WHY IS ECONOMIC HISTORY

NOT AN EVOLUTIONARY SCIENCE?

(With apologies to Thorsten Veblen).

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Is Economic history the obvious next frontier of Evolutionary theory? The seemingly obvious application is of course in that evolutionary economics is unashamedly historical, unlike much of neoclassical economics which at first approximation at least is not interested much in history. In a world of simple unique and stable equilibria, as standard economics was 20 years ago, history does not much matter. But at second glance, this obvious contrast between evolutionary and neoclassical economists is much overblown. For one thing, with growing awareness of the many reasons that exist for multiple equilibria and the persistence of shocks in macroeconomics, many neoclassical economists have become increasingly interested in economic history, full well realizing the many irreversibilities and path-dependencies that even simple neoclassical models will produce once the extreme assumptions leading to unique equilibria are abandoned. More interesting, economists of many different types have come to realize the importance of good institutions, social capital, beliefs, trust, and other things that fit poorly in doctrinaire neoclassical economics, and realize that much can be learned from economic history. I have taken a lot of encouragement from the growing interest in economic history in the so-called new growth theory. And yet, in the past 30 years economic history and evolutionary economics seem to have little interest in each other: economic history, for the most, stuck with the tried and trusted methods and tools of neoclassical market analysis and its offshoots, and evolutionary economics, while at times bowing to historical developments and surely interested in contemporary data and cases, with few exceptions stayed clear of detailed work in economic history.

Why would this be so? I can only venture a few guesses: one is that evolutionary economics has, I think, not fully figured out what its "unit of analysis" is. Economic history is clearly focused on entities that leave records and documents. Evolutionary economics tends to focus on processes and interactions, important and profound as they may be, they leave little record. If there is any unit on which evolutionary economics has focused, it is the firm; but economic history on the whole has left the study of individual business units to "business historians." It is easier to see why the new economic history has been so closely married to a non-evolutionary analysis: its main focus has been to show that markets worked, people were economically rational in the past, and that history makes sense. There are also explanations more closely focused on the sociology of economics which I would not venture upon.

My hunch is that economic history is now slowly switching out its somewhat narrow neoclassical molds and is reaching out to new topics of research. Of those, two have been explicitly suggested as topics suitable for an evolutionary analysis. One is institutions, which are by some account a proper"unit of analysis" in that institutional forms are "selected" over time in some way and are clearly one way in which the heavy hand of the past guides the path of the future. Some scholars, particularly Douglass North, have called for just that, following the earlier work of Edna Ulmann-Margalit and Andrew Schotter. This is a tantalizing suggestion, since much of economic history is the study of the causes and effects of certain institutions, from governments and laws, to antitrust legislation, guild regulations, contracts and so on. How precisely a Darwinian perspective could help us here is not entirely clear to me yet, though the possibilities are obviously endless.

Where I should like to focus my attention in my brief remarks today is in the economic history of **technological knowledge**. Knowledge, for obvious reasons, has eluded the market analysis that Cliometrics has tried to apply to economic history. While some work has been able to show, for instance, that nineteenth century patenting was to some extent responsive to market forces and that

inventors in some cases were interested in monetary rewards for their efforts, I think we have not really tried all that much to apply market analysis to the growth of technology in the past two centuries. The best work that has been carried out by economic historians interested in technology as such, has been more or less devoid of explicit theorizing, or has had to construct their own brand of non-neoclassical theory with path dependence, learning, and so on.

Thus far, most scholars working in this area have tended to apply evolutionary epistemology more to science than to technology. A more complete description of the logical building blocks of an evolutionary epistemology of technological knowledge is given in Mokyr (1991, 1998).

It seems hardly necessary to emphasize why knowledge is central to modern economic growth. Endogenous growth seems to have restored technological knowledge as a central features of the system to be explained. But in the final analysis, I get the uncanny feeling that this literature has opened the black box of technology only to find inside a smaller black box. Knowledge in the historical context is part of human culture, part of the human experience. It exists in human crania alone, though it can be transmitted from one cranium to another by a variety of means, some of which are codified and others are not.

