The population of the world is distributed very unevenly. Research by **Vernon Henderson** and colleagues explores the fundamental geographical determinants of the location of economic activity, notably differences in localities' suitability for agriculture and trade – and how the relative importance of these factors has changed over time.

The roles of nature and history in world development

Why do people live where they do, whether in the world as a whole or within a given country? Why are some places so densely populated and some so empty? In daily life, we take this variation in density as a matter of course, but in many ways it can be quite puzzling.

Key drivers of the distribution of population

Economists point to three factors to explain how population is distributed. The first is that there are differences in geographical characteristics – often referred to as 'first nature' – that make some places more amenable for living or producing output than others. This explains why mountainous regions, deserts, tundra and so on tend to have low population density – and why much of the world's population is situated in places where it is relatively easy to produce food.

The second factor is agglomeration. Because of economies of scale and gains from trade, we humans often find it efficient to gather in small areas. Of course, many industries, notably food production, don't benefit from such concentration, and are instead spread out in accord with the availability of first-nature resources.

What's more, there are limits to the benefits of agglomeration: because of congestion and transport costs, the urban population is spread among many cities, which are in turn spatially dispersed.

The final factor affecting the distribution of population is history. Once established, cities have a very strong tendency to stay put. This persistence results from many factors, often collectively described as 'second nature' (Cronon, 1992).

Among these factors are long-lived capital, political power and the fact that once agglomeration has started in a particular place, it will be a natural focus for future development. This persistence can be important even when the reasons that a city has been established in a particular location are no longer important (Bleakley and Lin, 2012; Michaels and Rauch, 2013).

Regions' suitability for agriculture and trade

The complete story of how nature, agglomeration and history have interacted

to give the world the distribution of population that we see today is far too complex to be captured in a single study. The goals of our recent research are less ambitious.

We ask how economic and technological development has changed the ways in which first-nature characteristics affect population distribution. While these characteristics themselves haven't changed too much over history (so far), the way in which they affect settlement has. Illustrative examples of such changes are the impacts of air conditioning, irrigation and the discovery of new uses for particular mineral resources.

We focus on the two natural characteristics where we think that changes associated with economic and technological change have been most important: first, the suitability of a region for growing food; and second, the suitability of a region for engaging in domestic and international trade.

Over the last few centuries, the importance of fertile land as a determinant of population density has declined. This is partly because agricultural productivity has increased, so that a smaller fraction of the labour force works on farms. It is also because transport costs have fallen, so that people don't need to live near where their food is produced.

Similarly, lower transport costs, along with increased opportunities for gains from trade, have raised the value of locations (such as those on coasts, navigable rivers, or natural harbours) that are accessible to

trade, either within or between countries.

Our goal is to show how these changes are reflected in the distribution of population today. In pursuing this goal, the effect of persistence turns out to be very important. We are interested in how technology in historical times affected agglomeration at those times, but the data on population density that we use are only available for the world today.

But if we know when (in a rough sense) agglomeration began in a country, then we can use the similarity of today's distribution to the historical distribution to learn about how the technology available at that time affected agglomeration.

## First-nature data and the distribution of population today

Before looking at the role of history, we start by simply examining the explanatory power of first-nature characteristics for today's world population distribution.

Our starting point in measuring the dispersion of population is lights observed at night by weather satellites. Specifically, we use the 2010 Global Radiance Calibrated Nighttime Lights dataset (Ziskin et al, 2010). In previous work (Henderson et al, 2012), we show that change over time in night-lights data is a useful proxy for the growth of GDP in countries with poor national income accounts data.

