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Can geography lock a society in stagnation?☆

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HIGHLIGHTS

- We extend Galor–Weil (2000) model to show how a society to be locked in stagnation.
- We introduce loss of technology and geographical factors in the model.
- We examine the importance of geography for the development process.
- We characterize geographical factors not supporting a society to escape stagnation.

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ABSTRACT

We extend Galor and Weil (2000) by including geographical factors in order to show that under some initial conditions, an economy may be locked in Malthusian stagnation and never take off. Specifically, we characterize the set of geographical factors for which this happens, and this way we show how the interplay of the available "land", its suitability for living, and its degree of isolation, determines whether an economy can escape stagnation.

1. Introduction

Galor and Weil (2000) advanced a unified growth model to explain the transition to modern growth as the result of the interaction between population, technology, and output. In their model, the authors show that the transition from stagnation to sustained growth is an *inevitable* outcome when the driving forces for technological progress are the education and size of the population. Specifically, in Galor and Weil (2000), technological progress is assumed to appear even for zero education investments and arbitrarily small populations so that, eventually, Malthusian stagnation vanishes endogenously, leaving the arena to modern growth forces and letting thus the economy take off and converge to a modern steady state growth. In this paper, we study conditions under which take-off is not inevitable, but rather stagnation is.

In order to understand how a society can be locked in stagnation it is useful to identify what exactly drives a take-off in Galor and Weil (2000). A key ingredient to the mechanism proposed there and that takes the economy out of stagnation is the positive dependence of technological progress on population. Still it is worth noting that this dependence is, nevertheless, not indispensable for an explanation. In effect, for instance Galor and Moav (2002) show that a society can still take off without having to assume a positive effect of population on technological progress. In this case, it is the composition of the population (in terms of the households' preferences about quality vs. quantity of their offspring) rather than the size of the population that matters in order to spur technological progress. In effect, the appearance of a fraction (even a tiny one) of

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"quality-loving mutant" households suffices for a society to take off in the long-run, regardless of population size, by triggering a change in the composition of the population. Still, if the population size does not matter in Galor and Moav (2002) it is because of their explicit assumption according to which the costs (not related to education) of rearing a child do not depend on the population size. Nevertheless, population density is known to have an impact on the childrearing costs that are unrelated to education. Specifically, evidence shows that when households have small dwellings, child production is more costly and households have fewer children (see De la Croix and Gosseries, 2012, citing evidence from Goodsell, 1937 and Thompson, 1938). It is precisely this kind of interplay between a population and its environment – and its impact on growth – what our model aims at capturing.[1]

In this paper, we build on Galor and Weil (2000), introducing geographical factors instead, in order to show that, under some initial conditions, an economy may be locked in stagnation, with a small population, a basic technology, and no education, *even if population size has, per se, a positive effect on technological progress* (so that the economy should eventually take off instead according to Galor and Weil, 2000). In order to show this, we take into account too the often overlooked role of technology losses in the determination (along with education investments and population size) of the technological level of the society.[2] The key mechanism is, in this case, that recurrent technology losses allow for technological progress only if the population size is large enough to offset them. When this is the case, the level of technology will increase until it reaches a threshold beyond which the returns to education are high enough to trigger investment in human capital, the tipping point where education kicks in and from which sustained growth obtains. Nonetheless, societies whose geographical factors cannot support a sufficiently large population never escape stagnation. This paper therefore makes stand out clearly the role of geographical factors – such as the amount of available land or, more generally, environmental resources, its suitability for living and production, and its degree of isolation – in the creation of a stagnation trap.

