Comments on Galor-Moav

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Oded Galor's tendency to ask big, important questions, to be tackled in ambitious and technically sophisticated models have earned him a well-deserved reputation as one of the most ingenious and interesting growth-theorists of our age. In this paper the authors try to "reproduce" everything that really mattered not just in human history but in the entire evolution of mankind. A less charitable interpretation might well remark that they rush in where many a wise scholar fears to tread, but without such dare-devil modeling of really important issues, what would be the point of all the hard work that economic historians have invested in reconstructing what we know about the past trajectories of technology and population?

The paper focuses on one very important aspect of human history, namely the possibility that some people are evolutionary r-strategists, that is they try to maximize the number of offspring in the hope that sheer numbers will maximize fitness and the chance of reproductive success, whereas others known as K-strategists will deliberately reduce the number of children and invest in their "quality." Better cared for children have a better chance to survive to adulthood and thus to reproduce themselves. Nature and elementary algebra teaches us that both strategies are viable, and that fairly small differences can make for one

strategy to be more successful than the other, depending on the relation between survival probability and the number of siblings, and the relation between the number of siblings and the amount of time that parents can and wish to invest in the "quality" of their children. Using this fundamental distinction, the authors assume that people come in two fixed types, type *a* investing in quality (K-strategists) and type *b* (r-strategists), who care less about quality and more about quantity. The assumption that drives the model is that the "type" is acquired at birth, inherited from parents, and that the children of type *a* are types *a* themselves. The proportion of the types *a* in the population is a very important variable that drives the model, and it is this changing frequency distribution over time that makes this model "Darwinian."

I hope people realize how rich, ambitious, and complex this paper is, and at the same time it is highly original. It is not a dynamic general equilibrium paper. In fact, it is a paper that in some ways does not seem to be about economics at all: there are no markets, nothing is sold and bought, there are no explicit prices, and in some ways it could be accused of being somewhat mechanical. In the Galor-Moav world, people do not respond much to incentives, and what is driving the model is the changing distribution of "types." This kind of mechanism is unusual in economics: we normally assume that people's behavior responds to changing parameters, so that we do not have to rely on "natural selection" to do the

responding for us as is the case in Darwinian models. In economic model behavior does not pass on from parent to child (either through genes or through "culture").

But of course, to some extent, that is how the world works, and by underlining this kind of mechanism, Galor and Moav have opened a new and potentially very fruitful vein of thinking about the history of economies in the very long run. To be more precise: the parameter ∃ in the model reflects the relative importance of "child quality" relative to child quantity in the parents' preferences. This parameter is fixed within dynasties. In some sense, however, this begs the question: why do people care about children at all? A Darwinian model suggests that we have an innate instinct to leave as much offspring as possible, and that K- and r-strategies are favored depending on the parameters of the environment.

There are some inevitable simplifications in the model that evolutionary theorists might object to. The population dynamics are very simple: genes are passed on through uniparental reproduction. There is no homo- or heterozygosity, no dominant or recessive genes. Moreover, it assumes that the critical parameter ∃ is determined by a single gene. This assumption drives the conclusion that change can happen quickly. But it is sometimes not wholly clear whether they mean mutations or selection. They may benefit perhaps from reading a bit about Conrad Waddington's idea of genetic assimilation, which argues basically that there are a lot of latent traits hidden in the genome that will come out under the right selective

pressures and will may look like “directed mutations” which they are not. But this model is about natural selection and we should face that directly.

The question arises how in a Darwinian model, quality-maximizers survive at all. Here, I think, there is a difference between the way they see the world and the way most demographic historians see the world: I would venture that investment in “quality” is Darwinian-motivated: Industrial Revolution increases the probability of any child to survive to adulthood, so that K-strategists can have an advantage over r-strategists, as more of their children reach reproductive age. This specification, however, is not in the model. Instead, Galor and Moav postulate a rigid minimum of subsistence, and the reason their type b-quantity -maximizers don’t drive out their brethren by multiplying and filling the earth is that they are too poor to actually have many children. It may well be that this is what is meant by z-tilde in the model, but I would suspect that it may actually both simplify and enrich the model if the growth of a dynasty was explicitly defined by a specification in which survival to adulthood was a function of income and “quality.”

