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Stagnation and innovation before agriculture

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ABSTRACT

During the roughly 190,000 years between the emergence of anatomically modern humans and the transition to agriculture, sustained economic progress was rare. Although there were important innovations in the Upper Paleolithic, evidence from paleodemography indicates that population densities were driven more by climatic conditions than by technological innovations in food acquisition. We develop a model in which technological knowledge is subject to mutation and selection across generations. In a static environment, long run stagnation is the norm. However, climate shocks can induce experimentation with latent resources. This generates punctuated equilibria with greater technical capabilities and higher population densities at successive plateaus. The model is consistent with archaeological data on climate, population, diet, and technology from the Upper Paleolithic through the early Neolithic.

1. Introduction

For almost all of the 200,000 years during which anatomically modern humans have existed (McDougall et al., 2005), technological progress has been extremely slow. Only in the last 10,000 years do we see precursors of modern society such as

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settled agriculture, draft animals, metallurgy, writing, and cities. Indeed, many foraging societies continued to use stone-age techniques until they encountered the modern world (Kelly, 1995; Johnson and Earle, 2000).

Economists have usually viewed such matters through the lens of growth theory (Kremer, 1993; DeLong, 1998; Becker et al., 1999; Galor and Weil, 2000; Jones, 2001; Galor, 2005; Olsson and Hibbs, 2005). These authors note that world population growth before agriculture was extraordinarily slow compared to growth rates afterward. They also suggest reasons why low levels of population might limit the rate of technological innovation, which in turn helps to explain the slow rate of population growth. We agree with these general points, but some further facts about foraging societies do not fit as comfortably into current models of long run growth.

1.1. Climate

Archaeologists have found that climate is a crucial determinant of prehistoric population. This is true both for colonization of new continents and for population density at the local and regional level. Until the onset of the Holocene about 11,600 years ago, climate shocks were large, frequent, and had massive effects on natural resources and population levels across much of the world.

Kelly (1995: 65–73) summarizes anthropological research showing that the diet of contemporary foragers likewise varies systematically with the natural environment. Baker (2008) finds that the best predictors of population density for hunter–gatherer societies are rainfall, number of frost months, land slope, and habitat diversity. Thus, we believe that any satisfactory theory of economic development among foragers must recognize the key roles of climate, geography, and ecology.

1.2. Population

Economists who write on the subject of prehistory often cite world population estimates obtained by identifying the inhabited regions of the world at various dates and multiplying these areas by modern hunter–gatherer population densities (for one influential example, see the pre-agriculture population estimates in Kremer, 1993, based on Deevey, 1960, and McEvedy and Jones, 1978). This yields a small positive growth rate simply because humans slowly colonized new continents over time. However, two issues arise. First, the estimates are based on very crude archaeological data and are therefore of questionable accuracy. Second, even if the estimates were accurate, they would not imply technological progress because migration opportunities could have arisen instead through climate change. To make a strong case for technological progress, one would need to show that population density increased within a fixed geographic region with fixed natural resources, and that this increase was not driven solely by migration.

Data that can be used to make such assessments are increasingly available from paleodemography. Relevant studies include Gamble et al. (2005) on western Europe during 25–10 KYA (that is, 25 –10 thousand years ago); Shennan and Edinborough (2007) on Germany, Denmark, and Poland during 9–4 KYA; Rick (1987) on Peru during 13–3 KYA; Lourandos and David (2002) on Australia from 35 KYA until European contact; and Holdaway and Porch (1995) on Tasmania during 35–10 KYA. Several of these studies find long periods of static population, and some find long swings or cycles that are clearly related to climate change. There is little evidence for exponential population growth (even at very low rates) within well-defined geographic regions prior to agriculture.

1.3. Technology

Direct archaeological evidence reveals a number of technological innovations associated with the Upper Paleolithic, which began about 45 KYA, and with the Mesolithic, which followed the last glacial maximum around 21 KYA. These innovations were episodic and did not lead to sustained growth (details will be provided in Section 5). Most long run growth models, on the other hand, predict smooth and at least exponential productivity growth (Kremer, 1993). One key advantage of our 'punctuated equilibrium' framework is that we can explain both stagnation and innovation, while conventional growth theory addresses only the latter.

We suggest the following way of thinking about these issues. Nature provides many potential food resources that could be exploited if a society had access to suitable technology. In a static environment, foragers become very competent at exploiting some subset of these resources, but they face long run stagnation because (a) there is an upper bound on productivity for each resource; (b) latent resources remain unexploited due to the limitations of existing knowledge; and (c) knowledge does not improve for resources that are never used.

To escape from such a trap, a foraging society must be exposed to shocks from nature. For example, an improved climate tends to increase population in the long run. If this scale effect is big enough, it may become attractive to exploit latent resources. Once this occurs, cultural evolution generates improvements in the techniques used to harvest, process, or store the new resources. As long as knowledge gains are irreversible, a series of positive or negative shocks can generate a ratchet effect in technological capabilities.

We define 'progress' to mean the increased capacity of a human population to obtain food in a given geographic region with given natural resources. We make the Malthusian assumption that productivity gains from new techniques are absorbed through population growth in the long run. Therefore, on an archaeological time scale technological progress should become visible through higher population densities. But population density can rise either because natural resources improve (hold-