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City origins

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ABSTRACT

The urban history, archeology, regional science and urban economics literatures all stress many different locational characteristics as important in driving city location. The availability of ever better, spatially more fine-grained, data on the historical and geographical characteristics of cities, and of locations that never developed into a city, makes it possible to start to enrich this debate with (much-needed) empirical evidence. Using this data in combination with more advanced empirical and computational methods will almost surely give us a better, empirically well-grounded, understanding of the relative importance of the many alleged *"city seeds"* in different parts of the world and at different points in history.

1. Introduction

City origins are often of shrouded in myth, legend or acts of divine or heroic proportion. The legendary foundations of cities as diverse as Athens, Uruk, Rome, Tenochtitlan, Carthage, Varanasi, Alexandria, Babylon, Eridu, and Cuzco all involve acts of divine intervention, or omens pointing to the best city location. These foundation legends give us clues as to what the gods or heroes were looking for when founding their city, or when convincing the people to found a city in their name instead of that of a competitor, but it is archeologists and urban historians, notably the early work of Weber (1922), Pirenne (1925), Childe (1950), Mumford (1961), Bairoch (1988) that started to systematically document the important reasons for cities to develop in some locations and not in others.[2]

Geography is the predominant determinant of city location stressed in this literature. However, the exact geographical features of importance mentioned are many, and they often differ between different parts of the world at different points in history. Generally speaking, with the advancement of human technology, more and more locations qualified as, in principle, viable city locations. Advances in agriculture, transport, and storage technology weakened the link between city development and favorable agricultural conditions; while at the same time advances in medicine and sanitation substantially limited the negative externalities associated with city life. As a result, cities can today be found in every corner of the earth - in some of its harshest climates, and even on reclaimed parts of the ocean floor. Wherever they arose, cities have been great engines of social and cultural change, technological progress, and the exchange of goods, people and ideas (Glaeser, 2011). They are also remarkably resilient. Once established, they typically persist. It makes understanding the important factors that gave rise to cities in particular places in particular time periods of great interest.

Until recently, the lack of comprehensive data sets on historical city location in many parts of the world meant that the debate on the origins of cities largely took place without solid empirical evidence on the (ir)relevance of the (many) different alleged *"city seeds"*. In this overview, I argue that recent advances in data availability and in our (computational) ability to handle this data means that we can start to fill this gap using state-of-the art empirical methods. First, in section 2, I provide a succinct overview of the most important alleged drivers of city location. Section 3 then lays out the basic empirical framework used to empirically quantify their (relative) importance, highlighting two important choices faced by any empirical study into the origins of cities. Subsequently, section 4, discusses the opportunities offered by the fast-expanding availability of very detailed geospatial data sets on historic city location, as well as on a wealth of geographic and climatic characteristics. In doing so, it highlights the promise held by exploiting

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[1] I am very grateful to Laurent Gobillon and Stephan Heblich for providing excellent comments and suggestions that have significantly improved the paper.
[2] See also Ullman (1941), Lampard (1955), Sjoberg (1965), or Cowgill (2004) for excellent overviews.

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quasi-random variation in e.g., the introduction of new agricultural, storage or transportation technologies, climatic changes, natural disasters or in the various attempts to plan and build cities from scratch.

2. City seeds - an overview

The *'where do cities locate'*-question that lies at the heart of this paper, is intricately linked with the question *'why do cities form to begin with'*. The earliest known cities started to emerge following the Neolithic Revolution. The surplus-food production associated with the spread of agriculture led to denser human populations. It also made it increasingly possible for large numbers of people to specialize in other activities than farming, hunting, or gathering food, leading to more complex human societies. In this context, clustering together in cities, or large settlements, provided several clear benefits, explaining their emergence. Importantly, they facilitate the easier provision of public goods, notably centralized food storage, canals and irrigation- or water-storage systems, safety and protection, the organization of long-distance trade, and (building) activities of religious nature.

In this context, the locational characteristics that are widely seen as important *"city seeds"* are either related to a location's ability to sustain denser human populations, or to its defensive or trade-related advantages. Over the course of history, technological advances in agriculture, transport, and storage capabilities weakened the link between city development and favorable agricultural conditions, resulting in a location's trade-related benefits becoming a more prominant determinant of city location. It also facilitated the "top-down" planning of city locations as part of a country's broader development (or political) agenda, leading to the creation of cities in sometimes unexpected places. I discuss these different *"city seeds"* in turn below.[3]

2.1. Food, water and building material

When transportation costs are high, a city can only arise in a location if it is able to provide enough food, water and building material for its citizens. This first of all means that a location's soil quality and climatic conditions need to make it possible to grow substantial agricultural surpluses so that a relatively small number of farmers can feed the large number city dwellers whose primary activity is not the gathering, growing or hunting of food. As such, soil and climatic conditions that allow for the production of sufficiently large surpluses of *high-yield, energy-rich* cereals suitable for long-term storage (grains, rice, maize, etc) are particularly good city seeds.

The availability of a reliable source of water is vital to meet the demand for fresh drinking water of the cities' inhabitants and their livestock, as well as for water needed for agricultural purposes. A location close to a river, lake or other source of fresh water is thus particularly attractive, as one can simply take the water directly from its source or, with relatively little effort, built an irrigation or water-storage system harnessing the water for dryer times. On top of this, direct access to a river or lake provides a source of fish, and an easy means to dispose of the city's waste.[4]

Finally, an important prerequisite for the formation of a city is the availability of sufficient building material, wood and stone, for the city's structures. Wood, moreover, served, for the largest part of human history, as the most important energy source used for heating, cooking, and metal smelting. And, given the (prohibitively) expensive transportation of large quantities of timber or stone, cities developed in places where these materials were readily available in close proximity. It is one of the explanations for why, for the most part of history, only (very) few cities can be found in the world's grasslands, savannas, or steppes where (large) trees do not grow very well.[5]

2.2. Military advantage

Cities' ability to provide safety and protection to its inhabitants made locations providing a particular military advantage attractive places for city development. A strategic location on a hill overlooking the surrounding countryside, an easily defendable location sheltered from attacks on multiple sides, or the narrowest part of a strait or sound where one can easily control the passing river- or maritime traffic, are good examples of such locations. Often, a fortress or military camp was first established in such places, attracting people and economic activity from the surrounding area, eventually developing into a town or city.

