Where Are We Now on an Evolutionary Theory of Economic Growth, and Where Should We Be Going?

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This essay has three parts. I begin by arguing that understanding economic growth ought to be the central focus for economics as a field of study, with changes in the pattern of resource allocation and prices being understood as an integral aspect of the growth process. A major advantage of evolutionary economic theory is that it is directly focused on the processes of economic change. Then, in Part II, I turn to the origins and nature of modern evolutionary growth theory, and propose that, while significant progress has been made proceeding along established paths, the endeavor now is running into diminishing returns. Part III offers my thoughts on new directions I think highly valuable to pursue, in order to develop a truly illuminating theory of economic growth.

I. Understanding Economic Growth as the Central Task of Economic Analysis

The cumulatively vast increases in living standards and productivity experienced by a significant part of the world's population clearly is the most dramatic and beneficial achievement of the market oriented economies that began to emerge in the late 18th and early 19th centuries. Surely the primary task of economic theory should be to illuminate how this miracle was accomplished, and the determinants of economic growth in the future.

The notion that economic growth ought to be the center of analytic attention is not a new one. Look again at Adam Smith's *The Wealth of Nations* (first published 1776). This book is basically an analysis of the factors driving the economic growth that was occurring in the U.K. in the late 18th century, along with a diagnosis as to why it was not occurring so effectively elsewhere. The treatise starts out with the famous discussion of the dynamics that Smith believed had so dramatically improved productivity in pin making. This central orientation to the phenomena of economic growth is present in many of the works of the19th century classical economists. Analysis of the determinants of prices and wages also was an important issue in the classical economics writings, but, as in Smith, tended to be treated after the sources of economic growth had been laid out.

However, this certainly is not the orientation of contemporary neoclassical economics, at least as the subject is laid out in general textbooks. There the heart of modern economic science is presented as being the neoclassical theory of the determinants of the pattern of inputs, outputs, and prices, under conditions of a hypothetical equilibrium. The orientation is partly positive, and partly normative, with the normative apparatus linked to the concept of Pareto optimality, and analysis of the conditions under which market equilibria meet, or deviate from, the necessary conditions.

This is not to say that economic growth is ignored in introductory texts. In many of them, analysis of economic growth is given high priority. However, generally economic growth is brought up as a subject of analysis only after the students are assumed to have standard microeconomic theory under control. And the tools of analysis of economic growth that are used are basically those of equilibrium microeconomics, augmented to take aboard the possibility of continuing technological advance. This is so not only in introductory treatments, but also on

more advanced neoclassical treatises on growth. Solow's pioneering theoretical and empirical writings on growth (1956, 1957) were based exactly on neoclassical simple microeconomic theory, principally the theory of the firm in market equilibrium, that was the standard then and is now, augmented to include the possibility of technological advance over time. It is fair to say that the new neoclassical growth theory has stayed very much like the old, in these respects. (For a discussion, see Nelson, 1998)

Put more generally, contemporary neoclassical economics is basically about conditions of general equilibrium. Analysis of economic growth is largely a graft on that subject.

The shift in the orientation of the main line of economics away from a central focus on long run economic growth, and towards a focus on conditions of economic equilibrium, comes with the rise of neoclassical economic theory. Marshall's reflections on this are interesting. In the preface to his *Principles of Economics* (1948, 8th edition first published 1907) he says, in effect, that the important questions for economics lie in the dynamics, and that biological conceptions seemed the appropriate route into economic dynamics. But then he goes on to say that the tools for analyzing equilibrium conditions were better honed, and so this is what his book would largely be about. Marshall never got around to writing that second volume on economic dynamics that he implicitly had promised.

Schumpeter's views here are highly relevant. In his writings from *The Theory of Economic Development* (1934) through his *Capitalism, Socialism, and Democracy* (1942) he is arguing against the prevailing trend among economists to define the core of the discipline as about firm and household behavior, prices and quantities, under conditions of equilibrium, whereas it was clear (to Schumpeter) that the main thing about Capitalism was that it was an engine of progress.

This certainly does not mean a lack of interest in the question of what lies behind the allocation of resources in an economy at any time, or the pattern of output and prices. But Schumpeter's view on these matters was dynamic not static. He argued that one could not understand the processes driving economic growth without consideration of what was going on in different economic sectors, which was leading to a changing pattern of prices and allocation of resources. That is, Schumpeter's theory of the mix of outputs and inputs among industries, and product and factor prices, was part of his theory of economic growth.

