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New Millennium economics evolved out of neoclassical economics over the last 100 years. The pace of change increased over time and in the first half of the 21st century, the economics profession changed as much, or more, than it did in the last half of the 20th century. The changes occurred both because of the internal tensions in the profession in the second part of the 20th century and because of technological changes that affected both the research methods of economics and the structure of higher education generally. In this paper I consider that evolution. I will organize my discussion in two sections: the first focusing on changes in the structure of economic education; the second focusing on changes in the content of what economists do.

From 2000–2050: Changes in the Structure of Graduate Economic Education

Although the number of economics graduate students expanded substantially in the 1950s and 1960s, the fundamental structure of graduate economic education did not change much at all in the second half of the 20th century. However, the structure of economic education has undergone profound changes in the 50 years since 2000.

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The Decline of Importance of Geographic Place: The Rise of the Virtual University

The first major change that occurred is external to economics: in 2000, "geographic place" was still central to education; by 2050, geographic place has become far less important; "brand" is far more important. Going to university or college used to mean going to a particular geographic place; for a few of the top colleges and universities this is still the case, but for a majority of students it no longer means that. Virtual universities, collections of scholars from around the world who have combined into an accredited program of study in a particular field, have grown enormously, and have significantly displaced many geographically-based programs.[1]

The burgeoning growth of these virtual universities has led to an increased importance of accrediting agencies; the highest level accrediting group, the International University Accreditation Association (IUAA), was created by an international consortium of universities. Many other alternative accreditation groups exist and although almost all of the 25,000 virtual universities worldwide are accredited by some agency, the IUAA is predominant. My discussion of structure deals only with the IUAA-accredited institutions. The development of these virtual universities was driven by developments in information and communications technology. Complete virtual classes, where each student is virtually recreated in an interactive classroom setting regardless of where they are, have replaced in-person classes as they were conducted even in the opening years of the 21st century.[2] Entrance into a typical university graduate program in economics now allows students a choice of 30 virtual discussion groups, 40 virtual classes, and 40 virtual seminars in economics.

With the enormous expansion of virtual universities has come a narrowing of IUAA-accredited schools, which has meant a significant shakeup in structure for graduate economics programs. Of the approximately 100 U.S. universities granting Ph.D.'s in economics in 2000, only 20 remain as IUAA-accredited stand-alone options, and even these stand-alone universities have entered into virtual partnerships that increase course options for their students. The others have merged into consortiums and the degrees they give are consortium degrees. Some of these consortiums are highly competitive; at present, three of the ten top-ranked schools in composite rankings of economic programs are consortium schools. The consortiums that developed from existing nonprofit universities still have their geographic homes where students can live if they choose, but a graduate student accepted into a "virtual university" can reside at any of the 20 or so locations that comprise the physical "university"—or can reside at none of them. Students attending these

[1] At the turn of the century most professors were only associated with one university whereas today they are associated with as many as 20 virtual universities, drawing a portion of their salary from each.

[2] The development of virtual transport in 2022, which made it almost impossible to distinguish "being there" and "virtually being there," had a devastating effect on the transportation industry and is believed by many to be an important cause of the depression of 2025.

virtual universities are generally geographic nomads, residing at two or three individual schools during their studies to work with specific mentors.

A Change in the Geographic Center of Gravity of Economics

This rise of virtual universities has meant a de-Americanization of graduate schools in general and of graduate economics programs in specific. Of course, the geographic center of the economics profession is harder to measure than it was back in 2000, since most of these foreign programs have U.S. components and, indeed, while most of the IUAA-accredited on-line universities are in large part foreign-based, all have U.S. schools in the consortium. However, the United States was clearly the center of the economic profession in 2000, and in 2050, it is far less so. In 2000, the American Economic Association was the premier economics organization in the world; today, of course, it is the International Economics Association; the AEA is one of many regional organizations. In 2050, the economics profession has three competing centers: one in Europe, one in the United States, and one in Asia. The seeds of the end of American dominance of the economics profession were sown back in the late 20th century when the student body of top economics programs became heavily dominated by foreign students. Throughout the early 21st century, the majority of these top foreign-born economists stayed in the United States. But when the Great Depression of 2025 struck, hurting the U.S. economy more than the rest of the world, geographic units of virtual universities in their countries of origin made lucrative offers to these economists to return home. As they moved back, they took top journals and reputations with them.