2.3. Trade: hubs, mineral resources, and market access

Cities have always been centres of trade; from the earliest cities' trade between its citizens and its hinterland farmers, to the, ever more important, (very) long-distance trade between different cities, countries, or even continents. Cities are therefore frequently found on navigable rivers, near natural harbors, or on the important overland transit routes, be it the caravan routes in Central Asia, India and North America, the easiest traversed routes across a mountain ranges, or the lowest cost routes to build roads or, later, railways.[6]

2.3.1. Hubs

Of particular interest are locations from which one can easily control these trade routes, and/or places where one can easily switch between different modes of transport. Natural harbors near the mouth of a navigable river, a conjunction of rivers, places where a river can be forded or where it is easier to build bridges, the beginning/end of a route traversing important mountain passes, or an oasis-type location providing abundant fresh water for overland travellers, are important examples. These "hubs" act as natural gravitational points for economic activity and as a result we find cities in many such locations.

2.3.2. Mineral resources

For most of history, mineral resources constituted some of the most heavily traded commodities. Many mineral resources occur in a spatially concentrated manner. These localized deposits acted as strong focal points for economic activity, often even if in remote or unfriendly environments. As a result, a town or city frequently developed in close proximity to the mineral deposit. This holds true for the various different minerals that have, sometimes to a varying degree, been important throughout human history: salt, iron, gold, copper, silver, marble, granite, and more recently, coal, oil, cobalt, lithium, or nickel.

[3] This section summarizes insights from a vast body of literature in urban history and archeology. Instead of filling it with references, I refer the reader to the important contributions mentioned in the first paragraph of this paper's introductory section (see also footnote 1).

[4] It is therefore no coincidence that the earliest cities are found in four of the world's most fertile riverine landscapes: Mesopotamia, and the Nile, Indus and Yellow river valleys. Or, in case of the earliest cities in Mesoamerica and the Andes, in places with fertile soil and regular, and sufficient rainfall that could be easily stored and harnessed for drinking and agricultural purposes.

[5] Trees also do not grow very well in tundra and desert environments as well as above the timberline, but many other characteristics of these places also make them very unattractive as potential city locations.

[6] Paradoxically, the trade-related advantages of being an easily accessible location can easily turn against a location in times of war, increasing the likelihood of marauding armies finding their way to the city. For example, settlements founded on the shores of the Mediterranean moved inland and/or uphill in response to the threat posed by Arab raiders during the late Medieval period. And, the Mongols used the exact same routes through the deserts and steppes of Central Asia and the Middle East as the trading caravans, wreaking havoc on the cities that they found in their path.

2.3.3. Location theory and quantitative spatial economics

Trade (costs) also play a crucial role in the early location theories (e.g. von Thünen (1826), Christaller (1933), Lösch (1938, 1941), as well as in the more recent quantitative spatial economic models developed in the urban and regional economics literature (notably the early work by Krugman (1993) and Fujita and Mori (1996, 1997); for more recent contributions see e.g., Konishi (2000), de Palma et al. (2019), Redding and Rossi-Hansberg (2017), or Allen and Donaldson (2021)).[7]

When the agglomeration benefits associated with urban density are low, and trade costs are high, this results in the so-called tyranny of distance (Duranton, 1999), and cities will, if at all, only develop in places where sufficient water, food and building material can be sourced from its immediate hinterland. But, when trade costs fall and/or agglomeration benefits strengthen, it becomes increasingly attractive to establish cities in new locations that were, given their own geographical characteristics, previously unsuitable for city development. Locations at intermediate distance from an already existing city in particular are predicted to be the most likely candidates for a new city to emerge. They face fewer competition with the existing city than locations at closer distance to that city,[8] while at the same time being better placed to take advantage of the trading possibilities that the already existing city offers compared to locations at further distance.[9]

2.4. Policy - planned cities

Throughout history city formation has mostly been a gradual process. Once a region is able to generate sufficient agricultural surplus, we see the formation of permanent settlements, some of which continue to grow into larger towns and cities because of one, or more, favorable geographic characteristics. In sharp contrast to these cities stand what I will refer to as *"planned cities"*: cities whose location is centrally planned by the government or ruler(s) in charge of the territory. When planning the location for the new city (or cities), the government does of course not disregard locations' geographical characteristics, but other (political or economic) motives often play a more crucial role. These planned cities can be broadly classified these into two different categories:

2.4.1. Capital cities

The aim of founding a new (regional) capital city was often either to signify a break with the past following the transition of power from one government or ruler to the next, to consolidate control over newly acquired territory, or, when governing an ethnically, religious or otherwise diverse country to avoid having a capital city that is viewed as 'belonging to' one of these groups. Examples of such planned capital and administrative cities can be found throughout the world.[10] Not infrequently, they are founded either in the geographic middle of the territory they govern, in economically lagging hinterland regions with the aim to stimulate (economic) development, or in places further away from a countries' borders or coastline that are less vulnerable from attack by foreign powers.

2.4.2. Industrial/urbanization/regional development policy

The second category constitutes cities planned as part of a country's wider industrialization, urbanization or regional development strategy. Such cities are a much more recent phenomenon, with notable examples being Russia's Monotowns (Shkvarikov et al., 1964), China's manufacturing towns, or India's new settlements built to promote industrialization in lagging regions in the early-to-mid 20th century. Many of these planned industrial cities can be found near or within easy reach of a valuable natural resource, with their economy heavily (over)reliant on the extraction and processing of that natural resource. Moreover, they are not necessarily found near the country's (largest) already existing, economically most advanced cities. On the contrary, in many cases these planned cities involved the (sometimes involuntary) move of people and resources to places that would otherwise most likely not have witnessed any urban development given their (extreme) remoteness.

A different type of centrally planned cities are those built in response to the rising population pressure, and resulting social challenges in existing cities, during the period after WWII in e.g. the United States (Title VII New Towns), Britain (New Towns), France (Ville Nouvelles), or The Netherlands (Groeikernen/New Towns). These new towns are often found within easy reach of a (large) already-existing city giving their inhabitants good access to the jobs and amenities in that city while avoiding the disamenities of large-city life itself (crime, congestion, higher cost of living).

In many of today's rapidly urbanizing, emerging, economies in Africa, the Middle East and Asia, we still witness the planned establishment of new cities (see e.g., van Noorloos and Kloosterboer, 2018). A majority of these are found near a country's already existing (larger) cities, and not in unchartered urban territory. An important reason for this is that most emerging economies' industrial policies are no longer aimed at attracting heavy (manufacturing) industries, but specialized tech-, finance, or other high-value added service firms instead. Attracting a highly skilled workforce is considered to be crucial for the success of such policies, explaining why good access to (inter)national markets as well as geographical characteristics related to urban amenities (climate, landscape) appear to matter heavily in choosing the location of these new city developments.[11]

3. Empirical evidence - moving beyond descriptives

The combined insights from the archeology, urban history as well as urban and regional economics literatures, summarized in the previous section, provide a variety of reasons that led to city development in particular locations and not in others. However, we still mostly lack (solid) empirical evidence into the (relative) importance of these various different city seeds stressed in the literature. Lack of data is mostly to blame for this. This started to change with the important work of urban historians putting together comprehensive data sets on the size and location of cities in various parts of the world at different points in history (notably, Chandler and Fox (1974), Skinner (1977), Adams and Jones (1981), Bairoch (1988) and Modelski (2003)). Based on these data sets they then paint a detailed descriptive picture of city development in the area and period covered by their study.