Nor does a central focus on economic growth play down the role of market organization of economic activity, the activities of for-profit firms, and competition, as key elements behind the successful performance of Capitalism. Rather, it views successful performance in a different light, and sees the role of competition in a different way.

In any case, the central reason I am an evolutionary economist is that evolutionary theory is, at its core, a theory of economic growth. It is indeed concerned with illuminating the factors behind prevailing patterns of outputs, inputs, and prices, but sees these as in a dynamic context.

II. The Development of Evolutionary Growth Theory, and Diminishing Returns

In the preceding section I noted how neoclassical growth theory was born of an effort to stretch an economic theory, concerned with an equilibrium configuration of quantities and prices, to deal with the phenomena of continuing economic growth. To do this required that the production function part of that theory be augmented to admit continuing technological advance. But the basic premises and features of that theory were kept largely intact.

I think it fair to say that a major reason why modern evolutionary growth theory was born was that cumulating empirical understanding of the processes involved in technological advance,

much of which was won through research of economists motivated by the then new neoclassical growth theory, was revealing phenomena that were completely incompatible with those basic premises. While Schumpeter had made the argument long before, the economists studying technological advance, pointed in that direction by Solow, came on their own to see that innovation, technological or otherwise, could not be understood within the confines of a theory that assumed continuing equilibrium. Rather, one needed a theory that saw technology, and other aspects of the economic system, as undergoing continuing evolution.

The proposals that one should model technology as evolving, and that economic growth more broadly should be understood as proceeding through an evolutionary process, scarcely were new ideas. Thus in the early 18th century Mandeville (1924, first published 1714) argued that the basic design of the sophisticated naval fighting ships of his day, which he regarded as the pinnacle of technological accomplishment then, was the result of a multitude of cumulative advances made over a long period of time by many people, rather than something that was the result of a coherent worked out plan. Adam Smith's discussion of the coevolution of advances in the technology of pin making and the increasing division of labor in the operations, both driven by and interacting with a growing extent of the market, has a similar evolutionary flavor. These early accounts, put forth well prior to Darwin, did not articulate a crisp theory of variation and selection as the cumulative mechanism at work, of the sort introduced in the new evolutionary growth theory. But something like that was implicit.

I confess that when Sidney Winter and I were developing *An Evolutionary Theory of Economic Change* (1982), while we clearly recognized the intellectual base of our work in Schumpeter, I did not realize the extent to which what we were developing had been foreshadowed by an earlier pre-modern neoclassical tradition in economics. Of course we had

available to us a large body of technique and pieces of theory that were not there at the times of the earlier writings, like the theorizing of the Carnegie Tech crew--Simon, March, and Cyert-- on bounded rationality, and their articulation of *A Behavioral Theory of the Firm* (1963). However, increasingly I am of the belief that modern economic evolutionary theory can be thought of as a renaissance of an older tradition in economics that got sandbagged.

What Winter and I did, of course was to marry an evolutionary theory of technological change, with a behavioral theory of the firm, augmented to include innovation as a central firm activity, and placed in a context of Schumpeterian competition. To attack the phenomena addressed by neoclassical growth theory, we treated technologies as activities that used labor and capital to produce output, and built in mechanisms regulating the change over time in supplies of labor and capital.

This formulation obviously struck a responsive chord. It has spawned a major research tradition. I want to express my particular enthusiasm for the fine mix of, and overlap between, empirical and theoretical research that has marked our research enterprise. The interaction between appreciative and formal theory has been strong, and I think very fruitful.

However, in my view much, too much, of the research within this tradition has stayed too close to certain features of the early work, which I think is causing the endeavor to run into sharply diminishing returns. Here I want to highlight three aspects of my early modeling with Winter that probably now are obstacles to further progress, and need to be got out of the way.

First, perhaps because we were so focused on showing that sophisticated effective practice could be explained without assuming that the individuals and organizations engaging in such practice had devised and chosen what they were doing from a large range of perceived alternatives, we played down the role of cognition, understanding, conscious problem solving,

in the evolution of practice. In so doing in effect we were playing down the importance of human knowledge in the advance of know-how, and in particular were repressing the important roles that the advance of science had played in the evolution of practice in a number of areas. It is time, I believe, to build more closely into economic evolutionary models the nature and evolution of the knowledge that guides attempts to improve practice.