Increased Specialization in Economics Training

In the 1990s, "graduate work in economics" was rather unidimensional. Becoming "an economist" meant studying economics at a graduate program in economics, and the majority of graduate programs, and all the top-ranked schools, were quite homogeneous. In the first years of graduate school, in particular, everyone learned essentially the same set of models, the same approaches.

Since then, the field of economics discovered Adam Smith's division of labor and need for specialization. In 2050, the majority of consortiums granting economic-related degrees have multiple tracks. People no longer become generic economists; instead, graduates are clearly designated as specialists in public finance, health care, macro forecasting, forensic economics, industrial relations, and other areas. To be sure, graduate study in economics still starts with one semester of general core courses: one in micro, one in complex systems analysis, and one in statistics. However, these courses are not technical courses, as there were in the 1990s; they are survey courses given to acquaint students with the broad field of economics. Immediately after these courses, students begin specialized study in one, or sometimes two, areas of specialty. Each of these areas of specialties, or tracks, has its own set of required courses and knowledge.

The track that is most equivalent to the program students followed in their first two years in the 1990s is the economic theory track. This track is now a specialty track for those few going on in theory and is very small; its requirements are very

difficult; and since few jobs are available for its graduates, most of its graduates have to spend some years in low-paid postdoctoral work hoping to find one of the few theoretical research positions available.

One of the tracks is a "general economics" track, which primarily serves to prepare individuals to teach economics principles to undergraduates, which remains one of economists' most important jobs. This track primarily gives an overview of various subfields rather than going deeply into the technical aspects. General-track economists often do work in another specialty area, as well. The liberal arts research college consortium, which started granting Ph.D.'s in 2020, and has grown enormously in the last 30 years, is the primary provider of degrees in this track. Almost no graduates of other programs go on to undergraduate teaching; most go on into business and government.

Redefinition of Boundaries

This increased specialization has been accompanied by a redefinition of boundaries of graduate economics programs within institutions. In the 1990s, firm institutional boundaries existed between public policy schools, arts and sciences schools, engineering schools, business schools, law schools, and medical schools. In 2050, these boundaries have broken down. Most of the existing specialties that comprise economics evolved out of a combination of schools or programs within schools. For example, a person studying health economics now will go to a health economics program that evolved out of a combination of economics programs, medical school programs, and public policy school programs. A person studying macroeconomics will study jointly with engineering complex systems schools and an economics program. In fact, one might say that in 2050 there are no longer "economists," but, instead, health economists, statistical specialists, simulations experts who focus on economic issues, public finance specialists, and so on.

The changing of the boundaries did not come easily and involved much infighting. The evolution of the changes is worth recounting. In the closing decades of the 20th century, graduate economics programs provided the professors to teach in public policy and business schools. As those programs grew, and become more specialized and rigorous, these schools became self-replicating. They hired their own Ph.D. graduates to teach in their programs, developed their own journals, and split off from economics per se. Public policy schools in particular developed their own brand of economics which grew in importance throughout the first part of the 21st century. By about 2020 they had become the major suppliers of economists not only to their own programs but to other programs as well, as traditional graduate programs in economics shrank in size or merged into virtual universities.

With the Liberal Arts Research Consortium siphoning off many of their students who were planning to go into undergraduate teaching, the old style economic graduate programs found they had lost much of their clientele. The depression of 2025 hit the economic graduate programs hard and many were simply closed; those that continued did so by becoming subcomponents of the

larger public policy consortiums. The individual tracks in economics developed as part of this consolidation.

Changes in the Content of Economics

Let me now turn to changes in the content of economics—changes in what graduate students in economics are taught as opposed to changes in the structure of the institutions within which they are taught.

