Creative Careers: The Life Cycles of Nobel Laureates in Economics

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Abstract

This paper studies life cycle creativity among Nobel laureate economists using citation data. We identify two distinct life cycles of scholarly creativity. Experimental innovators work inductively, accumulating knowledge from experience. Conceptual innovators work deductively, applying abstract principles. We find that conceptual innovators do their most important work earlier in their careers than experimental laureates. For instance, 75% of the most extreme conceptual laureates published their single best work in the first 10 years of their career, while none of the experimental laureates did. Thus while experience benefits experimental innovators, newness to a field benefits conceptual innovators.

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At what stage of their careers are scholars most creative? Even beyond its intellectual challenge, this question has obvious practical significance. If they do not ask it in any other context, most scholars consider it in evaluating appointments and promotions in their own departments, as they try to assess the likely future path of other scholars' research.

In view of the practical importance of the life cycle of scholarly creativity, it is surprising that it has received little systematic study, and virtually none by economists. This may be because many academics think they already understand it. Many economists, for example, appear to believe creativity is the particular domain of the young. One prominent economist, President Lawrence Summers of Harvard University, vetoed offers of tenured professorships to two 54-year-old scholars out of concern for what the university's dean of the faculty called the problem of "extinct volcanoes." In support of Summers, a 35-year-old professor of earth sciences explained that "It's more exciting to be around a place where things are going on now - not a place where people have done important things in the past." (Golden 2002).

There is a systematic relationship between age and scholarly creativity, but it is more complex than many academics appear to assume. By studying the careers of a group of Nobel laureates in economics, we will show that there are two distinct life cycles of scholarly creativity, with peaks at very different stages. The evidence furthermore reveals that which path a scholar follows is related to the nature of his work. This understanding of the life cycles of innovative economists constitutes an important step toward a theory of human creativity in general.

To the best of our knowledge, we are the first to find differences in the life cycle of scholarly creativity within a single discipline and to relate these differences to the nature of individual scholars' work. While psychologists have studied life cycle creativity, they have generally aggregated practitioners by discipline, and have considered differences across disciplines in peak ages of creativity (e.g. Lehman 1953, Chaps. 15-16; Simonton 1988, pp. 66-71). Moreover, they have attributed differences across disciplines to the nature of the disciplines themselves, not to the individuals who are active in those disciplines.

We believe it is important to recognize that there are important practitioners of both types described in this paper within most, if not all, intellectual activities; the differences the psychologists have found across disciplines in the central tendency of important contributors' peak achievements by age may be largely a consequence of differences across disciplines in the relative numbers of the two types of innovators. Viewing life cycle creativity as an individual and not a disciplinary phenomenon also suggest that there may be systematic changes over time in the mean age of peak creativity within disciplines as the relative numbers of the two types of innovators changes in response to contributions made in those disciplines.

Conceptual and Experimental Innovators

Recent research on the careers of modern painters, poets, and novelists has revealed that there have been two very different types of innovator in each of these activities. (Galenson 2001, 2003, 2004). The basic distinction between the two turns on whether the individual artist works deductively or inductively. Conceptual innovators, who are motivated by the desire to communicate specific ideas or emotions, have precise goals for their works. They often plan them carefully in advance, and execute them systematically. Their innovations appear suddenly, as a new idea produces a result quite different not only from other artists' work, but also from the artist's own previous work. In contrast, the goals of important experimental innovators are ambitious but vague, as they seek to present perceptions that are less precise. The imprecision of their goals leads them to work tentatively, by a process of trial and error. They arrive gradually and incrementally at their major contributions, often over an extended period of time.

The long periods of trial and error often required for important experimental innovations make them tend to occur late in an artist's career. So for example Paul Cézanne, Robert Frost, and Virginia Woolf all arrived at their greatest accomplishments after many years of work. Conceptual innovations are made more quickly, and can occur at any age. Yet the achievement of radical conceptual innovations depends on the ability to perceive and appreciate extreme deviations from existing conventions, and this ability tends to decline with experience, as habits of thought become more firmly established. The most important conceptual innovations consequently tend to occur early in an artist's career. Thus for example, Pablo Picasso, T. S. Eliot, and Herman Melville all made their greatest contributions early in their long lives.