These descriptive accounts however still provide no, or at best suggestive, answers to the question why cities appeared in some locations and not others. By only documenting the (characteristics of) cities that *did actually develop*, they all risk highlighting geographic characteristics

[7] These models formalize the important role for trade (costs) in city formation and/or persistence. They in fact provide a formal foundation for the regularly spaced grid-type structure of the urban systems stressed by the early location theorists. Their theoretical predictions have even been successful in helping to idenfity the location of lost settlements (Barjamovic et al., 2019).

[8] The existing city may even put strong restrictions on, or use its military power to prevent, any new city development in its immediate backyard (e.g., the German 'Bannmeile' or French 'banlieue').

[9] Bosker and Buringh (2017) find strong support for this non-linear effect of distance to already existing cities on locations' urban chances.

[10] Notable examples are China's imperial administrative cities (Trewartha, 1952), Abuja (Nigeria), Amarna (Egypt), Baghdad (Iraq), Ayutthaya (Thailand), Baghdad (Iraq), Brasilia (Brazil), Canberra (Australia), Islamabad (Pakistan), Naypyidaw (Myanmar), Nouakchott (Mauritania), Quezon City (Philippines), Saint Petersburg (Russia), Sejong (South Korea), Washington D.C. (USA), Yamoussoukro (Cote d'Ivoire), and recently Indonesia unveiled plans to move its capital from Jakarta to East Kalimantan.

[11] Notable examples are: Alamein New City (Egypt), Cyberjaya (Malyasia), Yachay Knowledge City (Ecuador), Konza Technology City (Kenya), Songdo (South Korea), Mohammed VI Green City (Marocco), Masdar City (Abu Dhabi), NEOM (Saudi Arabia), or Gujarat International Finance City (India).

as important city seeds that, in fact, also characterize many locations that never developed into a city. In the absence of information on such locations, the only thing that one can hope for to convincingly establish, is the importance of *time-varying* locational characteristics. In that case, a location itself, before/after actually becoming a city, serves as the relevant counterfactual. In order to credibly identify the importance of a location's time-invariant characteristics,[12] however, only potential city locations that never developed into a city provide the researcher with the relevant counterfactual.[13]

Only recently, applied urban and regional economists have started to evaluate and address this potential risk of selection bias (see Bosker and Buringh (2017), Motamed et al. (2014), Michaels and Rauch (2018), Alix-Garcia and Sellars (2020) or Bakker et al. (2021) for notable examples). To do so, they all exploit the now readily available wealth of very detailed geospatial datasets on an ever-expanding set of climatic and geographic characteristics. Importantly, these data sets cover *all locations*, whether they ever developed into a city or not.

In the rest of this section, I lay out the basic empirical framework used in these recent papers, describing two important challenges/decisions that one faces when using it to study the origins of cities. Next, in section 4, I discuss the promises that recent advances in data availability, in our computational ability to handle or even generate these datasets, as well as in the use of novel applied econometric techniques, hold for expanding and improving our (empirical) understanding of city origins.

3.1. Empirical framework

The empirical framework used in all recent empirical studies into the origins of cities can be summarized by the following simple linear regression equation:

$$c_{it} = \mathbf{X}_i \boldsymbol{\alpha}_t + \mathbf{X}_{j(i)t} \boldsymbol{\beta}_t + \mathbf{X}_{it} \boldsymbol{\gamma}_t + \epsilon_{it}, \tag{1}$$

where i and t are indexes denoting *potential city locations* and *time periods* (e.g. a year or century), respectively, and $j(i)$ denotes a spatially more aggregated geographical unit where i is located (e.g., a region or a country). c_{it} is the outcome variable of interest indicating the presence of a city or urban development in general. X_i, X_{it}, $X_{j(i)t}$ are row vectors whose elements contain information on a location's time-invariant and time-varying characteristics, and on the (time-varying) characteristics of the broader geographical unit that a location belongs to, respectively.[14] ϵ_{it} is the error term capturing all variables that are of importance for city development but that are not, or incorrectly, captured, by the included explanatory variables. Finally, column vectors $\boldsymbol{\alpha}_t$, $\boldsymbol{\beta}_t$, and $\boldsymbol{\gamma}_t$ are to be estimated. When done so correctly, their elements inform us about the, possibly time-varying, importance of each of the included locational characteristics.

Besides the usual choice which variables to include and which estimation method to use, any empirical study into the origins of cities faces two very important decisions.

3.1.1. City definition

First of all, what makes for a city? Any empirical study will have to take a stance on this question in order to be able to define its left-hand-side variable, c_{it}. This question has plagued archeologists, urban historians, and empirical urban economists alike. Urban archeologists and historians proposed a variety of social, economic, architectural or institutional characteristics that distinguish cities from smaller settlements (as an example Table 1 lists Childe (1950)'s ten(!) criteria). Many of these characteristics however turned out to not necessarily set cities apart from other (smaller) settlements.[15]

As a result, urban historians started to converge on a more concise city definition that focussed primarily on the size and economic function of a settlement (see e.g. Sjoberg (1965)). This got a final stimulus with the emergence of the first quantitative urban history studies. Besides calling for a well-defined city definition that was useful across all the years and regions under study, they also needed a city definition that was *practical* or *operational*. Collecting information on all the important economic, social or institutional features for all cities/settlements considered would be a complicated, very time-consuming exercise. As a result, these studies (quickly) settled on the use of a simple population- or area-based criterion to define a city (see e.g. Skinner (1977) or Bairoch (1988)).[16]

Most recent empirical studies on historical city development make use of such a population- or area-based cutoff to define cities.[17] The underlying assumption when doing this, is that once a settlement is of a certain size it will almost always feature all the economic, religious, social, institutional and architectural characteristics that urban historians associate with a city. The only important choice to make is thus the exact number of inhabitants, or spatial extent, that makes for a city. Certainly, the "right" cutoff does not exist, and is further complicated when studying city development over many centuries, and in many different parts of the world.[18] As such, one should always compare results using different, possibly even time-varying, cutoffs, to verify how potential measurement error, induced by the use of a different (wrong) cutoff, affects our findings (see also Bosker and Buringh (2017)).