The lights data are distributed as a grid of pixels of dimension 0.5 arc-minute resolution (1/120 of a degree of longitude/latitude). We aggregate into a grid of 1/4-degree squares, with each

Geography matters for where people live, but the aspects of geography that matter change over time

Figure 1:
Demeaned lights

Value
High: 10.3153

Low: -7.53645
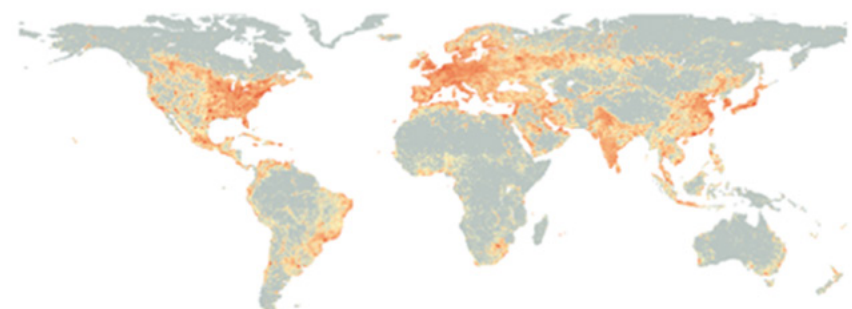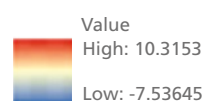
square covering approximately 770 square kilometres at the equator. At this resolution our sample is roughly 240,000 grid squares (excluding squares made up solely of water). Figure 1 shows this grid cell data for the world as a whole.

The first-nature variables we use in predicting lights are in three groups. The first – 'agriculture' – comprises factors that seem clearly related to producing food. These include six continuous variables (temperature, precipitation, length of growing period, land suitability for agriculture, elevation and latitude) as well as a set of 14 indicators for biomes (mutually exclusive regions encoding the dominant natural vegetation expected in an area, based on research by biologists.)

The second group of variables – 'trade' – focuses on access to water transport. These measure whether the centre of a grid cell is within 25 kilometres of a coast, navigable river, major lake or natural harbour, as well as including a continuous measure of distance to the coast.

Finally, we define a 'base' group of two variables – ruggedness and malaria ecology – which seem to be roughly equally relevant for agriculture and trade.

Figure 2a shows how lights in a grid square are explained by our three sets of first-nature variables. Together, these variables explain 47% of the variation in lights.

But there are two potential problems with jumping from this result to the conclusion that nature really does explain such a large fraction of variability in population density. The first is that variation in visible light is not solely determined by population density. The other big determinant is income per capita. It is for this reason that in Figure 1, Japan is so much brighter than Bangladesh, even though the latter is more densely populated.

The second problem is that a statistical correlation between geographical characteristics and either income or population density might not indicate a true effect of geography, but rather be acting as a proxy for the effect of something correlated with geography. For example, if European colonisers implanted good institutions in places where the climate was amenable to their settlement and bad institutions in places that were not (Acemoglu et al, 2001), then a European-type climate will predict higher income,

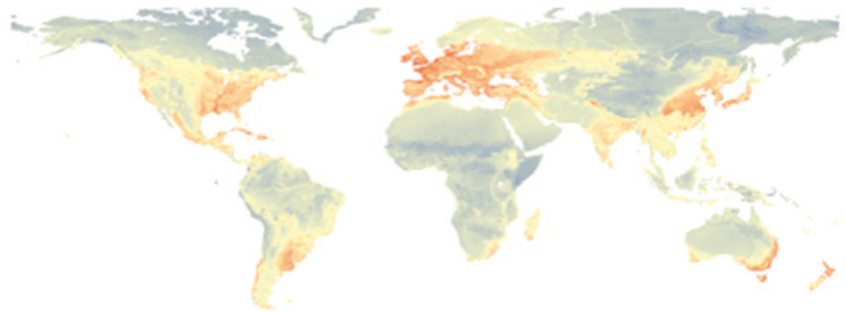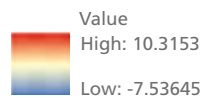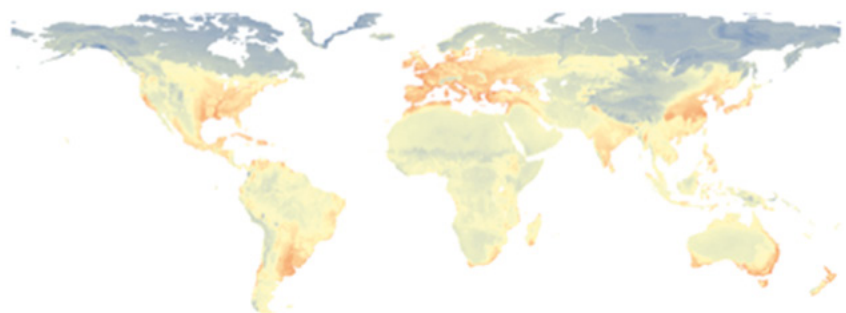Figure 2a:
Demeaned predicted lights without fixed effects