The distinction between deductive and inductive innovators applies equally to economists. Conceptual economists pose precise problems, and solve them deductively. They may do this throughout their careers, but their most general - and consequently most important - innovations tend to come early in their careers, when they are more likely to challenge basic tenets of the discipline that are widely treated as rules by more experienced scholars. In contrast, experimental economists may pose broader questions, which they solve inductively by accumulating evidence that serves as the basis for new generalizations. The more evidence they can analyze, the more powerful their generalizations, so the most important experimental innovations are often the product of long periods of research.

This paper extends the study of the life cycle of creativity to a select group of innovative economists. Based on the analysis presented above the hypothesis to be tested is that economists who have made important conceptual innovations should tend to make their most important contributions earlier in their careers than their counterparts who have made experimental innovations.

Data

We measure the importance of work using citations. Citations were collected from the Web of Science, an on-line database comprising the Social Science Citation Index, the Science Citation Index, and the Arts and Humanities Citation Index.[1]

We collected the number of citations to all works in each year of each laureate's career made between 1980 and 1999.[2] These data on citations to the works each laureate published in each year of his career are our units of analysis. For purpose of the empirical analysis, laureates are included in our sample from the time they received their doctorate or from the time of their first cited publication if it preceded their doctorate or if they never earned a doctorate. Citations measure influence.[3]

The importance of scholars depends primarily on their most important contributions. We use two methods to identify the years in which the laureates made

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[1] We searched for citations under each Nobel laureate's last name and initials. For laureates who published with their middle initial, we searched for citations with and without the middle initial. To exclude citations to other authors with the same last name and initials, citations were checked against publication lists. The database lists coauthored papers under the lead author's name. Citations to the Modigliani-Miller papers were included in the counts for both laureates.

[2] Collecting citations to individual works would have been prohibitively costly given the number of published works and the number of citations. In virtually all years with high citations, a single work dominates the citations. Citations to important books were assigned to the year the first edition was published. Works published around 1980 will receive more citations than those published earlier or later. The dates will also reflect any publication lags. There is no reason that these factors will bias our estimates toward early peaks for conceptual laureates and late peaks for experimental laureates.

important contributions. One method is to identify all years in which citations are above a threshold. To do this, we first estimate the mean and standard deviation of each laureate's annual citations. We define years in which a laureate's citations were 2 of his standard deviations above his mean to be his important years. To estimate the year in which each laureate made his single most important contribution, we also consider the single year with the most citations for each laureate. We refer to this year as the laureate's single best year.

There is considerable variation in the total number of citations the laureates received. We do not use citations to make inter-personal comparisons, only to determine when each laureate did his most important work.

Classification of the Laureates

Our theory distinguishes experimental from conceptual innovators. Experimental innovators work inductively. Their innovations derive from knowledge accumulated with experience. Because empirical research frequently involves generalizing from a body of evidence, empirical innovators are often, but not always, experimental. An example of a conceptual empiricist would be someone whose primary contribution was testing hypotheses formulated *a priori*.

Conceptual innovators work deductively. Their innovations derive primarily from *a priori* logic and are often direct responses to existing work. Theorists tend to be conceptual. The most abstract theorists tend to be highly conceptual.

An innovator whose work is literary does not inherently belong to one approach or the other. As with innovators using mathematics or statistics, a literary innovator whose primary contribution arises from generalization from accumulated evidence is experimental. A literary innovator whose primary contribution involves deductive reasoning, perhaps illustrated with examples, is conceptual.

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[3] On citations as a measure of scientific importance, see Simonton 1988, pp. 84-85.

Some econometricians make empirical contributions as well as contributions to econometric theory. How these laureates are classified depends, in part, on whether their most important contribution is empirical, which tends to be experimental, or in econometric theory, which tends to be conceptual.

While our distinction between experimental and conceptual work is different from the distinction between theoretical and empirical work, we are not aware of any systematic classification of the laureates even as theoretical or empirical.[4] Thus, any categorization we use will involve difficult judgments. We have classified the laureates based on our understanding of the nature of their primary contribution.