3.1.2. Potential city locations?

The second important choice facing any empirical study into the origins of cities, is how to incorporate all potential city locations, also those that never developed into a city, into the analysis. All recent empirical studies into the origins of cities tackle this issue by dividing the entire geographic area covered in their study into a number of equally sized *grid cells*, and use either all these grid cells or a random

[12] Or to separately identify the effect of a time-varying variable for each period that the data is available.

[13] Unless of course one can credibly argue that the locational characteristic of interest is not correlated with any unobserved locational characteristic related to a location ever developing into a city.

[14] Note that equation (1) also easily accommodates a fixed effects setup. In that case $\mathbf{X}_i$ and/or $\mathbf{X}_{j(i)t}$ would each simply be a full set of dummy variables: one for each potential city location in case of $\mathbf{X}_i$, and one for each broader defined geographical unit *in each time period* in case of $\mathbf{X}_{j(i)t}$.

[15] For example, in China an urban settlement was only considered a city if it had city walls, whereas in Egypt and Mesoamerica we do not have evidence of cities having walls. And, in Europe, many towns obtained so-called city rights, but the granting of such rights was often politicised by the ruling elites and not necessarily based on clear well-defined criteria for what it took for a settlement or town to be a city.

[16] Population sizes of the earliest cities are often based on considering the area that these cities covered, multiplied by an (assumed) number of people per km2 based on evidence on the average number of dwellings per km2 and the average number of people per dwelling. This explains why population density is not - or implicitly - used as a criterion by any of these studies.

[17] Exceptions are studies that face the absence of information on the population size or area of the settlements that they study (see e.g. Michaels and Rauch (2018) or Bakker et al. (2021)). These either resort to using the settlement-town-city classification used by the (historical) atlas that they use to locate cities, or they simply take any evidence off (urban) development as an indication of (urban) development.

[18] A forthcoming issue of the *Journal of Urban Economics* focusses on the modern-day equivalent of this problem: the proper *delineation of the spatial extent of cities* using (a combination of) very detailed day- or nighttime satellite-imagery, cadastral records, and/or commuting patterns.

sample thereof as their baseline sample.[19]

The important choice to make when doing this is the *size of the grid cells* used. The larger these grid cells, the more ambiguous it becomes to construct the right measure(s) of a cell's (urban) development as well as its locational characteristics based on the underlying spatially more disaggregated data.[20] Moreover, the use of larger grid cells increases the likelihood that such grid cell level variables are sensitive to the exact placement of the grid. All these (aggregation) concerns can have non-trivial consequences for the resulting statistical inference. From this perspective, the use of smaller grid cells is clearly preferred, especially when the aim is to establish the relevance of a spatially highly localized characteristic, such as location close to a fordable place in a river, a point-source natural resource, or on a hill overlooking the countryside. It allows one to fully exploit the spatially very localized variation in the characteristic of interest, as well as in city development itself.[21]

This is not a call for always using extremely finegrained grid cells however. First of all, cities are not points, but cover a larger area depending on their size. The use of grid cells smaller than the city diameter implied by the population cutoff used to define a city can be argued to be of little additional benefit.[22] Second, using very small grid cells implies larger sample sizes that can quickly lead to computational issues, especially when the area under study is large, when studying urban development over multiple time periods, when using non-standard (non-linear or simulation based) estimation techniques, or when requiring the calculation of detailed measures of spatial dependence between grid cells.[23]

All recent empirical studies clearly state how they define the observational unit chosen as the baseline for their empirical investigation. Most do not however discuss the assumptions underlying, as well as the consequences of, their choice of grid cell size. Future studies should always relate this explicitly to the spatial extent of a city implied by the population- or area-based city definition used, as well as to the observed degree of spatial variation in the locational characteristic(s) of primary interest. Moreover, they should always show the sensitivity of their results to (sensible) changes in the cell size, shape, and/or orientation of the grid used to incorporate the necessary information on potential city locations.[24]

[19] Bosker and Buringh (2017) draw a random sample of coordinate pairs with coordinates rounded up to 3 digits behind the comma. This sets an implicit minimum distance between sample locations of about 100m. It can thus be considered as (approximately) randomly sampling from an exhaustive grid of 100 m × 100 m grid cells, taking the midpoint of each cell as representative of the entire cell.

[20] Should we e.g. classify a grid cell as urban when it is home to at least one city of a certain size? Or, should we instead consider the total number of cities, or the total urban population in the grid cell? Similarly, should we classify a grid cell as riverine as soon as a river runs through it, or use its river density instead? And, should we calculate a grid cell's distance to a port, capital or nearest other city starting from its midpoint, its largest settlement, or from the grid cell's boundary?.

[21] The effect of a locational characteristic that varies only gradually over space (e.g., rainfall, temperature), is very hard to identify using the localized variation in city development itself, limiting the advantages of using a very finegrained grid.

[22] Using the generally accepted average density for (historical) cities of 100 people per hectare, and assuming that the city is of circular shape, the often-used population cutoffs to define a city of 5000 or 10,000 inhabitants imply a city that extends about 400m or 560m to all sides.

[23] Taking a random sample of grid cells can be a solution for some of these issues, provided that it is large enough so that a sufficient number of the drawn potential city locations actually do develop into a city during the period under study, ensuring sufficient power to test the hypotheses of interest.

[24] See Briant et al. (2010) or Bosker et al. (2021) for examples in different contexts.

4. Expanding empirical possibilities

Having laid out the basic empirical framework used to identify the important factors in city location, I now turn to the promises that recent advances in data availability hold for our (empirical) understanding of city origins.

4.1. Better data

4.1.1. Historical city location

The early data sets on historical city location mostly focussed on medieval and early-modern Europe and the Mediterranean. Recently, the spatial and temporal coverage of such data sets has greatly expanded. This is in no small part due to the ever better ability to digitize old maps, atlases, archives and other written data sources, harbouring a wealth of information on the location of cities and their characteristics. Increasingly researchers are exploiting advances in automatic hand-written text recognition, in the ability to (automatically) digitize features shown on old maps for use in GIS software (Combes et al., 2021), or even in the detection of (previously unknown) settlements using machine-learning techniques scanning through satellite data (see e.g., Orengo et al., 2020).

Importantly, these developments make it increasingly possible to empirically identify the important determinants of city location in other parts of the world than Europe and the Mediterranean. Moreover, it might make it feasible to shed empirical light on the important, yet so far empirically unexplored, question why some early (small-scale) settlements developed into cities whereas others never grew beyond the size of a village, or even disappeared again (see Ploeckl (2021) for a first empirical pass at this question). Table 2 in the Appendix lists several notable examples of such data sets.

