation to urban trajectories (Hanson, 2016; Visser, 2016). This is largely due to the fact that the decisive transformations known under the header "the urban revolution" (Childe, 1950) took place in this time span (Bairoch, 1988; LeGates, Stout, 2011; Trigger, 2003). Additionally, as noted by Hanson (2016), in statistical terms it is essential to have as many observations as possible covering the entire urban hierarchy over vast areas and long time frames in order to understand overall patterns and trends or study underlying dynamics.

Even though recent advancements made in archaeological methods and scale have increased the amount and quality of the data greatly (Smith, Feinman, Drennan, Earle, Morris, 2012), and expectations are that the amount of data will even increase manifold (Barcelo, Bogdanovic, 2015), and already some summary databases on ancient urban population numbers and networks have been developed (Chandler, 1987; Modelski, 2003; Reba et all., 2016), one of the main hurdles remains that the insertion of the data lacks a standardized approach and does not account for differences in accuracy, statistical precision and semantics for different point estimates (Lawrence, Bradbury, Dunford, 2012). It is unknown what the precise effect is of neglecting these differences in data quality and precision, but in the case of archaeological data, which is prone to uncertainties, these might be large (Feinman, Price, 2007; Jongman, 2014; Kennedy, 2006; Parkin, 1999).

In this article, a theoretical framework is developed that guides the construction of an archaeological urban database that records differences in accuracy, precision and semantics of estimates on two key quantities in urban economics, namely the areal extent and population size of cities. Difficulties of measuring these two key quantities for both modern as well as for ancient cities start with finding a practical way to define 'a city' (Hanson, 2016; Modelski, 2003). However once for modern cities a definition is chosen, the geographical boundaries as well as the number of inhabitants within these boundaries can be established quite accurately and precisely for a particular moment in time by one of the four methods described by Rozenfeld et all. (2011), each relating to a slightly different definition of 'a city'.

For ancient cities on the other hand, a certain definition of what a city entails is only at the start of a long list of factors causing uncertainties in the estimates of urban area and population numbers (Kennedy, 2006; Postgate, 1994; Storey, 1997). Several geomorphological factors can cause biases with regard to estimates of the areal extent of ancient cities. Additionally, also issues with establishing chronologies and differing methodological approaches of archaeologists impact estimates (Lawrence, Bradbury, Dunford, 2012). Since areal extent is then used as one of the main inputs for estimating the number of urban inhabitants (urban areal extent times population density), the estimates for urban population numbers reflect even more uncertainties (Kennedy, 2006). Luckily, information on different levels of accuracy, precision and semantics of the data has the ability to significantly improve calculations (Lawrence, Bradbury, Dunford, 2012). This is especially the case when the aim is to estimate *regional* urban population numbers (Hanson, 2016; Morley, 2011). As for this study, all potential biases and different levels of precision are documented, examined and if possible their size and probability distribution are estimated.

To this end, a database has been developed containing all ancient cities of Southern Mesopotamia with estimates for urban areal extent and urban density from 3700 BCE to 1000 BCE. By defining probability distributions for both areal extent and urban density, it becomes possible to characterize the uncertainty in the total urban population number of an urban system. The parameters of the probability distributions are derived from a subset of cities for which (nearly) complete information is available. To quantify the error propagation Monte Carlo (MC) simulation is used, and for testing the robustness of results we will vary the probability density functions such as the uniform distribution, the normal distribution, and the log-normal distribution. The advantage of this approach is that by accounting for uncertainty, certainty is to a certain extent created with respect to total urban population numbers through time. Confidence intervals indicate the band in which the true value for total urban population might lie and enhance the comparability of the data with different time frames or different urban systems.

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