This procedure ensures that the laureates are classified in accordance with the conceptual-experimental distinction we propose. Any judgment-based classification is open to some questions. In some of our analyses, we employ an instrumental variables strategy, in which we instrument for our classification with objective characteristics of the laureates' single most important contribution. In this procedure, we only use the component of our classification that is predicted by objective characteristics of the laureates' work.

While the scholars vary continuously in their approaches, for empirical analysis it is useful to categorize the laureates into discrete groups. Initially, the laureates are simply divided into two groups – experimental and conceptual. Later, the conceptual group is further separated into extreme conceptual and moderate conceptual groups.

It is easiest to classify the people at the extremes of the distribution. Recognizing this, we have chosen to be conservative in classifying the laureates into the experimental category here and into the extreme conceptual category below. In this way, the experimental group, and later the extreme conceptual group, will contain the laureates

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[4] The Nobel Commission, for instance, does not systematically indicate whether the prizes were awarded for empirical or theoretical contributions.

whose approach is most clear.

While discussing the classification of each individual in our sample would be prohibitive, some discussion of individuals will clarify the factors we considered in classifying the Nobel laureates and the experimental-conceptual distinction. In the rare case of Gerard Debreu, a scholarly analysis of his work is available. Weintraub's (2002) discussion of (and with) Debreu emphasizes the conceptual nature of Debreu's work.

In a number of cases, it was possible to classify laureates based on explicit statements in their major works. For instance, Paul Samuelson begins his *Foundations of Economic Analysis* of 1947 by stating,

> *The existence of analogies between central features of various theories implies the existence of a general theory which underlies the particular theories and unifies them with respect to these central features....* It is the purpose of the pages that follow to work out its implications for theoretical and applied economics (p. 3).

Trygve Haavelmo's essay "The Probability Approach to Econometrics" of 1944 is "an attempt to supply a theoretical foundation for the analysis of interrelations between economic variables (p. iii)." He justifies it stating,

> If we want to apply statistical inference to testing the hypotheses of economic theory, it *implies* such a formulation of economic theories that they represent *statistical* hypotheses, i.e., statements – perhaps very broad ones – regarding certain probability distributions. The belief that we can make use of statistical inference without this link can only be based upon a lack of precision in formulating the problems (p. iv).

Haavelmo and Samuelson both explicitly state that their contribution is to provide a rigorous, unified methodological foundation for existing work, making their work conceptual. Nor is Haavelmo's work experimental because its subject is estimation.

On the experimental side, Robert Fogel concludes his 1989 book, *Without Consent or Contract*, by discussing the evolution of his understanding of slavery over the two decades he studied it. He explains how his findings contradicted the traditional view of slavery he held when his research began stating,

> Engerman and I delayed publication of our preliminary findings for nearly two years as we investigated these possibilities and searched for new data that might reverse the computation. The results of these searches did not relieve me of the dilemma. Quite to the contrary, the new evidence further eroded my confidence in conventional views of the moral problems of slavery (p. 391).

That the accumulation of evidence, which took decades, would cause Fogel's conclusions to contradict his expectations so thoroughly indicates that he is an experimental researcher.

These laureates are classified relatively easily. We also consider a few laureates whose classification is more difficult. George Stigler's most heavily cited work is his suggestively titled "The Theory of Economic Regulation" of 1971. This paper contains a verbal theory, some empirical work, and discusses a number of examples. While empirical work is common in experimental research, Stigler's empirical analyses are tests of hypotheses derived from his theory.[5] Suggesting that Stigler's theory did not evolve from his empirical work, many of the coefficients in one of his analyses are insignificant and have the "inappropriate sign," which he dismisses writing, "The crudity of the data may be a large source of these disappointments (p. 15)." Stigler's work is conceptual, although his use of specific cases and his empirical work, indicate that his work is not the most extreme conceptual work.

Ronald Coase's two most important contributions, which have similar numbers of citations, are "The Nature of the Firm" of 1937 and "The Problem of Social Cost" of 1960. Coase's work on the firm is conceptual. He writes, "The main reason why it is profitable to establish a firm would seem to be that there is a cost of using the price mechanism (p. 390)." Coase does not make this statement after detailed empirical

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[5] Friedman (1999) emphasizes that in Stigler's work, theory was primary even though his theories were empirically relevant and often tested them. He writes, "His many contributions to economic *theory* were all a byproduct of seeking to understand the real world, and nearly all lead to an attempt to provide some quantitative evidence to *test the theory* or to provide empirical counterparts to theoretical concepts [Italics added]."

analysis, but asserts it after a theoretical discussion of alternative explanations.