4.1.2. The locational characteristics of (potential) city locations

At the same time, we have seen an explosion in the availability of spatially extremely detailed georeferenced datasets on an ever expanding array of a location's geographical characteristics. It is the result of ever better, often satellite-based, methods to observe and analyze the earth's soil characteristics, ecosystems, weather patterns, elevation, rivers, coastlines, land cover, agricultural suitability, mineral deposits, and prevalence of natural disasters.[25] Most of these data sets document the geographical state of the world today, at most going back 10 or 20 years. In many cases this is not so much of a concern when studying cities' historical origins, since many geographical features are only changing extremely slowly over time. However, when studying the emergence of the earliest cities, hundreds (or even thousands) of years ago, the assumption that particular geographic features are time-invariant becomes more and more untenable.

Increasingly however, researchers are also developing georeferenced data sets documenting what a location's geographical characteristics looked like in the past. These are based on digitized historical atlases documenting historic land cover, the historic course of rivers and coastlines, or the location of historic mines and quarries (see e.g., the ORBIS or OXREP database, or the Ancient World Mapping Centre); or on the use of geospatial modelling techniques to infer locations' climatic conditions from point-based observations of tree rings, ice cores, soil deposits, or contemporaneous observations from ships' logbooks and other textual meteorological records. See www.historicalclimatology.com for useful links to many such (finished and still ongoing) efforts, or www.hgis.org.uk for useful links to many interesting historical GIS projects and data sets.

[25] Notable sources include NASA, ESA, the USGS, NOAA, the European Environment Agency, the FAO, and WorldMap, but many such data sets are also hosted and developed by universities, research institutes or other national environmental agencies.

4.2. Better data - expanding possibilities

These, much more detailed, data sets expand our ability to identify the most important city seeds in several important ways.

4.2.1. More precisely specified locational characteristics

First of all, it allows us to consider a much wider range of, more precisely measured, locational characteristics. For example, we can now include detailed measures of a location's soil suitability for cultivating a wide range of *individual* crops. We can further distinguish between different riverine locations based on features of the river that they are located on (its water flow, whether it is fordable, or how far one can sail up- or downstream). Or, instead of including simple measures of a location's elevation above sea level or the ruggedness of the surrounding terrain, we can now precisely capture the elevation of a location vis-a-vis its nearby surroundings (e.g., location on a hilltop overlooking the surrounding area, or at the entry of a valley or mountain pass).

This much improved precision also holds for measures of a location's distance to other cities, or to particular geographic features (e.g., a natural harbor, mineral deposit, or source of potable water). Most studies to date use the simple geodesic distance between locations (Bosker and Buringh, 2017; Barjamovic et al., 2019; Bakker et al., 2021). It is now increasingly (computationally) feasible, to calculate least cost, or fastest, routes between locations instead, based on detailed geographic information on the terrain and/or water bodies that one has to cross to travel from one location to another; possibly also depending on the transportation mode/technology used (see e.g., Faber (2014); Verhagen et al. (2019); Feyrer and Sacerdote (2009); Pascali (2017); Seror (2020), or ORBIS).

From an identification perspective, the substantial increase in localized spatial variation in these more precisely measured geographic characteristics is an important virtue. It allows for the identification of their effect on city emergence based on this localized variation only (by e.g., including a spatially much more detailed set of fixed effects), hereby significantly reducing endogeneity concerns related to omitted variable bias.

4.2.2. The differential importance of locational characteristics

Second, the much-improved data availability provides the researcher (many) more degrees of freedom. It makes it possible to move beyond estimating the simple average effect of a particular locational characteristic, and instead aim to identify how it possibly differentially affects city formation depending on a location's other geographical characteristics, or characteristics of the period, or part of the world, under consideration.

The existing empirical papers on city emergence have made some attempts to do this, but they are mostly limited to allowing the effect of a particular locational characteristic to vary over time or across countries or continents.[26] Although finding interesting patterns in the effect of particular locational characteristics,[27] the exact reason(s) for, or mechanism(s) behind, these patterns are often not clearly pinpointed. The fast expanding scope and detail of the data sets discussed in sections 4.1.1 and 4.1.2 provide possibilities to do this more carefully, possibly even making use of novel data-driven methods to identify heterogenous treatment effects (Athey and Imbens, 2015).

4.2.3. Data-driven or model-based inference

In fact, one could take this one step further and use such machine learning approaches to select those (combinations of) potential city seeds that best rationalize the observed spatial distribution of city location in the geographic area and time period under consideration. One could do this either in a purely data-driven way, collecting information on as many alleged city seeds as possible and running the prediction algorithm (see Düben and Krause (2020) for an example; or Athey and Imbens (2019) for a general discussion of machine learning methods). Alternatively, one could firmly base oneself in spatial economic theory and use the available data to calibrate a spatial economic model of city formation that is rich enough to allow one to fully exploit the richness of the available data, while at the same time capturing the important features of the economic and urban context in the geographic area and time period under consideration. In subsequent counterfactuals one can then assess the (relative) importance of individual locational characteristics for city emergence (see Nagy (2020) for an example). Arguably, such methods are especially interesting when lacking a convincing source of exogenous variation to identify the effect of the city seed(s) of interest.

4.3. Better data - improved causal inference

Last, but certainly not least, the much improved scope and detail of the now available data sets on city development and its origins also widens the possibility to exploit exogenous changes in (the importance of) particular locational characteristics to identify their causal effect on city emergence. Using such 'natural experiments' as sources of exogenous variation has increasingly found its way into applied work in urban and regional economics, as well as in economic history (see Baum-Snow and Ferreira (2015) and Cantoni and Yuchtman (2020) for excellent overviews). The existing empirical papers on city emergence have not yet (explicitly) used such methods, instead relying on the inclusion of fixed effects and (many) other observed determinants of city development for the conditional independence assumption to hold. Future studies should aim to improve on this. Four different types of natural experiments are particularly interesting in the context of city emergence:

4.3.1. Naturally occurring geographic or climatic shocks

Climate change, long-term changes in (the volatility of) rainfall patterns and/or temperature primarily affect a locations' agricultural potential. If profound enough, it may substantially change a location's, or even an entire region's, urban prospects (e.g. contributing to the demise of the Indus Valley Civilization or the Mayan cities in Mesoamerica). However, it typically evolves only slowly over time and only varies gradually across space. Exploiting the variation that it offers thus calls for data on city development, as well as the climatic variable(s) of interest, over a sufficiently long period of time and a sufficiently large geographic area. Moreover, a concern is that people start to adapt or mitigate its consequences, complicating the identification of its effects.