Figure 2b:
Demeaned predicted lights with fixed effects

Value
High: 10.3153
Low: -7.53645

even though it may not directly affect income at all.

Both of these problems are addressed by looking at variation in lights and natural characteristics within countries. Figure 2b is an example of this: we estimate the effect of first-nature characteristics using only within-country variation in lights, and then from values for the world as a whole.

As the figure shows, knowing only how geography affects population within countries, one would still do a pretty good job of predicting the variation in population density the world over. The agriculture and trade variables account for slightly more than a third of within-country variation.

The changing importance of first-nature characteristics
We now turn to the question of how the importance of natural characteristics as a determinant of the distribution of population has changed over time. Key to our approach is comparing countries where agglomeration took place early, thus reflecting the weights put on natural

History – the ways in which geography mattered in the past – is still reflected in the spatial distribution of population today

characteristics further back in time, with those that agglomerated later.

Unfortunately, we don't have a consistent measure of exactly when agglomeration took place, so instead we use data from 1950 on urbanisation and two proxies: education and GDP per capita. Our assumption is that countries with higher values of these measures at that point in time also started their urbanisation process earlier.

We use several statistical approaches to parse the data. One is to estimate coefficients on our 'agriculture' and 'trade' variables separately for early and late agglomerators, while simultaneously letting the data determine where the threshold is between these two groups of countries. Applying this method using urbanisation in 1950, for example, we find that the cut-off between early and late agglomerators is an urbanisation rate of 36.2%, which puts 70 out of 189 countries (57.2% of our grid squares) in the 'early' category.

We then analyse the impact on visible lights of the set of base variables, the base plus agriculture variables and the base plus trade variables. The improvement in explanatory power that comes from adding agricultural variables is much larger in the early agglomerators than in the late ones; correspondingly, the improvement that comes from adding trade variables is much larger in the late agglomerators than in the early ones.

We find a similar pattern when we use education or GDP per capita in 1950 to split the data, and we find it also when we look solely within the New World or the Old World.

These results tell what at first seems to be a puzzling story: late agglomerators are generally poorer countries and, on average, are more dependent on agriculture than early agglomerators. Yet it is in the latter group of countries in which agricultural variables do a better job of predicting the location of population and economic activity.

Our explanation of this apparent puzzle looks to the timing of when agricultural productivity rose and trade costs fell. In countries where agglomeration got going early, the rise in agricultural productivity preceded the decline in transport costs. In other words, people began moving from farms to cities at a time when it was still relatively expensive to move food from place to place. As a result, cities were

located close to areas conducive to food production.

By contrast, in late agglomerators, the rise in agricultural productivity that allowed urbanisation came later relative to declining transport costs, and so the latter was relatively more influential as a determinant of location.

Figure 3 shows some of the data that support this argument: it plots the urban share of the population in groups of early and late agglomerators, as well as a global index of transport costs. The figure makes clear that transport costs were far lower when late agglomerators reached any particular level of urbanisation than when the same level was reached by early agglomerators.

One implication of this analysis is that countries that are only urbanising now have population distributions that are more appropriate to modern technology than those that urbanised earlier. For example, even though in Europe coastal areas already have particularly high population densities, our estimates imply that if Europe had developed later, coastal density would be even greater. Similarly, if Africa had developed earlier, interior areas such as the Ethiopian highlands and the Congo basin would have higher relative population densities than they actually do.