Coase's work on social cost arose from "The Federal Communications Commission" of 1959. Both papers discuss examples, but their primary contributions are theoretical. We classify Coase as moderately conceptual. His extensive use of examples and applied subjects indicate that he is not extremely conceptual. He is not experimental in that he does not derive his theory from examples, but uses examples to illustrate his theory.

Milton Friedman's two most important works, which have similar numbers of citations, are his *Essays in Positive Economics* of 1953 and *A Monetary History of the United States, 1867-1960* of 1963 written with Anna Schwartz. The *Monetary History* is empirical, but it follows much of Friedman's work in monetary theory. This work is moderately conceptual insofar as it derives from and tests his monetary theories. In keeping with this assessment, in the "Methodology of Positive Economics," the introduction to Friedman's *Essays,* Friedman argues that positive economics involves the derivation of hypotheses for the purpose of testing. Friedman views the construction of hypotheses as a "creative act," about which he explicitly states he has little to say (p. 43), a view that is hard to reconcile with an experimental approach.

Coase, Friedman, and Stigler all also made important contributions to a wide range of problems. The variety of their contributions is a common feature of conceptual innovators, and is rare among experimental innovators.

Our data cover Nobel laureates in economics born in or before 1926 who published primarily in English.[6] Because the youngest experimental laureate was born in 1926, this cutoff ensures that both groups of laureates are from the same cohort. Our classification of the laureates is given in Table 1. Table 2 provides descriptive statistics.

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[6] Maurice Allais, Leonid Kantorovich, and Tjalling Koopmans were excluded because of language of publication.

The mean age in our sample is 55, with little difference between the experimental and conceptual laureates.

Estimates

To determine the life-cycle pattern in the importance of work for both groups of laureates, we estimate the probability that a laureate had an important year on polynomials in age interacted with whether the laureate was experimental or conceptual. Let i index laureates and t index the calendar year. Let Age_{it} denote laureate i's age in year t. $Experimental_i$ and $Conceptual_i$ denote dichotomous variables for laureate i's type. Our dependent variable, $Important\ Year_{it}$, is a dichotomous variable equal to 1 if laureate i had citations 2 of his standard deviations above his mean in year t and zero otherwise. Our specification is

$$Important\ Year_{it} = \begin{cases} 0 \text{ if } \beta_0 + \beta_1 Experimental_i \cdot Age_{it} + \beta_2 Experimental_i \cdot Age_{it}^{2} \\ \quad + \gamma_0 \cdot Conceptual_i + \gamma_1 \cdot Conceptual_i \cdot Age_{it} + \gamma_2 \cdot Conceptual_i \cdot Age_{it}^{2} + \varepsilon_{it} \leq 0 \\ 1 \text{ if } \beta_0 + \beta_1 \cdot Experimental_i \cdot Age_{it} + \beta_2 \cdot Experimental_i \cdot Age_{it}^{2} \\ \quad + \gamma_0 \cdot Conceptual_i + \gamma_1 \cdot Conceptual_i \cdot Age_{it} + \gamma_2 \cdot Conceptual_i \cdot Age_{it}^{2} + \varepsilon_{it} > 0 \end{cases}$$

Assuming that ε_{it} is normally distributed implies a probit structure. Each laureate contributes an observation for each year of his career. We employ quadratics in age because cubic terms are insignificant for both groups.

Table 3 presents the estimates. Figure 1 plots the probability of an important year implied by the model for both groups. Table 4 presents the implied peaks of the profiles.

The profiles for the experimental and conceptual laureates differ markedly. For conceptual laureates, the probability of a major work is 3.3% in the first year of the career and it reaches a peak at age 43. For experimental laureates, the probability of a major work is zero at the beginning of the career. It reaches a peak at age 61.

The F-statistic for the equality of the two profiles is 3.483 (the 95% critical value for an F-statistic with 2 and 1770 degrees of freedom is 3). The profile of the experimental laureates peaks 17.9 years later than the conceptual laureates. The t-statistic for the equality of the peaks is 4.299. Thus, we find that the conceptual laureates tend to have their important years considerably earlier in their careers than the experimental laureates.