Natural disasters (e.g., earthquakes, floods, pandemics, or crop diseases), do not so much face this latter concern. Even if a location is known to be vulnerable to particular disasters, their exact timing and scale is hard to predict, which is a clear plus from an identification perspective. However, exploiting the occurrence of natural disasters to identify the effect of particular geographical characteristics on a location's urban chances comes with its own difficulties. They often affect multiple locational characteristics at the same time, and generate substantial spillover effects on locations not directly affected by the disaster as people move away from the affected area. Moreover, the occurrence of some natural disasters (e.g., erosion, soil depletion, or droughts) may depend nontrivially on a region's (urban) population density raising possible endogeneity concerns.[28]

[26] See e.g., Bosker and Buringh (2017), Michaels and Rauch (2018), or Alix–Garcia and Sellars (2020).

[27] Notably, an increased importance of a favorable location for (water-borne) trade, as well as of being located at medium distance from an already-existing city, for locations' urban chances.

[28] Martincus and Blyde (2013), Carvalho et al. (2020), Koyama et al. (2019), Iyigun et al. (2017), Hornbeck (2012) levy natural disasters or climate change for identification purposes in different settings.

Finally, a location's direct access to the sea or a river is a noteworthy category that is, especially when considering longer time periods, subject to change as rivers silt up or change their course, and coastlines shift due to floods or sea level rises/drops. The availability of detailed geospatial information on changes in the historic course of rivers and coastlines offers interesting possibilities to quantify the importance of access to (navigable) water in determining city location (see e.g., Seror (2020) or Allen et al. (2020)).

4.3.2. Technological change

Second, one can exploit the (unexpected) introduction of a new, or the redundancy of an old, technology, in combination with (exogenous) variation across space in the introduction, applicability and/or usefulness of the new technology.[29] The introduction of new crops or agricultural technologies can e.g., differentially change locations' potential to grow a sufficient surplus to sustain a thriving city, or, in the case of cash crops, their economic potential in general and hereby their ability to attract permanent settlers. Also, the introduction of new storage and food preservation techniques made it possible for cities to emerge in places that, given their own agricultural potential, were no viable city site before.[30]

Similarly, the discovery of a new mineral deposit, or of new, economically viable, ways to extract them, the depletion of a mineral deposit, as well as changes in a mineral's (un)importance due to technological advances in other areas, can have profound effects on locations' urban chances by changing the incentive to cluster near the mineral deposit.

And last, but certainly not least, changes in transportation technology have not only made it possible to transport ever more goods, in easier and cheaper ways, hereby diminishing the importance of a fertile agriculture hinterland for city development. Often, different geographical characteristics are important in the construction of different types of transportation infrastructure, introducing interesting variation across space and time in the likelihood that a location is well-served by a particular transportation technology.[31]

4.3.3. Planned cities

Third, the top down planning of new city locations (see section 2.4) offers interesting possibilities to identify the importance of particular city seeds. Notably, we can exploit the construction of these planned cities to identify how they, or the novel roads and railways connecting them to the outside world, affect the urban chances of other (nearby) locations. These other locations, as well as their characteristics, are very often not given much weight by the policy makers planning the site(s) of the new city(ies). As such, one can view the construction of the planned cities as an exogenous, differential, shock to one (or more) of these other locations' characteristics that can be used to identify their importance for locations' urban chances. If available, one could even exploit details of the political decision process selecting the new city locations, or the fact that some cities were planned but never built, in the construction of a plausible (set of) control location(s).[32]

4.3.4. Military destruction

And, in a very similar vein, the destruction of cities, the agricultural/economic potential of their hinterland, or the infrastructure connecting them to the outside world, can also provide useful quasi-experimental variation. Notably, one could exploit the fact that locations closer to the now-destroyed city, or the now-destroyed infrastructure links, suffer bigger losses in market access. In doing so, one can think of levying information on the military constraints, or objectives, determining why some places suffered more destruction than others, or by focussing on locations that, by unfortunate coincidence, happened to be located along the (planned) routes taken by an army on its way to the city or cities targeted by the military campaign.[33]

5. Conclusion

The debate on the (most) important locational characteristics explaining the origins of cities did, until recently, take place without solid empirical evidence assessing the many (theoretical) claims by urban historians, location theorists, regional scientists or urban economists. This has started to changed in recent years. The availability of ever better, spatially more finegrained, data on the historical and geographical characteristics of cities, as well as of locations that never developed into a city, in combination with more advanced empirical and computational methods will almost surely see a better, empirically well-grounded, understanding of the relative importance of the alleged different drivers of city location in different parts of the world and at different points in history. Although, undoubtedly, there will certainly always remain some room for myths in the error term.

Author statement

Bosker: conceptualization, methodology, writing.

Declaration of competing interest

None.

[29] Examples of papers levying the (plausibly) exogenous timing of the introduction of new agricultural, mining, or transportation technologies and/or the exogenous nature of particular geographical features important for these new technologies (or for the now redundant technology that they replace) in different settings than city formation are many. See e.g., ***transportation:*** Pascali (2017), Donaldson (2018), Brooks and Donovan (2020), Bleakley and Lin (2012); ***agriculture:*** Nunn and Qian (2011), Jia (2014), Bustos et al. (2016); ***mining:*** Fernihough and O'Rourke (2021), Berman et al. (2017).

[30] Artificial refrigeration, airconditioning, water desalination, and land reclamation techniques have even made cities possible in some of the world's harshest desert environments, or at the bottom of the sea.

[31] For example, improved sailing techniques increased the importance of a favorable location for (long-distance) seaborne transport; the introduction of the camel in the Middle East and North Africa diminished the importance of locations along the former Roman road network; and advances in tunnel and bridge building weakened the importance of location on (the entry to) a mountain pass or particular harbors.

[32] For two recent examples, see Cermeño and Enflo (2019) and Carter (2020) that exploit the location of new towns in early modern Sweden, and of military forts in the American West, respectively. Also, see Morten and Oliveira (2018) or Dell and Olken (2020) for examples in different settings.

[33] See Davis and Weinstein (2002), Bosker et al. (2008) or Miguel and Roland (2011) for examples in different settings.

A. Appendix

Table 1
What makes for a city? - V. Gordon Childe (1930).