Second, the model Winter and I developed to try to explain experienced economic growth focussed on technologies as the body of practice that had experienced the most rapid evolution. While we stated that other aspects of business practice also went through evolutionary change, we didn't do much with that proposition. A major reason, or at least my reason, was conviction that it was the rapid and continuing evolution of technologies that was the basic driving force behind the growth that had been experienced.

I think the tack we took was the right one, then. But I think evolutionary growth theorizing has, until recently at least, neglected the evolution of business practice, organizational forms, and institutions more generally. Bhaven Sampat and I (2001) have proposed that these kinds of variables can be regarded as "social technologies", as contrasted with physical technologies, and that the evolution of social technologies is an important, and usually neglected, part of the economic growth story. In many cases social technologies have had to change in order that society be able to take advantage of the new physical technologies. At the same time the evolution of social technologies seems to be more sticky and less well oriented than the evolution of physical technologies. Getting a better grip on this set of issues ought to be high on the research agenda.

Third, we followed Solow and other neoclassical growth theorists in seeing economic growth as a macroeconomic phenomena. Solow's 1957 empirical article, while linked to his

1956 theoretical piece, also was in a tradition of empirical analysis of the factors behind economic growth that was being conducted by scholars at the NBER, that made use of the newly available time series of GNP. The GNP series provided an aggregate measure of the total production and growth over time of an economy's output, which could be compared with aggregate measures of an economy's labor inputs and its capital stock and the changes in these over time. The evidence that aggregate output had increased at a significantly faster rate than had total inputs was reported in several publications prior to Solow's famous paper, and these earlier publications also put forth the proposition that the greater increase of output than inputs was evidence of the importance of technological advance.

I believe that it is highly useful to have an aggregate measure of economic production, and of the rate of economic growth. However, a long time ago, particularly in his *Business Cycles*, Schumpeter insisted that viewing growth as a macroeconomic phenomena blinded the analyst to the fact that the real economy consists of many different economic sectors, and that economic growth involved in an essential way the rise of new industries and sectors and the decline of old ones. As Stanley Metcalfe has argued in several recent essays (2002, 2003), creative destruction is not simply about firms, but about industries. The current generation of evolutionary growth models has not recognized this adequately. I consider it an open question whether Schumpeter's long wave theory, the heart of which is the proposition that the driving force of growth at any time lies in the rapid advance of a small number of critical technologies, is basically correct or not. But I think it important that evolutionary growth theory be able to address that debate.

I believe that our common efforts to date on developing an evolutionary theory of economic growth have been very successful. But there are clear diminishing returns in continuing down the old paths. It is time, I would like to argue, for setting out in new directions.

III. Promising New Directions

I focus here on the three limitations of the earlier evolutionary growth theory that I have identified above, and give my thoughts as to promising new directions to take.

As I noted, the early versions of evolutionary economic theory perhaps leaned backwards too far in trying to demonstrate that the often very sophisticated and powerful human practices that were involved in economic activity could be, and should be, understood not as the result of human omniscience and global deliberation, but as the long-term achievements of an evolutionary process in which individual action and choice in any instance generally involved no more than ordinary sophistication and skill. The human and organizational "rationality" in evolutionary theories clearly is a bounded rationality. The amazing progress achieved in many areas over the long run is the result of the power of the evolutionary processes at work.

While I am sure the basic perspective here is absolutely correct, it tends to repress the fact that, at least in modern times, the strength of human knowledge that is brought to search and problem solving in a number of areas is extremely impressive. And while that knowledge itself needs to be understood as having been the result of an evolutionary process, the character and strength of knowledge at any time profoundly affects how the evolutionary processes at work at that time proceed. Joel Mokyr (2002, 2004) has argued that the development of strong scientific knowledge relevant to advancing technologies, which occurred during the 19th century, was the

key factor enabling technological to become a sustained phenomena, rather than proceeding in fits and starts.

Economic evolution, human cultural evolution more generally, clearly differs from biological evolution in that the human and organizational actors are purposeful, they often make conscious efforts to find better ways of doing things, and their efforts to innovate are far from completely blind. I propose that when the knowledge that can be used to guide search (and problem-solving within search) is strong, it lends power to the effort in four different ways. (The following discussion follows on that of Nelson, 2000).

First, it enables the searcher to focus effectively; knowledge identifies certain potential pathways as likely dead ends, and identifies others as promising to pursue. Second, strong knowledge highlights markers that one can see if one goes down a particular path that indicate whether that path is going in a plausible broad direction or not, and also the kinds of changes in direction that seem appropriate. Third, after a new practice is developed and actually employed, the strength of knowledge affects the ability to accurately evaluate that practice in a timely fashion.