The history of the world, according to Galor and Moav, goes something like this. For countless generations a population that had been blind quantity maximizers whose numbers were constrained by poverty. Actually, the type *b* people care about quality as well, but they were too busy surviving so in effect

aggregate quality was zero. One bright day a mutation occurred, and the world was "invaded" by a new type of people, who spent more time investing in their children's human capital and accordingly had fewer children. These people become richer, and because for them the subsistence constraint is not binding, they actually have both more offspring *and* offspring of higher quality. In this economy, average income is low and static, but there is one creeping change, namely, type-*a* people slowly increase their weight in the population.

This is where the second assumption that drives the History of the World comes in: technological progress depends on quality, and is thus a function of q, the proportion of K-strategists. The paper shows that there is a level q-hat, at which the proportion quality-minded parents is high enough to change the entire dynamics of the model. That is because technological progress, generated by the clever children of the b-types, starts driving up everyone's income, and eventually even the a-types will start getting rich enough to invest in the quality of their children.

Much of the story follows from the clever and intricate nexus between technology, demographic behavior, and investment in human capital. In the Galor and Moav world, better quality children are smarter and more creative and increase productivity, but they are also better able to deal with a world in which technology is changing and which therefore renders *existing* human capital obsolete. For that

reason a higher rate of technological progress increases the marginal product of human capital. This creates a positive feedback that generates the "modern age" of a constant rate of growth and technological progress. Perhaps one of the more striking features of this model is that the "Malthusian equilibrium" is really a temporary state of the world, and not a true stationary state, because underneath the surface, the b-types are slowly increasing in numbers and eventually will the rate of technological progress to the point where an "Industrial Revolution" occurs – inevitably in this model.

The model also generates, almost as a bonus, the widely-observed phenomenon that in a Malthusian regime there is a positive correlation between income and fertility, which is reversed in a modern growth regime. The other, somewhat startling, result is that in the end the high-quality types, who play such an important historical role in lifting the economy up by its bootstraps and taking it to the promised land of milk, honey, and steady-state growth, disappear and go extinct. This happens because the higher income that technology generates and the higher rate of return on human capital that constant technological change generates, allow the type *a* people to invest in child-quality themselves to the point where they can generate steady-state growth. Since these type-*a* people have inherently more children, they outbreed the others and eventually become "fixed" in the population.

How much of this will "ring true" among economic historians? Inevitably, of course, questions will arise what is mean by "child quality" and why people care about it at all. If quality means, as I argued above, survival probability, much of it will have taken the form of better food, housing, clothing and the like, and will therefore not have much to do with human capital. Indeed, investment in skills and smartness may not count for much in pre-modern history by the model's own prediction, since the main benefit of education is to allow you to deal with rapid technological change, of which there isn't any, yet. Even when people invest in education, however, it is far from clear that such education resembles anything that correlates with technological change. Most groups of quality maximizers that historians can identify and who could afford an education for their young did not bother to teach them material that would in any shape or form benefit technology: whether it was religion, law, philosophy, astrology, or military skills, it is hard to see how, before the Scientific Revolution, education led to technology.

In other words, Galor and Moav are right when they say that in the long Malthusian transition the educated were rich. But they were educated because they were rich, not the other way around. Their impact on technology was minimal – exactly as the model predicts. But this is not, as I will argue below, because the numbers of the educated were too small. It is because "knowledge" takes many forms, and so do "education" and "quality" and the critical shift that brought the

Industrial Revolution was not the proportion of type-*b* individuals, but the nature of desirable knowledge and its relation to what young people were taught. Incidentally, it is ironic that during the most successful pre-Industrial Revolution technological spurt, which was not in the Greco-Roman age but in the "high" middle ages (say, 900 to 1200), the most active educated group were the regular clergy (that is to say, monks) who were, one supposes, not too deeply involved in procreation and would fit in poorly in a pure Darwinian model.