To set the stage for how economics has changed in the first half of the 21st century, it is useful to begin by thinking back to the evolution of economics in the second half of the 20th century. Twentieth century economics generally was called neoclassical economics, although the term does not do justice to the transformation of economics during that century. For example, as Robert Solow (1997) pointed out, back in the 1940s, economics was basically a descriptive, institutional subject for a "gentleman scholar."[3] The textbooks of the time were "civilized" and discursive—a melding of insights, numerical examples, and classifications. They had sensible discussion of economic policy and serious looks at recent history as it would be seen by an economist. Formal analysis was minimized. This approach made economics the domain of intuitive economists. It was a domain that some people found too hard and some found too easy. Keynes (1924) summed up the difficulty in this approach in his well-known pronouncement that economics requires a mixture of common sense and analytic ability that is quite uncommon.[4]

By 2000, the economics profession had changed fundamentally, and in the modern study of the history of economic thought we often use 2000 as the end of the neoclassical era and the beginning of the New Millennium Era.[5] Solow (1997, p. 41) defined the economics of the 1990s as "a collection of analytical tools to be applied quite directly to observable situations." The shift in emphasis from the 1940s to the 1990s did not occur suddenly; it occurred slowly over the period as older economists retired and younger ones came in. What distinguished the economics of the late 1990s was not formalism per se. While the economic models

[3] The discussion that follows is based on Robert Solow's essay. I would like to explain the referencing mechanism used in the paper (putting authors, dates and a bibliography in the paper) which I am sure looks strange. This is the referencing system typically used at the turn of the century. For all pre-2010 references, I thought it would be useful to maintain that system to give an idea of the practices then. For supporting statements on all post-2010 references, I use the Network Standard Referencing System. Simply highlight the text you are interested in and use your Inquire command to access my references, my supporting arguments, and to carry out a complete literature search in this area, with the findings prioritized by the IAB Weighting System. For similar reasons, I give an "e-mail address" at the start of this article which was a system of communication used before direct access was developed.

[4] The precise quotation from Keynes (1924, pp. 321–22) is the following: "The study of economics does not seem to require any specialized gifts of an unusually high order. Is it not, intellectually regarded, a very easy subject compared with the higher branches of philosophy and pure science? Yet good, or even competent, economists are the rarest of birds. An easy subject at which very few excel!"

[5] For a discussion of the transformation and for an early use of the term "New Millennium" economics see Colander (2000b).

of the 1990s often contained a hearty dose of mathematics, the mathematics itself was almost never deep. Moreover, relatively few economists worked on formal theory at the turn of the century. Instead, the key component of the economics in the late 1990s was "model-building." In graduate schools, students didn't learn much about actual institutions or problems; instead, they all learned the same basic set of analytic models, which they then applied directly to reality. Undergraduate teaching was somewhat different, reflecting easier models, and in the 1990s there was a significant tension between the two, with a large proportion of the graduate students having a relatively weak background in undergraduate economics. Solow attributed the spread of model-building to several factors: the problems the older discursive approach had with maintaining objectivity, the demand of policymakers for quantitative answers, and the fact that even the primitive computers of that time had produced an increased availability of data and the greater ease of analyzing that data.

New Millennium economists still use models, but they are quite different models than the deductive models of the 1990s that Solow (1997) described. Modern models are more like weather models in the late 1990s. These new models come to many of the same conclusions as the old models; economists still believe price incentives are important and that markets solve coordination problems, but that belief is not held with the almost religious conviction with which it was held in the neoclassical era.

Specifically, New Millennium economics does not base policy on the neoclassical welfare theorems, which were part of its broader "right price" view of policy. That view of policy has been replaced by our current "right institutions" view of policy.[6] This is not to say that the optimal rationing ideas found in the welfare theorems are not still used—they are. It is only to say that they are used as a subcomponent of a broader institutional policy analysis. They provide insight given institutions, not about institutions.