Fourth, a strong knowledge base often permits a good deal of the searching and problem-solving to proceed "offline." In so doing, it changes the nature of the exploitation versus exploration conflict that Jim March and others have highlighted, by permitting much of the latter to proceed offline, until strong evidence is accumulated that the practice being explored should be adopted. If one reflects on it, this is exactly what Research and Development is all about - offline exploration through doing theoretical calculations, constructing and testing models, and working with pilot plants or test vehicles to learn more about their properties, without a commitment to actually put the new design or practice into operation until it is well tested.

Under this perspective, evolutionary processes are very much learning processes. A certain portion of the writing in evolutionary economics recognizes this, implicitly or explicitly. Of course, from a certain point of view, biological evolutionary processes can be interpreted as learning processes in which a species learns how better to survive and prosper. But what is going on in human cultural evolution is that knowledge is accumulating in the heads of human beings. Individuals, and individual organizations, are learning to do things better, and the society as a whole is learning.

A central part of that learning is simply learning about ways of doing things that had not been thought of before, or at least not seriously explored, and about the performance of these ways of doing things. However, it is clear that in the process of learning about and how to implement new practices, like Mandeville's ship designs, what is learned transcends the details of particular practices, techniques, and designs, and a broad body of understanding thus evolves along with a body of practice. Mandeville's ship designers improve their general understanding of the principles of good ship design as they go about modifying their old designs, in most cases for the better, but occasionally for the worse.

However, while important parts of the knowledge base for search and problem solving in a field develop almost as a byproduct of actual experience, particularly over the last two centuries a large number of fields of applications oriented science have been institutionalized. Today, virtually every field of human practice, from ship designing, to the design of computers, to medical practice, to the practice of business management, has associated with it an applications-oriented field of research and training, like the engineering disciplines, or fields like pathology and bacteriology, managerial economics, and organization theory. But it is clear that some of these applications oriented sciences are much more powerful than others.

More generally, the strength of the knowledge base to guide search and problem-solving, that has been achieved both through drawing the lessons of experience, and through the development of the background applications oriented sciences, differs enormously across fields of human practice. In some areas, efforts at design and problem-solving work from a strong enough base of understanding that theoretical and empirical calculation can relatively sharply identify highly promising directions, and evidence gained through offline experimentation and testing can provide quite reliable estimates of how a particular new design, or practice, will actually work. This powerful background knowledge does not eliminate the need for learning through actual doing and using, but it enables an enormous amount to be learned before the innovator actually has to go online, with the major commitments that that usually entails.

In other cases the knowledge base may be quite weak. Calculation and analysis of perceived alternatives may not take the venture very far, and the ability to learn through offline experimentation and testing may be highly limited. In this latter situation, about the only way to move forward is through actual trying, and learning through doing and using, and even that learning may be relatively unreliable and slow in coming. I propose that the rate of progress in the latter cases is going to be much slower than the rate of progress in the former.

I want to set this line of analysis aside for a moment and get into my second line of discussion, about the high priority of bringing organizational practice, organization form, laws and public policies, and institutions more broadly, explicitly into an evolutionary theory of economic growth. However, the connections I will draw shortly between theme 1 and theme 2 might already be obvious.

The evidence is overwhelming that it is the advance of technology that has been the basic driving force behind the increase in productivity and living standards that has been achieved

over the past two centuries. But changes in organizational practice and form, and institutional structures more broadly, also are an important part of the story. Adam Smith recognized this, in his discussion of pinmaking. There he highlighted both the invention of many different kinds of machinery, and the increasing division of labor, associated with the dramatic increases in mechanization both as cause and effect.

Albert Chandler's great studies (particularly *Scale and Scope*,1990) were focused on the changes in the structure of business firms, and business practice, that were needed to take full advantage of the development toward the middle of the nineteenth century of railroad and telegraph technologies, that opened the potentiality for firms to buy inputs and sell outputs over a much wider range of space than had been customary before, and the complementary advances in capital goods technologies, which together opened up the possibilities of great economies of scale and scope. Chandler notes that these much larger firms required a larger and more sophisticated managerial team than could be recruited through tapping family and friends, which had been the custom when companies were small. The concept of "professional management" came into existence, and shortly thereafter business schools arose to train professional managers. The very large financial requirements of the modern corporation led to changes in the organization of banking, and gradually to the emergence of the modern stock market. A wide range of new law was needed to support, and control, these developments.