Where quality matters, is in the education of craftsmen and artisans who were taught skills by masters art considerable expense to themselves. However, if what Galor and Moav have in mind is something like the apprenticeship system of pre-industrial Europe, they need to realize that this system for much of its history was quite conservative and much of the technological progress in Europe was generated despite the guild system rather than through it.

The question then arises what drove the discontinuity we call the Industrial Revolution. Numbers (or proportions, to be exact) of "quality" and educated people in and off themselves will not do the trick. Much of the technology that Galor and Moav are concerned about was generated by individuals whose education gradually shifted in the seventeenth century from fields that were by and large useless to technology to more applied knowledge or the "useful arts." The evidence does not really support the hypothesis that the process was driven by a

rise in the *number* of educated people, but rather by what educated people focused their activity on, and why. It would take us too far from this paper, but it is worth noting that people living at the time saw it very much in those terms.

Moreover, it was widely recognized that the entire Baconian program of applying knowledge of natural regularities to production depended on a small minority of critical people. David Hume, insightful as ever, noted in his *Of the Rise and Progress of the Arts and Sciences* that the progress of "learning," precisely because it depended on the actions of a small number of people, was more attributable to chance than to a systematic cause. Less than a century earlier, the great scientist Robert Hooke made the same point. [slide].

Even so, the connection between human capital and the Industrial Revolution, as much of the work by historians shows, is anything but straightforward. Certainly many contemporary observers, above all Karl Marx, felt that for the majority of workers, the growth of machinery and technological sophistication was de-skilling. Whether the average education of a factory worker in 1850 was higher than that of the population of handicraft workers in 1650 remains to be see, but surely the variance was higher. Galor and Moav, in another ingenious paper entitled *Das Human Kapital* have dealt at length with this issue. But it is telling that Adam Smith's colleague in Edinburgh, Adam Ferguson wrote in 1767 that "Many mechanical arts require no capacity ... ignorance is the mother

of industry as well as superstition... Manufactures, accordingly, prosper most where the mind is least consulted." Much of the ingenuity of engineers and inventors of the Industrial Revolution was devoted to reducing the need of workers to be educated and skilled. As long as the rate of technological progress is not too fast – so that workers in a lifetime have to learn and unlearn many skills – the connection between human capital and technological progress is less straightforward than it seems to Galor and Moav and it may well be the case that more advanced technology is complementary with lower skills, meaning that education might take a different form as it seems to have done in the nineteenth century. Whereas in the pre-Industrial Revolution education of apprentices was much like what we imagine investment in human capital to look like, factory owners increasingly stressed social conditioning such as docility and sobriety.

None of this is meant to detract from the achievements of this pioneering paper, which is a breakthrough in its use of populational dynamics in long-term historical change and which, I suspect, will lead to a literature of other scholars who will learn from it that a great deal can be gained by applying Darwinian logic to the history of mankind.

There hath not been wanting in all ages and places great numbers of men whose genius and constitution hath inclined them to delight in the inquiry into the nature and causes of things, and from those inquirys to produce somewhat of use to themselves or mankind. But their Indeavours having been only single and scarce[ly] ever united, improved, or regulated by Art, have ended only in some small inconsiderable product hardly worth naming. But though mankind have been thinking these 6000 years and should be soe six hundred thousand more, yet they are and would be ...wholly unfit & unable to conquer the difficultys of natural knowled[ge]. But this newfound world must be conquered by a Cortesian army, well-Disciplined and regulated, though their numbers be but small.

Robert Hooke, 1666

There is no subject in which we must proceed with more caution that in tracing the history of arts and sciences; lest we assign causes which never existed and reduce what is merely contingent to stable and universal principles. Those who cultivate the sciences in any state are always few in numbers: The passion which governs them limited: Their taste and judgment delicate and easily perverted: And their application disturbed with the smallest accident. Chance, therefore, or secret and unknown causes, must have a great influence on the rise and progress of all the refined arts...But I am persuaded that in many cases good reasons might be given, why a nation is more polite and learned than any of its neighbours. At least, this is so curious a subject that it were a pity to abandon it entirely.

David Hume, 1742.