The Fall of Loose-Fitting Positivism and the Rise of Pragmatism

At the end of the 20th century, Solow (1997) called the methodology underlying the policy-oriented models "loose-fitting positivism." By that he meant that economists believed that they were taking models that in some sense were consistent with "standard" economic principles and "testing" the validity of those models empirically. Through the 1990s, economic researchers typically started with a set of principles: for example, utility-maximizing by consumers and profit-maximizing for firms, far-sighted individual rationality, and a belief in equilibrium, which meant that, structurally, individual's decisions in the models fit reasonably well together. These principles were probably best embodied in Debreu's *Theory of Value* (1959). During the second half of the 1900s, they first became comprehensively embedded in microeconomic models, and then, as Keynesian economics declined and New

[6] For an early discussion of New Millennium policy issues, see Brock and Colander (2000).

Classical macroeconomics became dominant in the 1980s, they spread to macroeconomics as well. By the late 20th century, these principles formed the core of economists' vision of reality, in the sense that all economic models were built on these principles, or around variations of these principles like assumptions of bounded rationality or imperfect information.[7] Thus, in the 1990s, economists saw the models that were deduced from first principles as providing a theoretical foundation for their work.

However, in the closing decades of the 20th century, it became clear that the models actually being used for policy purposes were diverging from the underlying formal general equilibrium models at their core. With some justice, the policy models became viewed as more and more ad hoc. Instead of being closely tied to underlying general equilibrium core models, policy models embodied selectively chosen empirical regularities and principles. As a result, controversy arose over how to interpret policy models. To critics, the policy models were seen as "data mining," where the analytics provided scientific cover for the desired policy conclusions of the authors, rather than objective analysis leading to reliable results.[8] One article of the time referred to empirical work of this time as a "zero-communication informational equilibrium," in which "the researcher has the motive and opportunity to present his results selectively, and the reader, knowing this, imputes a low or zero signal-to-noise ratio to the reported results" (Cooley and Leroy, 1981, p. 826).

The critics could point to some evidence for their distrust of empirical work. The editors of the *Journal of Money, Banking and Credit* found that even when they had requested the data from authors (which was almost never done at this time, because of the primitive state of computing power), they could not replicate the results of the studies (Dewald et al., 1986). Remember, this was straightforward replication, not even taking into account whether the particular ad hoc model chosen by the author was especially appropriate! McCloskey and Ziliak (1996) found that statistical inference was incorrectly used in a large majority of articles in the *American Economic Review*, the premier research journal of the period. Little wonder that in a 1997 survey of economists, 95 percent of the respondents were at least somewhat skeptical of empirical work (Mayer, 1997).

These problems led to changes in the way data analysis was conducted and reported. In 2050, economists no longer believe that a set of canonical principles will lead to a single model which is then tested in empirical work. Today, most of the simulation models that form the core of what students are taught deviate from the old-style canonical principles in some way or another. In 2050, the belief of economists in derived analytical models has given way to a belief that the underlying reality is too complex to be understood with these sorts of models.

Economists in 2050 do empirical work in a wider variety of ways than they did

[7] For a discussion of these key assumptions in the mind-set of economists in the later 1990s, see Kreps (1997).

[8] Some prominent critics in the 1980s and 1990s included Tom Mayer (1993, 1997) Donald McCloskey (1985) and Edward Leamer (1983), who captured much of this concern in their writings.

at the turn of the millennium. They both create data and analyze it. Experimental economics is now an extremely important way of creating data; interestingly, it only began in the late 20th century.[9] Economists today also use natural experiments and randomized field trials to create data much more than they did earlier. Finally, New Millennium economists tease information out of data sets with complex statistical programs that automatically report correlations under multiple specifications and undertake standard robustness tests of those correlations. Such statistical analysis is routinely done with all data sets. New Millennium economists do not believe that they are testing a particular model which was deduced from first principles; instead they are simply looking for possibly exploitable patterns in the data. The loose-fitting positivism of 50 years ago has changed to a loose-fitting pragmatism.

The Rise of Complexity Science

The movement of economists away from deductive principles was based on an evolving belief that complexity science was the appropriate domain for economics. This belief followed the rise of complexity science within the scientific community generally and the growing understanding that complex systems are not beyond scientific analysis.