1. more extensive in area and population size, and more densily populated	4. truly monumental public buildings	8. conceptualised and sophisticated styles of art
2. the presence of full-time specialists (craftsmen, merchants, priest, etc	5. presence of a ruling class (priests, civil and military elites)	9. regular trade over quite long distances
3. ability to concentrate the surplus agricultural production of its hinterland	6. writing	10. a state organization based on residence rather than kinship
	7. the elaboration of exact and predictive sciences	

Table 2
Data on historic city/settlement location - some examples

1. Pleiades - continuously updated database of ancient places - pleiades.stoa.org	9. Bosker et al. - North Africa and Middle East
2. Ancient coastal settlements and ports - ancientportsantiques.com	10. Ancient Near East (Mesopotamia) - lingfil.uu.se/research/assyriology/earth; Barjamovic et al. (2019); Allen et al. (2020)
3. Roman Empire - oxrep.classics.ox.ac.uk/databases; darmc.harvard.edu	
4. Medieval Europe - darmc.harvard.edu; Bairoch database; various national archives/maps	11. Early Medieval Arabic World - althurayya.github.io
5. China (various periods) - sites.fas.harvard.edu/chgis; Skinner et al. (2008)	12. Colonial Spanish America - www.hgis-indias.net
6. Japan (various periods) - sites.fas.harvard.edu/chgis; Skinner et al. (2013)	13. Mayan sites Central America - Wayeb GIS Atlas; MayaGIS
7. Modelski and Chandler data - Reba et al. (2016)	14. Neolithic sites Europe/Near-East - Pinhasi et al. (2005)
8. South-Asia - Jha (2013); bhuvan-app1.nrsc.gov.in/culture_monuments	15. Early missionary sites Africa - Nunn (2010); Cagé and Rueda (2016)

References

Adams, R.E., Jones, R.C., 1981. Spatial patterns and regional growth among classic maya cities. Am. Antiq. 301–322.
Alix-Garcia, J., Sellars, E.A., 2020. Locational fundamentals, trade, and the changing urban landscape of Mexico. J. Urban Econ. 116, 103213.
Allen, R.C., Bertazzini, M.C., Heldring, L., 2020. The Economic Origins of Government. Northwestern University. Working paper.
Allen, T., Donaldson, D., 2021. Persistence and path dependence: a primer. Reg. Sci. Urban Econ. forthcoming.
Athey, S., Imbens, G.W., 2015. Machine Learning Methods for Estimating Heterogeneous Causal Effects. Stanford University. Working Paper.
Athey, S., Imbens, G.W., 2019. Machine learning methods that economists should know about. Annual Review of Economics 11, 685–725.
Bairoch, P., 1988. Cities and Economic Development: from the Dawn of History to the Present, translated edition. University of Chicago Press (by Braider, C).
Bakker, J.D., Maurer, S., Pischke, J.-S., Rauch, F., 2021. Of mice and merchants: connectedness and the location of economic activity in the iron age. Rev. Econ. Stat. forthcoming.
Barjamovic, G., Chaney, T., Coşar, K., Hortaçsu, A., 2019. Trade, merchants, and the lost cities of the bronze age*. Q. J. Econ. 134 (3), 1455–1503.
Baum-Snow, N., Ferreira, F., 2015. Causal inference in urban and regional economics. In: Handbook of Regional and Urban Economics, vol. 5. Elsevier, pp. 3–68.
Berman, N., Couttenier, M., Rohner, D., Thoenig, M., 2017. This mine is mine! how minerals fuel conflicts in africa. Am. Econ. Rev. 107 (6), 1564–1610.
Bleakley, H., Lin, J., 2012. Portage and path dependence. Q. J. Econ. 127 (2), 587–644.
Bosker, M., Brakman, S., Garretsen, H., Schramm, M., 2008. A century of shocks: the evolution of the German city size distribution 1925–1999. Reg. Sci. Urban Econ. 38 (4), 330–347.
Bosker, M., Buringh, E., 2017. City seeds: geography and the origins of the european city system. J. Urban Econ. 98, 139–157.
forthcoming Bosker, M., Park, J., Roberts, M., 2021. Definition matters. metropolitan areas and agglomeration economies in a large-developing country. J. Urban Econ..
Briant, A., Combes, P.-P., Lafourcade, M., 2010. Dots to boxes: do the size and shape of spatial units jeopardize economic geography estimations? J. Urban Econ. 67 (3), 287–302.
Brooks, W., Donovan, K., 2020. Eliminating uncertainty in market access: the impact of new bridges in rural Nicaragua. Econometrica 88 (5), 1965–1997.
Bustos, P., Caprettini, B., Ponticelli, J., 2016. Agricultural productivity and structural transformation: evidence from Brazil. Am. Econ. Rev. 106 (6), 1320–1365.
Cagé, J., Rueda, V., 2016. The long-term effects of the printing press in sub-Saharan Africa. Am. Econ. J.: Appl. Econ. 8 (3), 69–99.
Cantoni, D., Yuchtman, N., 2020. Historical Natural Experiments: Bridging Economics and Economic History. NBER working paper, p. 26754.
Carter, C.E., 2020. Forts and the Frontier: the Us Army and the Spatial Distribution of Population.
forthcoming Carvalho, V.M., Nirei, M., Saito, Y.U., Tahbaz-Salehi, A., 2020. Supply chain disruptions: evidence from the great East Japan earthquake. Q. J. Econ..
Cermeño, A.L., Enflo, K., 2019. Can kings create towns that thrive? the long-term implications of new town foundations. J. Urban Econ. 112, 50–69.
Chandler, T., Fox, G., 1974. (Three Thousand) 3000 Years of Urban Growth. Academic Press.
Childe, V.G., 1950. The urban revolution. Town Plan. Rev. 21 (1), 3–17.
Christaller, W., 1933. Die Zentralen Orte in Süddeutschland. Gustav Fischer, Jena.
Combes, P.-P., Gobillon, L., Zylberberg, Y., 2021. Urban economics in a historical perspective: recovering data with machine learning. forthcoming Reg. Sci. Urban Econ..
Cowgill, G.L., 2004. Origins and development of urbanism: archaeological perspectives. Annu. Rev. Anthropol. 33, 525–549.
Davis, D.R., Weinstein, D.E., 2002. Bones, bombs, and break points: the geography of economic activity. Am. Econ. Rev. 92 (5), 1269–1289.
de Palma, A., Papageorgiou, Y.Y., Thisse, J.-F., Ushchev, P., 2019. About the origin of cities. J. Urban Econ. 111, 1–13.
Dell, M., Olken, B.A., 2020. The development effects of the extractive colonial economy: the Dutch cultivation system in java. Rev. Econ. Stud. 87 (1), 164–203.
Donaldson, D., 2018. Railroads of the raj: estimating the impact of transportation infrastructure. Am. Econ. Rev. 108 (4–5), 899–934.
Düben, C., Krause, M., 2020. The Emperor's Geography-City Locations, Nature, and Institutional Optimization. (Working Paper).
Duranton, G., 1999. Distance, land, and proximity: economic analysis and the evolution of cities. Environ. Plann.: Economy and Space 31 (12), 2169–2188.
Faber, B., 2014. Trade integration, market size, and industrialization: evidence from China's national trunk highway system. Rev. Econ. Stud. 81 (3), 1046–1070.
Fernihough, A., O'Rourke, K.H., 2021. Coal and the European industrial revolution. Econ. J. forthcoming.
Feyrer, J., Sacerdote, B., 2009. Colonialism and modern income: islands as natural experiments. Rev. Econ. Stat. 91 (2), 245–262.
Fujita, M., Mori, T., 1996. The role of ports in the making of major cities: self-agglomeration and hub-effect. J. Dev. Econ. 49 (1), 93–120.
Fujita, M., Mori, T., 1997. Structural stability and evolution of urban systems. Reg. Sci. Urban Econ. 27 (4), 399–442.
Glaeser, E.L., 2011. Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier. Penguin Publishing Group.
Hornbeck, R., 2012. The enduring impact of the american dust bowl: short- and long-run adjustments to environmental catastrophe. Am. Econ. Rev. 102 (4), 1477–1507.
Iyigun, M., Nunn, N., Qian, N., 2017. Winter Is Coming: the Long-Run Effects of Climate Change on Conflict, 1400-1900. National Bureau of Economic Research. Working Paper 23033.
Jha, S., 2013. Trade, Institutions, and Ethnic Tolerance: Evidence from South Asia. Am. Polit. Sci. Rev. 107 (4), 806–832.
Jia, R., 2014. Weather shocks, sweet potatoes and peasant revolts in historical China. Econ. J. 124 (575), 92–118.