Nobody would seriously dispute the proposition that living standards today are higher than in the eleventh century primarily because as a collective we know more than medieval peasants. I do not submit that we are smarter (there is little evidence that we are) and we cannot even be sure that it is because we are better educated (though of course we are) or that we have better institutions that allocate resources more efficiently (though I believe we do). The main thing is that as an aggregate we know more. But who is "we"? What is meant by "know," how is knowledge transformed into acts that affect economic outcomes and what kind of knowledge really matters?

A few of those questions can be answered quickly. The kind of knowledge that matters is what Kuznets called many years ago "useful knowledge" -- mostly knowledge of the natural world, mechanics, chemistry, geography, biology, and so on. Technology consists of manipulating the forces of nature, and while it is not necessary that we fully or even partly understand those forces, the more we know about what phenomena exist and what kind of empirical regularities they exhibit, the better we will be in utilizing these forces. The question "who knows" can also be answered: a given society "knows" something if at least one person knows it, but the economic impact of this knowledge depends on the access costs that others have to pay to acquire this knowledge.

The advantages of an evolutionary approach to the "history of knowledge" have been widely discussed and need not be restated here. A large and growing field of evolutionary epistemology has been arguing now for decades that knowledge shares many features with living beings. It depends crucially on selection and variability, with entities having differential fitness which means they have different probability of being selected. Evolutionary models are characterized by a dynamic structure in which the present produces the future in some way as an image of itself plus some possible innovation, but which displays a great deal of persistence. In evolutionary models of knowledge, the creation of innovations is not strongly correlated with the needs of the system, and what gives it directionality is mostly -- in some cases exclusively -- the selection criteria. Cultural systems, of which knowledge is a part, have long been recognized to have these features.

Moreover, much like in nature we recognize that there are potentials (genotypes) and manifest entities (phenotypes), technological knowledge consists of useful knowledge, (also called "abstract and

general knowledge" by Arora and Gambardella) and *instructional* knowledge which actually translates knowledge of nature into techniques, that is, sets of instructions. The details of how such a model would work in reality will have to be left for another time. It is worth pointing out here that the analogy with orthodox Darwinian (or better Weissmanian) dogma is partial at best and misleading at worst. Above all, "natural selection" through some kind of fitness criterion is only a *metaphor* in evolutionary biology. Nobody, of course, does any real selecting. In evolutionary epistemology this is not the case: there is conscious selecting. The "choice" of technique is a reality for every engineer, every farmer, every artisan, every homemaker. Choosing a technique is costly in that at the very least involves an opportunity cost, and often it involves real resources. But evolutionary theory is much bigger that biology which, though the origin of this intellectual species, is a very special and limited case of a historical process that can be termed evolutionary. Yet these models share certain characteristics that are foundational to our understanding of history. I cannot emphasize enough that in models of knowledge -- and in fact in all cultural models - evolutionary thinking is more than just saying that "history matters." Evolutionary thinking imposes certain regularities and certain constraints on the outcomes possible. It forces us to distinguish between the forces that make us choose an item on a menu, and the forces that determine what is on the menu and what is not.

Much of that is of course widely-know. A number of points are worth restating, however. The hard question of contingency vs destiny comes up in all evolutionary models. There is a great deal of debate among historians --as there is between evolutionary biologists -- whether the outcomes we observe were inexorable, the results of powerful historical forces (as historical determinists on both the extreme right and extreme left would have us believe), completely fluky and accidental (as S.J. Gould for instance would have it) or something in between. Economic historians love counterfactuals, and they make sense in an evolutionary framework, precisely because such a framework views history as a branching process in which each choice is made at time t to take one path and not another, choices that cannot be readily reversed. This raises particularly horny issues in the history of science and technology. We can ask questions at two levels: had individual i not discovered or invented j, what would have happened? Or we can be more extreme and ask, if j had not been discovered at all, what would happened?

The answer to the former might be that if Gutenberg or Edison had never been born, someone else would have, sooner or later, done what they did. Simultaneous discoveries and inventions clearly point in this direction. But this seems circular, since all this suggests that the existing body of knowledge was already sufficiently close to make the invention probable conditional on the initial state. The issue can be well-illustrated by the following example: the discovery of America by Europeans was one of the greatest additions to the set of useful knowledge in Western society in its history. It is hard to believe that the discovery itself -- as opposed to the timing -- was contingent: had Columbus not made the journey, sooner or later someone else would have made the journey and America would still have been there in exactly the same location. Is the same true, say, for the laws of physics and chemistry, for our understanding of infectious disease, indeed for the theory of evolution itself? Are most natural laws and regularities "facts" that await our discovery, and that sooner or later will become part of Ω simply because they are "true"? Or are they, as many modern scholars in the humanities assert, social constructs much like the American constitution or the rules of basketball? Would another society but Western Europe have discovered a very different way of looking