Finer Categorization

As indicated, the true distinction between the conceptual and experimental approaches is not qualitative, but quantitative. Although we believe the binary division made above is useful, it is also possible to recognize a finer range of categories, based on the degree of reliance by scholars on deduction or induction. Developing a full scale is an ambitious project, beyond the scope of the present study. The limited number of experimental scholars in the present sample furthermore makes more detailed empirical analysis of this group impractical. Yet we can take a first step toward understanding the impact of differences among conceptual scholars in the extent of reliance on deduction, by dividing our sample to see whether there are further differences in life cycles that are associated with the degree of abstraction used by these scholars in arriving at their principal contributions.

A division of the conceptual laureates is presented in Table 5. This categorization is tentative, for it necessarily involves more difficult decisions in categorizing individual scholars. Yet we believe that there is a difference between the two groups in the degree of abstraction typically used in their major achievements, and that the extreme conceptual scholars typically worked at a higher level of generality than those we have categorized as moderate conceptual scholars.

As indicated, we have been conservative in allocating laureates to the extreme conceptual category. Consequently, some of the laureates in the moderate conceptual category might be classified into the extreme conceptual group or the experimental group. Within the moderate conceptual group, those laureates whose work is relatively experimental tend to exhibit life-cycles that are more similar to the experimental laureates. Similarly, the life-cycles of the most conceptual of the moderate conceptual laureates tend to be more similar to the extreme conceptual laureates.

We estimate the mean age at which the laureates in each group had important years. The mean age of important years provides less information about the relationship between age and creativity than the probit analysis, but estimating the mean age of important years is less demanding on the data, which is valuable given the finer categorization.

Table 6 shows that the important years of the extreme conceptual laureates occurred when they were an average of 42.6 years old. The moderate conceptual laureates' important years occurred when they were an average of 47.9 years old, 5.3 years later than the extreme conceptual laureates. The experimental laureates' important years occurred 12.7 years later in their careers, when they were an average of 60.6 years old. The differences between the successive groups shown in table 6 are statistically significant. The extreme conceptual laureates thus tend to have their important years earlier in their careers than the moderate conceptual laureates, who in turn tend to have their important years earlier than the experimental laureates.

The most important conceptual innovations arise from challenges to basic principles, and are likely to occur early in the career, before routine thought patterns have been established. By this logic, the more radical, and the more abstract, the conceptual innovation, the earlier in a career it is likely to occur.

We hypothesize that the gap between the extreme conceptual laureates and the moderate conceptual laureates will be particularly pronounced for the most important contributions. We therefore test for differences across the groups in the mean age of the single best years.

Table 7 reports the mean age of the single best years for the laureates in each group. The extreme conceptual laureates' single best years occurred on average at the age of 35.8. The moderate conceptual laureates' single best years occurred 8.9 years later, at an average age of 44.7. The experimental laureates in turn had their single best years 11.3 years later in their careers than the moderate conceptual laureates, at an average age of 56. The differences between the successive groups are statistically significant. As expected, the difference in timing between the extreme and moderate conceptual groups is particularly large for the single best years.

We also hypothesize that there will be a difference in the mean age of the single best years and the important years other than the single best for the extreme conceptual laureates. Our prediction is that the most important contributions of the most abstract scholars will tend to occur earlier in their careers than their other significant achievements. To test this hypothesis, we estimate the mean age of the single best years and of important years other than the single best year for the three groups of laureates.

Table 8 tests for differences within each of the three groups of scholars in the timing of the single best years and of the important years other than the single best. It shows that among the extreme conceptual laureates the single best years came on average 11.3 years before the important years other than the single best, with the difference statistically significant. The differences for the other two groups are smaller and are not statistically significant.

Instrumental Variables Estimates

As indicated, classifying the laureates based on our understanding of their work ensures that our classification fully reflects the conceptual-experimental distinction, but any judgment-based classification can be questioned. We have obtained objective characteristics of each of the laureates' single most cited work.[7] The characteristics used

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[7] We examined 19 pages from each laureates' single most cited work. When the work contained 20 or more pages, we sampled 19 pages evenly spaced through the work – pages 5%, 10%, 15% and so forth.

and the means for the three groups of laureates are reported in table 9.