Konishi, H., 2000. Formation of hub cities: transportation cost advantage and population agglomeration. J. Urban Econ. 48 (1), 1–28.
Koyama, M., Jedwab, R., Johnson, N., 2019. Pandemics, Places, and Populations: Evidence from the Black Death. CEPR working paper. No.7524.
Krugman, P., 1993. On the number and location of cities. Eur. Econ. Rev. 37 (2), 293–298.
Lampard, E.E., 1955. The history of cities in the economically advanced areas. Econ. Dev. Cult. Change 3 (2), 81–136.
Lösch, A., 1938. The nature of economic regions. South. Econ. J. 71–78.
Lösch, A., 1941. Die räumliche Ordnung der Wirtschaft. Gustav Fischer, Jena.
Martincus, C.V., Blyde, J., 2013. Shaky roads and trembling exports: assessing the trade effects of domestic infrastructure using a natural experiment. J. Int. Econ. 90 (1), 148–161.
Michaels, G., Rauch, F., 2018. Resetting the urban network: 117–2012. Econ. J. 128 (608), 378–412.
Miguel, E., Roland, G., 2011. The long-run impact of bombing vietnam. J. Dev. Econ. 96 (1), 1–15.
Modelski, G., 2003. World Cities: -3000 to 2000. Faros. 2000.
Morten, M., Oliveira, J., 2018. The Effects of Roads on Trade and Migration: Evidence from a Planned Capital City. NBER Working Paper, p. 22158.
Motamed, M.J., Florax, R.J., Masters, W.A., 2014. Agriculture, transportation and the timing of urbanization: global analysis at the grid cell level. J. Econ. Growth 19 (3), 339–368.
Mumford, L., 1961. The City in History: its Origins, its Transformations, and its Prospects, vol. 67. Houghton Mifflin Harcourt.
Nagy, D.K., 2020. Hinterlands, City Formation and Growth: Evidence from the Us Westward Expansion. (Working Paper).
Nunn, Nathan., 2010. Religious conversion in colonial Africa. Am. Econ. Rev. 100 (2), 147–152.
Nunn, N., Qian, N., 2011. The potato's contribution to population and urbanization: evidence from a historical experiment. Q. J. Econ. 126 (2), 593–650.
Orengo, H.A., Conesa, F.C., Garcia-Molsosa, A., Lobo, A., Green, A.S., Madella, M., Petrie, C.A., 2020. Automated detection of archaeological mounds using machine-learning classification of multisensor and multitemporal satellite data. Proc. Natl. Acad. Sci. Unit. States Am. 117 (31), 18240–18250.
Pascali, L., 2017. The wind of change: maritime technology, trade, and economic development. Am. Econ. Rev. 107 (9), 2821–2854.
Pinhasi, R., Fort, J., Ammerman, A.J., 2005. Tracing the origin and spread of agriculture in Europe. PLoS Biol. 3 (12), e410.
Pirenne, H., 1925. Medieval Cities: Their Origins and the Revival of Trade, 2014, translated edition. Princeton University Press (2014 edition)).
Ploeckl, F., 2021. The next town over: on the clustering of towns and settlements before modern economic growth. Reg. Sci. Urban Econ. forthcoming.
Reba, M., Reitsma, F., Seto, K.C., 2016. Spatializing 6,000 years of global urbanization from 3700 BC to AD 2000. Sci. Data 3 (1), 1–16.
Redding, S.J., Rossi-Hansberg, E., 2017. Quantitative spatial economics. Annual Review of Economics 9, 21–58.
Seror, M., 2020. Random River: Trade and Rent Extraction in Imperial china. Université de Québec à Montréal. Working paper.
Shkvarikov, V., Haucke, M., Smirnova, O., 1964. The building of new towns in the ussr. Ekistics 18 (108), 307–319.
Sjoberg, G., 1965. The origin and evolution of cities. Sci. Am. 213 (3), 54–62.
Skinner, G.W., 1977. *The City in Late Imperial China*. Reith Lectures. Stanford University Press.
Trewartha, G.T., 1952. Chinese cities: origins and functions. Ann. Assoc. Am. Geogr. 42 (1), 69–93.
Ullman, E., 1941. A theory of location for cities. Am. J. Sociol. 46 (6), 853–864.
van Noorloos, F., Kloosterboer, M., 2018. Africa's new cities: the contested future of urbanisation. Urban Stud. 55 (6), 1223–1241.
Verhagen, P., Nuninger, L., Groenhuijzen, M.R., 2019. Modelling of Pathways and Movement Networks in Archaeology: an Overview of Current Approaches. Springer International Publishing, pp. 217–249.
von Thünen, J.H., 1826. *Der isolirte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*. Handelsblatt-Bibliothek "Klassiker der Nationalökonomie.". Hamburg: Perthes.
Weber, M., 1922. The City. Translated and. In: Martindale, D., Neuwirth, G. (Eds.), 1958 edn. The Free Press, New York. 1958.