It is interesting to note an alternative mechanism that De la Croix and Dottori (2008) propose to explain the road to stagnation followed in Easter island in particular. In that paper, the authors argue that the population collapse in Easter island was the result of a population race – that played the role of an arms race given the labor-intensive warring technology – triggered by the non-cooperative bargaining between clans about the allocation of the society's total output (in case of disagreement, a war would break out whose outcome would be determined by relative population sizes of the belligerent clans, so that in order to improve their bargaining power, each clan would increase its size to the point of jointly depleting natural resources and leading eventually the society to collapse). Therefore, in De la Croix and Dottori (2008) the conflict-driven population race is the prime cause of stagnation in an environment whose resources are bounded but not necessarily insufficient for sustaining take-off in the absence of conflict. On the contrary, in this paper, the cause of stagnation is a geography unable to support a population large enough to offset technology losses.[3]

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 characterizes its equilibria. Geographical factors under which an economy is unable to escape stagnation are studied in Section 4. Specifically, we show that a society for which (i) the population level guaranteeing technological progress, and (ii) the level of technology guaranteeing education investment, imply a high enough *effective population density*, never escapes stagnation, under some initial conditions. Section 5 makes a summary and concludes the paper.

2. The model

2.1. Geographical factors

We refer by "land" to the set of geographical and environmental conditions supporting the life and economic activity of a society (obviously, living and production conditions depend on how suitable for that the ecosystem around us is). How much of this land can be put to productive use depends on the interplay of its intrinsic suitability for that purpose and the level of technology. The suitability of land captures its adequacy for people to live and work in the ecosystem as a whole, such as temperature, humidity, orography, river density, bio-diversity, etc. Typically, suitability and technological constraints prevent people to make the most of their environment, i.e. the available land. For instance, people may just occupy the part of their geographical territory that is most suitable for their lives, or may be unable to tap certain resources with the current technology. We refer to the fraction X_t of the available land X that is put to productive use at period t as "productive land" and its size depends positively on its suitability θ and (moreover concavely) on the technological level $A_t \geq 0$, i.e.

$$X_t = \chi(\theta, A_t)X \tag{1}$$

with $\chi(\theta, A_t) \in (0, 1)$, $\chi_\theta(\theta, A_t) > 0$, $\chi_A(\theta, A_t) > 0$, $\chi_{AA}(\theta, A_t) < 0$.

2.2. Production and technology

The productivity of each household in period t is determined by its human capital $h_t \geq 0$ and the technological level A_t, so that the output per household in period t is

$$y_t = f(A_t)h_t$$

where $f(A_t) > 0, f'(A_t) > 0$.[4]

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[1] Whether the Galor and Moav (2002) population-composition mechanism allows too for a stagnation trap when population composition itself affects the childrearing costs remains an open question.

[2] Diamond (1997) provides evidence that some societies show no sign of escaping stagnation on their own due to losses of technology and culture, in particular small and isolated societies. An extreme case, but by no means the only documented one (see Aiyar et al., 2008 for technological losses driven by population shocks and, more generally, footnote 5 below), took place on the Tasmania island. Aborigines in Tasmania were separated from mainland Australians due to rising sea level around 10.000 years ago. With a stable population of 4.000, Tasmanians had, at the time of arrival of Europeans, the simplest material culture and technology of any people in the modern world. Like mainland Aborigines, they were hunter–gatherers but they lacked many technologies and artifacts widespread on the mainland. Some technologies were brought to Tasmania when it was still a part of the Australian mainland, and were subsequently lost in Tasmania's cultural isolation. For example, the disappearance of fishing, and of awls, needles, and other bone tools, around 1500 BC (Diamond, 1997, pp. 312–13). Diamond argues that a small population of 4.000 was able to survive for 10.000 years, but was not enough to prevent significant losses of technology and culture, as well as the failure to invent new technology, leaving it with a uniquely simplified material culture.

[3] Mariani et al. (2010) address a related topic noting the possibility of an environmental poverty trap in a setup in which environmental quality and life expectancy are jointly determined. In such a setup multiple equilibria are possible according to which agents either invest in both environmental quality and longevity, or do not, which may lock an economy in an environmental poverty trap in the latter case. However, the mechanism there is basically a coordination problem where population growth and its interaction with the environment are abstracted.

[4] In order to make stand out clearly the importance of the interplay between population, education, and environment, we abstract from land as an input of the production function. Introducing land in the production function does not change the qualitative analysis.