at nature, one that would not have led to relativity and quantum theory and microbiology but to something entirely different, unimaginable but possibly equally able to explain the observable world around us and map them into techniques that are widely used? This is one of the trickiest questions in the philosophy of science and I am not going to solve it here. But one factor persuading us that knowledge is really "there" and is not just what Cohen and Stewart have called a "brain pun," is that our knowledge of nature maps into techniques that work visibly: chemistry works – it makes nylon tights and polyethylene sheets. Physics works – airplanes fly and pressure cookers cook rice. Every time. Strictly speaking, this is not a correct inference, because a functional technique could be mapped from knowledge that turns out to be false.

A second point about evolutionary theory as a historical tool is that it explains the form of creatures not in terms of their "DNA" but in terms of their historical development within a changing environment. A Newtonian explanation of why "an entity" is what it is is time-**in**dependent. In Lebow et al.'s (2000) formulation, God gave the easy problems to the physicists. Evolutionary models provide explanations that are historical, that is, an entity is what it is because this is what happened over time. They tend to be open, time-variant systems and do not lend themselves to precise formulations that predict accurately, given only sufficient boundary conditions. Moreover, as Ziman (2000) points out, whereas closed systems such as physics tend to be statistical in that they reflect *expected* values, evolutionary systems – of any kind – tend to amplify *rare* events (such as successful mutations or brilliant ideas). Because these "rare" events are themselves not inexorable, and because it is unknown *which* of them will actually be amplified as opposed to being rejected by the selection process for one reason or another, they infuse an irrepressible element of indeterminacy into the system. A counterfactual analysis can then proceed under the assumption that a "rare event" that did in fact occur did not happen.

A third point worth keeping in mind when applying evolutionary models to this kind of historical question is the role of the "environment". In evolutionary biology the role of the environment is to set the selection criteria by which selection occurs. In the history of technology, the best-known example of this are factor prices: in economies in which labor is dear and resources are cheap, such as nineteenth century North America, techniques will be selected in a different way than, say, in India. It is also clear that certain features will be selected regardless of environment, because they are superior in any contingency. But the environment also includes the institutional set-up of the economy, such as patent laws, contract enforcement, the political acceptability of certain innovations and so on. Just as is the case in biological systems, however, at a higher level of analysis than individual fitness, the feedback of technological selection on the environment cannot be disregarded and no adaptation can be regarded as final. Richard Nelson has suggested a wonderful example of such an interaction, namely to co-evolution of American large-scale business firms and technology in the late nineteenth century. The large industrial corporation, originating with the railroads, created institutions that were conducive to R&D which created technology that further enhanced scale effects. Peter Murmann has emphasized the co-evolution of the German chemical industry and the research and education institutional framework in which it operated.

Issues which are shared between the literature of economic history and evolutionary biology are many and striking. One is the debate on gradualness vs. saltationism. Both disciplines have recognized that extreme positions on the rate at which change occurs are not convincing: mutants that

would completely alter the phenotype in one generation, known as "hopeful monsters" are simply not viable. Similarly, a single invention, no matter how dramatic, will not change an entire economy. The steam engine, electricity, computers, all changed the direction of history, but all took their sweet time to do so. Yet debates are still raging. The punctuated equilibrium debate in evolutionary biology has an almost uncanny counterpart in the "was there an Industrial Revolution debate."

Another debate in which the two literatures overlap is on the ability of the selection process to produce outcomes that are in some definable way "efficient" or even "desirable." Those familiar with the debates in biology will recognize this as the debate on "adaptationism" or the so-called "Spandrels" debate after a famous -- or notorious -- paper by Gould and Lewontin. The literature in economic history us similarly influenced by one paper, namely the work on the qwerty typewriter keyboard. Whether that debate has been somehow resolved and in whose favor is something I will not discuss today, but it is interesting that Gould would have picked up Paul David's famous paper in his quest to explain the "Panda's Thumb."What both literatures share is a sensitivity to something known as frequency dependence, that is, when selection depends not only on the intrinsic traits of the entity upon which selection occurs, but also on the number of other specimens that are in existence. Network externalities are one example of this, but so are informational economies and simple conformism. When frequency dependence occurs, any hopes of ex ante efficient outcomes must be abandoned. How pervasive frequency dependency is in history, and whether there are economies it is a more serious problem than in other, is an issue that has to be placed on the economic historians' agenda.