New Millennium economics divides phenomena into those which are susceptible to what might be called "structural simplification," in which models with linear dynamics and unique analytic solutions are used, and those susceptible to "replicative process simplification" in which data are simplified into nonlinear dynamic models with no unique analytic solution.[10] In the 1990s, structural simplification existed as the only scientific approach. If economics was unsusceptible to structural simplification it was beyond science; not surprisingly, economics of the time followed a structural simplification program. The structural simplification research program held that simplicity was to be found in structural models. To keep those models tractable, researchers typically had to assume simple (often linear) dynamics, relatively simple structural equations, and adhere to the first principles of maximizing behavior, rationality, equilibrium, and so on.

The replicative process research program, also known as the complexity approach, follows a different pattern. Instead of beginning from certain principles and assuming linear dynamics, a wide variety of organizing principles and dynamics became conceivable. The 1990s saw the beginning of complexity science. By 2020, complexity science had developed to the point where most scientists accepted the view that the old-style research path worked well for structurally simple systems, but the complexity path was necessary for complex systems. By 2030, most economic researchers believed that the economy was a complex system that belonged within complexity science.

[9] Remember, Vernon Smith and Charles Plott did not win the Nobel Prize for their work in experimental economics until 2006.

[10] Zipf's Law and Per Bak's Scaling Law are early examples of the replicative process simplification. For a further discussion of replicative process simplifications, see Brock (2000).

Let me mention just one change that characterizes the difference in approach. In the 1990s, an active research program in economics looked for microeconomic foundations on which to build macroeconomic theories. The methodology held that if aggregate macroeconomic results were to be trusted, they had to be derived from microfoundations where were built on rationality, maximizing behavior. The acceptance that economics was a complex system ended that belief—now we believe that microfoundations are contextual and that the order we observe in complex systems arises spontaneously. Complexity science finds the temporary pattern in complex systems.

Complexity science has a less ambitious agenda than did standard science. It does not search for general results that hold for all times; instead, it searches for temporary patterns that develop spontaneously in complex systems. Equilibrium may sometimes occur, or it may not. Complex systems are always evolving and expanding with new complex patterns emerging, making all patterns of complex systems potentially temporary.

The Increase in Computational Power

The reason complexity science developed in the 1990s was the development of computer technology, which even in the clunky technology of that time (they still used keyboards!) had begun to allow meaningful analysis of more and more complex systems. The implications of this change resonated throughout economics. For example, as late as the opening decade of the 21st century, supply and demand graphs were still the central organizing feature of economics, and the workhorse of economic pedagogy. Of course, in 2050, supply and demand graphs are seldom used explicitly. Instead, the developments in computer power have allowed use of on-line dynamic simulations in which students play scenarios.

The huge drop in the relative costs of computation has also had a dramatic effect on the way in which applied and theoretical economics is done. In the 1990s, one pictured an economic policy analyst sitting with a pen and paper working with an analytic model—then going to the computer to test it. In 2050, the picture of an economist is of a person sitting at the computer doing analytic and data analysis simultaneously, relying on computer programs that take data, analyze it, and suggest eight or ten alternative models that fit it. Of course, the modern approach poses issues of its own, as discussed in the "Symposium on the Robustness of Simulation Models" in the Summer 2048 issue of this journal, but the problems are different in kind from the problems that arose a half-century ago.

It may be instructive to review how the change came about. Decreased costs of computation lowered the cost to understanding via computer brawn, and thereby reduced the relative value of the analytic deductive approach to understanding used in the 20th century.[11] Economic theory no longer needed to be built from a deep bedrock of fundamental results; instead, it could be based on computer-aided

[11] For an early discussion of this pattern, see Judd (1998).

observation and search for patterns. In the 1990s, the usual proof of a proposition in economics relied little on previously observed economic patterns and instead relied on a combination of structural assumptions and existing mathematical theorems; in New Millennium economics, "proofs" in economics rely much more heavily on empirically determined economic patterns that have developed through simulation work, experimental work, and economic modeling built on generally-accepted observed patterns. What Charles Pierce, the 19th century philosopher, called "abduction" replaced deduction.