Samuel Beer (1959) and Peter Murmann (1993) have told a parallel story regarding the rise of the modern dyestuff industry during the last half of the nineteenth century. As with the Chandler story, advances in physical technology, in this particular case enabled by significant improvements in understanding and technique in organic chemistry, started the cascade of developments. The industrial research laboratory emerged as a structure enabling firms to hire

and effectively employ inventors with advanced training in the relevant fields of science. The rapidly growing dyestuffs industry was the source of a large and rapidly growing demand for highly trained chemists. The German university system adapted to meet these demands, helped by significant funding coming from governments.

Or consider developments in medical care over the last century. Again, the driving force has been significant improvements in scientific knowledge bearing on medicine, and the development of a wide range of chemical substances, physical devices and artifacts, and medical practice, that are effective across a wide range of diseases. These advances greatly increased the skill requirements of physicians, and led to the development of the modern medical school. Hospitals changed their nature from places where the sick and dying were, in effect, simply kept, to places where sophisticated medicine was practiced. The new medicine was also very expensive. The institution of medical insurance began to arise. And a wide variety of new government policies came into place, both to provide financial support for the practice of medicine, and also for medical research. The modern research-based pharmaceutical company, drawing scientific understanding and trained people from the universities, and selling its products on a market dominated by third-party payment, is largely a post-World War II phenomena. And so are various forms of pharmaceuticals regulation.

In each of the cases above, while the advance of physical technologies was central in the story, development also involved new modes of organization and organizational practice, and new institutions more broadly. I have told these different stories in a certain amount of detail to make persuasive my argument that economic growth needs to be understood as a process driven by the coevolution of physical and social technologies, to use the terms Sampat and I proposed.

It is fair to say that neither neoclassical nor evolutionary growth theory has taken the social technologies part of that story as seriously as it should.

Let me now link the discussion back to my earlier proposition about the significance of differences across areas of human practice in the extent to which the knowledge base permits sharp focus on promising pathways for improvement, ability to learn a lot by relatively low-cost offline experimentation, and quick reliable feedback of the efficacy of a new practice once it is put in place. Without denying significant intra-class variability, the apparent differences on average in these respects between efforts to advance physical technologies, and social technologies, are striking. Virtually all stories that I know about of significant physical invention in the twentieth century describe the calculation, the offline experimentation, the deliberate and usually reliable testing, that was involved in the efforts. In contrast, these aspects are strikingly missing from the accounts that I know about of efforts to advance social technologies, to implement a new business practice, or put in place a new public policy. Institutional learning seems to be just much more difficult than learning regarding physical technologies.

I want to turn now to the third area that I flagged. I think evolutionary growth theory needs to recognize more explicitly the multi sector nature of economic activity. This would involve, first, recognizing and incorporating inter industry differences in the pattern of growth being experienced at any time, and second, coming to grips with inter-industry coordination mechanisms. There are two building blocks I want to highlight here: the growing literature on industrial dynamics, and the new writings on Schumpeter's theory of "long waves".

I don't know if the scholars who have been contributing to the advanace ot empirical and theoretical understanding of "industrial dynamics" (for example Malerba and Orsenigo, 1997

and Malerba, 2002) would consider their work to be part of growth theory. But I would. A key characteristic of this work is that it recognizes, and attempts to explain, differences across industries. These differences have included the size of the firms who are most active in innovation, whether innovation is coming from firms in the industry or from upstream firms or both, and the links of technological advance in the industry with science. As the result of this work, we are now able to see significant differences across industries in these regards.

Also, technologies and industries change over time. Many (not all) seem to experience a more or less systematic product or technology cycle, from infancy to maturity. To some extent, cross-industry variation at any time is associated with the different levels of maturity of different industries (see for example Klepper, 1996). A problem with the industry life cycle literature, at least in its early form, was that implicitly it saw industries as having a single cycle. However, as empirical research in this area has proceeded, it has become clear that many industries experience a succession of cycles, with a particular cycle being associated with the emergence of a promising technology, and then its maturation, followed by a renaissance of activity in the industry as a new technology emerges and replaces the older one, etc. (See for example Mowery and Nelson, 1999).