Countries urbanising now have population distributions more appropriate to modern technology

Locational decisions made today will have effects in centuries to come

Figure 3:

Urban share of the population in groups of early and late agglomerating countries; and a global index of transport costs
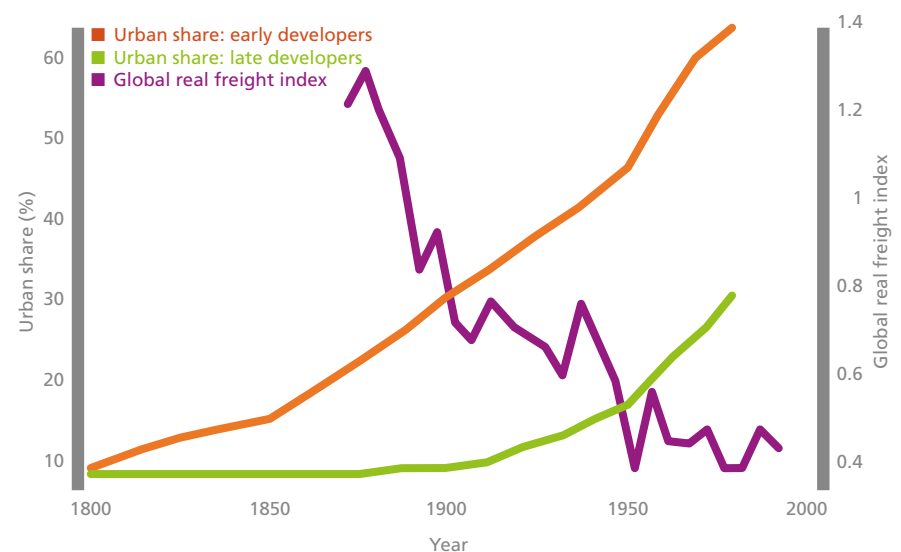
Note: Global real freight index excludes periods including world war years.
Sources: Bairoch (1988); Mohammed and Williamson (2004).

Further implications of our analysis involve spatial inequality within countries. We expect early agglomerators, with their activity focused around agriculturally suitable land, and a distribution of population inherited from a period when transport costs were high, should have a higher degree of spatial equality in lights overall than late agglomerators with their heightened coastal focus and low transport costs.

Conclusion

The saying that 'geography is destiny' is often attributed to Napoleon. Meanwhile, the American industrialist Henry Ford really did say that 'history is bunk'. Our research shows that when it comes to thinking about how population is distributed within countries, there is reason to doubt both of these statements.

Geography clearly matters quite a bit for where people live. But the aspects of geography that matter change over time. Further, there is enormous persistence in location, so that the ways in which geography mattered in the past – that is, history – are still reflected in the spatial distribution of population today.

To many readers, sitting in cities founded hundreds of years ago, sipping coffee grown thousands of kilometres away, none of this will come as a great surprise. But understanding the dynamic interplay of geography, technology, economic growth and history – a project in which our study is only a small step – is of great import in thinking about many issues facing the world today.

Not only are the impacts of different geographical characteristics continuing to change with economic and technological development, but also in decades to come, geographical characteristics themselves will be changing at an ever-increasing rate. At the same time, in much of the developing world, urbanisation is taking place at a rapid pace. The locational decisions made today will have effects in centuries to come.

This article summarises 'The Global Spatial Distribution of Economic Activity: Nature, History and the Role of Trade' by Vernon Henderson, Tim Squires, Adam Storeygard and David Weil, SERC/Urban and Spatial Programme Discussion Paper No. 198 (http://www.spatialeconomics.ac.uk/textonly/SERC/publications/download/sercdp0198.pdf).

The summary was first published in the VoxEU ebook 'The Long Economic and Political Shadow of History' edited by Stelios Michalopoulos and Elias Papaioannou (http://voxeu.org/article/new-ebook-long-economic-and-political-shadow-history).

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Further reading

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