Of course, characteristics like rationality and maximizing behavior have not disappeared from economic analysis, but their extent and direction now need to be observed, not assumed. For example, the degree of rationality, the extent of information, the consistency of beliefs over time and in the face of various situations, are all among the empirical regularities determined in behavioral economics, rather than based on assumptions. Purposeful action is still a hallmark of economic models, but what is "purposeful" is now developed endogenously, based on observations of actual behavior; again, it is not exogenously assumed. Likewise, equilibrium is a pattern that can occur and may even last for a time, but it is never assumed. Instead, it is always temporary, part of a wider "complex adaptive system" in which new patterns are constantly emerging.

Change in Theoretical and Applied Models

Let me put these changes in the content of economics into perspective by briefly considering some early harbingers of the complexity approach around the turn of the century. The first paper I want to consider is a turn-of-the-century largely theoretical paper written by Peter Howitt and Robert Clower (1999).[12] They began with a number of observations, which they translated into a set of rules. Then, they built a theoretical simulation model based on these rules, and studied the self-organizing patterns that emerged from the model. Put another way, they "grew" their economic model rather than assuming it. In their simulation model, all economic organization, including equilibrium (or the lack of it) and markets themselves, are outcomes following from the rules about transactions costs, not assumptions.

An early example of the use of complexity approach in applied economic work can be seen in the work of Quirmbach (1993), who evaluated the tradeoff between the degree of competition and the level of investment. In the standard view of the 1990s, if future competition was expected to be very intense, then the current levels of investment in R&D may be lower than socially desirable. Quirmbach computed hundreds of cases of different market structures, implying differing degrees of competition, and found a robust pattern that suggested that allowing collusion or monopoly to stimulate the appropriate level of R&D was usually a poor idea from a social welfare perspective. The interest here is not the result, but the method. His

[12] The underlying model in C+ of this paper is still kept on the web at ⟨http://www.econ.ohio state.edu/howitt⟩ as a museum piece.

result was not a "theorem" in the traditional sense of economic theory, but it was a valuable policy result, because the robustness of his findings was unsuspected.

As computational costs dropped, this pattern-search approach to policy expanded and became the dominant method of policy analysis. It substantially reduced the need for a deductive foundation and thereby played a role in the changing structure of economic graduate education discussed above. Initially, the economics profession fought the computer approach with the vehemence that Luddites of the 19th century and the linotype operators of the 20th century fought technical change in their occupations. Because of deductive economists' structural control of the profession in the early 21st century, initially this fight was highly successful, but, eventually, the new technology won and computation replaced deduction as the primary workhorse of applied and theoretical economics.

Conclusion

Robert Solow (1997) concluded his summary of the state of economics near the end of the 20th century with a paraphrase of Oscar Wilde's description of a fox hunt—"the unspeakable in pursuit of the inedible"—saying that perhaps economics was an example of "the overeducated in pursuit of the unknowable." Despite the ongoing controversies in the field of economics today, New Millennium economists are far more comfortable with what they do after the changes in the structure and content of economics over the last half century.

The better feeling about being overeducated has occurred because of the change in the structure of economics. The view that economists were overeducated followed in large part from the approach to economic training in the 1990s, in which all students went through the same extensive training—and inevitably, ended up using relatively little of it in their later professional work. New Millennium economic training is much more individually focused, with the training of students concentrating on those aspects of knowledge more relevant for their proposed field.

Rather than bounding after the unknowable, and trying to deduce analytically models that hold for all times, economics has reduced its search to what it believes is knowable. New Millennium economists search for patterns in data, try to find temporary models that fit the patterns, and study the changing nature of those patterns as institutions change.

In some ways, the economics profession has come full circle back to the more descriptive and institutional approach which was common a full century ago, in the middle of the 20th century. The underlying mathematical structure of models and computational techniques that economists use in 2050 is, of course, much more complicated, but most economists are being trained to use these tools, not to derive them. This frees the training of graduate students to focus what textbooks of the 1940s focused on—melding together insights, numerical examples, classification, and simulations to arrive at sensible discussions of policy—and allows me to

describe economists in 2050 as the "appropriately educated in search of the knowable."

■ *The title of this paper is adopted from an article by Robert Solow (Solow, 1997), a famous economist of the late 20th century. I would like to thank the editors of this journal for helpful comments on an earlier version of this paper.*

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