Related, but not quite the same, is the question of how the system generates innovation. The leading evolutionary epistemologist of our age, David Hull, has pointed out that the process that generates innovation in nature is extremely wasteful. The vast bulk of mutations are detrimental or neutral and never get fixed in the population. Moreover, even many potential advantageous mutations may not catch on because of a variety of factors having to do with heterozygosity. One could argue a similar case for the analog in technological knowledge, “new ideas.” The vast majority of them are duds, many other potentially beneficial ideas that for a variety of causes do not make it. Enormous numbers of hours and other resources are spent on techniques that do not work, or when they do are not practical for one reason or another. If new technology was entirely generated by trial and error, the world of technology would be very close to that of Darwinian mutations: the correlation between what we need and what we get is zero. In fact, however, this was never quite the case and in the past 100 years has become less so. The “search” for inventions is focused, directed, it responds to financial and social incentives, follows the perceived needs of society as channeled down by NSF bureaucrats. All the same, the correlation between perceived needs and what actually is proposed and even selected is low. We may no longer be groping in the dark, but it is still rather dusky. Experimentation, trial and error, and serendipity still form the core of R&D in many industries. To be sure, these searches have become more efficient thanks to sophisticated computer programs such as genetic algorithms that test different designs against each other. There is a new technology to create new technology, and it is creating a growing wedge between the way nature creates innovation, and the way we go about it.

In other aspects, however, the two remain share some remarkable features. Because of the persistence built into evolutionary systems, each selection has implications not just for the period immediately following the selection but also for subsequent generations. But selection process tend

to be myopic, in the simple sense that the longer-run implications of selection are not taken into account in the selection process. In nature this is so by definition; in knowledge systems myopia is somewhat mitigated by a sense that some path may have some future potential, but in competitive systems such ability to look forward is constrained not only by our ability to look down the road and project where new knowledge may lead, but also by capital markets willing to be patient. Irreversibility in nature becomes absolute when some forms have gone extinct. In technological systems, knowledge of the past that has become seemingly obsolete can be resurrected because information can be stored exosomatically.

To return to economic history, what can we learn from such evolutionary ideas? One lesson that I would plead for is that the History of Science and Technology is too important to be left to the specialists. In trying to explain modern economic growth, we have recently spent much time in worrying about the operation of incentives, institutions, markets, and resources. These set the environment which selects from a menu of options, but it has little to say on what appears on the menu itself. It often seems that economic historians somehow believe that if economic conditions are only ripe, new techniques will follow automatically, provided by an elastic supply curve of innovations. But this cannot be literally true: the reason that cheap steel, chemical fertilizers, Diesel engines, and antibiotics did not occur at an earlier period was not that they would not have no value, but that the knowledge on which they were based was not available. Analogously, we may ask why homo sapiens did not appear, say right after the destruction of the dinosaurs, at the end of the cretaceous 65 million years ago, or at some point during the Eocene? The answer is likely to be that the right genetic material was not available, and that nature experimented with thousands of different mammals, until it hit on a formula that produced us.

This takes me to my final point, namely the magnification of *recent* history. Modern scholars warn us against the sins of teleology, that is the belief that History necessarily leads to some goal, and specifically that this goal is Us. At the same time, both natural history and economic history suggest that the past is not what it used to be. Change seems to have accelerated in recent time: the appearance of humans in what in geological time is very recent has changed the ecology and the selection criteria for most species of flora and fauna on the planet. Similarly, while short spells of technological change has occurred in many societies before 1760, the Industrial Revolution has begun a period in which not only continuous change has become the norm, but it seems that *accelerating* change seems to be the norm. The conclusion, with which many a Schumpeterian can live, is that classical or neoclassical equilibrium models do not describe the world in which we live. Human knowledge does not play by those rules. The challenge is to design new types of models that will allow us to make mores sense of the past even if we are powerless to predict the future. That, after all, was what Darwin was all about.