My own contribution to research in this area has been to propose that an industry or technology life cycle needs to be understood as involving the evolution of social technologies, as well as physical technologies, or rather the coevolution of both. Thus, organizational forms and practice, and the supporting institutional structures, change over the course of a technology or an industry life cycle. An extremely interesting question is whether the social technologies that are fruitful in one technological era also are the ones needed to be fruitful when a new technology succeeds the old. The considerable business school literature on competence enhancing and

competence destroying technological advance is basically about this question. (For a survey and a collection of good studies see Dosi, Nelson, and Winter, 2000)

While there is little cross-referencing, the literature on technology life cycles, and the rapidly growing literature on long waves of economic activity have a lot in common. The latter literature is, of course, motivated by Schumpeter's theory put forth in his *Business Cycles*. Schumpeter's basic proposal was that economic growth in Europe and the United States had gone through a number of eras, with economic growth in each era largely driven by technological advance in a few key industries, whose effects fanned out to influence the economy as a whole. The "wave" aspect of the theory was very similar to the "life cycle" properties in the literature I have just discussed. In Schumpeter's case, a new cluster of technologies emerge, then advance rapidly, then slow down as they mature. The successive cycles phenomena in particular industries that I have described is very similar to Schumpeter's theory that growth more broadly proceeds in successive waves.

After a brief flurry of attention shortly after he put it forth, Schumpeter's long wave theory received little continuing attention, perhaps because it seemed to have nothing to do with the neoclassical growth theory that soon emerged. Nor until recently have evolutionary theorists paid much attention to it. However, largely through the work of Carlotta Perez (1983) and Christopher Freeman (particularly in Freeman and Louca, 2001), in recent years there has been a surge of writing on growth oriented by that theory, but with a new twist.

What Perez and Freeman have done is to bring institutions and institutional evolution to the picture. The argument is that the forms of business organization and practice, legal structures, government policies, institutions more generally, that facilitate progress in one era often are not the same as those that facilitated in the preceding era. And institutional innovation,

or change more generally, is difficult. Thus, the countries that led the world in one era often tend to fall back in the following era, where different countries are fortunate enough to have in place the bases for the institutions that have become appropriate, or somehow are able to create the right ones.

I find the broad outlines of this theory convincing. Thus far its development has been exclusively through the vehicle of what Winter and I have called appreciative theorizing. But the time may be coming when some more formal theorizing can help sharpen and advance conceptualization.

It should be apparent that the basic theoretical ingredients needed to model industry product cycles also are needed to model broader economic development over a long wave, or a sequence of them. There is a need to explore the sources of diminishing returns to efforts to advance technology in a field, and the factors that renew opportunities. The effects of the pace and pattern of technological change on firm and industry structure needs to be modeled. There is need to incorporate social technologies in a model, in a way that captures the ways in which social technologies and their evolution both mold and reflect developments in physical technologies.

But there also is a need to deal explicitly with the multi-sectoral nature of economic activity. Under long wave theory economic growth in any era is driven by rapid technological advance in a small number of industries. However, these rapidly advancing technolgies are affecting a large number of industries, partly through providing new inputs, partly because some industries are complements and others substitutes for the sectors where technological advance is most rapid. We need to learn to model these interactions, and their effects on relative prices, and

in turn how changes in relative prices affect the allocation of resources across different industries.

I propose that we already have built into evolutionary economic theory the heart of an analysis of the factors causing changes in relative prices over time. To a first approximation, prices move with unit costs, although perhaps with a lag. Relative prices decline in industries experiencing the most rapid productivity growth, rise in those experiencing little progress.

To proceed further down this path, of course, requires that we develop a more explicit theory of how demand is influenced by prices than that contained in contemporary evolutionary models. Such a formulation would include specification within an evolutionary theory of concepts analogous to substitutes and complements in final consumption as well as in production. I suggest that this would involve both opening up the routine concept to incorporate variations tied to prices, and more elaborate treatment of how prices influence the direction of search, along the lines Winter and I sketched in chapter 7 of our 1982 book. These adaptations, together with more detailed treatment of the response of investments to differences in profits from pursuing different paths of expansion, would take evolutionary theory a long way forward.

I want to conclude this essay by observing that a successful development of evolutionary growth theory along these lines would do much more than simply improve its ability to illuminate economic growth as we have experienced it. It would enable evolutionary theory to encompass much of the subject matter treated in neoclassical economics as aspects of "general equilibrium" theory. But it would treat the prevailing pattern of inputs, outputs, and product and factor prices as a frame in the moving picture defined by the evolutionary processes driving economic growth. In my view, this would be an enormous accomplishment.

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