Experimental work relies on direct inference from facts. The two characteristics that measure use of facts with the least processing are references to specific items – places, time periods, and industries or commodities – and tables reporting raw data. Both of these rise in prevalence from the extreme conceptual laureates to the moderate conceptual and experimental laureates.

Conceptual work involves deriving results from assumptions made *a priori*. One variable measures assumptions, assumptions, equations, and proofs. Another is the presence of a mathematical appendix or introduction. Both are most common among the extreme conceptual laureates and less common among the moderate conceptual laureates and the experimental laureates.

Moderate conceptual work originates from *a priori* analysis, but has greater empirical relevance. Two features tend to distinguish the work of the moderate conceptual laureates. First, like the experimental laureates, the moderate conceptual laureates' work frequently contains empirical analysis. Unlike the experimental laureates, their work relies less heavily on unprocessed data and more heavily on statistical analysis. In table 9, a variable for the use of statistical methods is greatest among the moderate conceptual laureates. Second, the work of the moderate conceptual laureates often combines theoretical and empirical analyses. In their theoretical work, the moderate conceptual laureates tend to rely less heavily on proofs than the extreme conceptual laureates and more on other formal methods, including equations, diagrams, and tables. We construct an interaction between the use of all empirical methods (specific references, tables of raw data, and statistical methods) and non-proof mathematical methods. As

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When a page was blank or partially blank, we used the following page or, if that was partially or completely blank, the preceding page. Complete pages of references were replaced by the last page that was not in the references section. Appendix pages and pages of notes were included. When a laureates' single most cited work was a collection of essays, the second most cited work was used.

shown in table 9, this variable is highest among the moderate conceptual laureates.

We use these objective characteristics to instrument for our classification of the laureates. Our estimates are identified by the component of our classification that can be predicted based on objective characteristics of the laureates' work. We generally anticipate a concave relationship between the objective characteristics of the works and the probability of being in any given category – the first specific reference, for instance, provides more information that someone is experimental than does the thirty first. To account for this tendency, we take the square root of each of the variables.[8]

Our specification is,

$$Age_{ij} = \beta_1 Moderate\,Conceptual\,or Experimental_i + \beta_2 Experimental_i + \varepsilon_{ij},$$

where Age_{ij} gives the age at which laureate *i* published important work *j*; $Moderate\,Conceptual\,or\,Experimental_i$ gives a dummy variable equal to 1 if the laureate fell into either of these categories; and $Experimental_i$ gives a dummy variable equal to 1 if the laureate was experimental. The advantage of this specification is that the difference between the successive categories is given by the coefficients β_1 and β_2.

The first stage regressions are in Table 10. The dependent variable in the first column is $Moderate\,Conceptual\,or\,Experimental_i$. There is a concave relationship between this variable and the use of assumptions, equations, and proofs, which peaks at 25.78, and then declines. The interaction between all empirical methods and non-proof, mathematical methods is positively associated with $Moderate\,Conceptual\,or\,Experimental_i$. The second column reports estimates where

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[8] A linear assumptions, equations, and proofs variable is included because the difference in the presence of assumptions, equations, and proofs between the three categories is particularly large and because both linear and square root terms proved statistically significant. The non-proof, mathematical methods variable was dropped because it proved statistically insignificant.

$Experimental_i$ is the dependent variable. This variable is positively associated with the use of specific references and data tables. It is also increasing in the use of assumptions, equations, and proofs, which presumably arises because of collinearity. It is negatively related to the use of statistical methods, mathematical appendices and the interaction between all empirical methods and non-proof mathematical methods. The R^2 statistics for the first stage regressions are .492 and .691 respectively. Both first stage regressions are highly significant.

The top panel of Table 11 reports second stage estimates of the differences between the three groups and the mean ages of important works. The bottom panel reports analogous estimates for the mean ages of the single best years. Although the instrumental variables are less precise than the non-instrumental variables estimates, the point estimates are remarkably similar. Given the similarity of the two sets of results, we do not employ instrumental variables in the remaining analyses.

First 10 Years of the Career

For each group of laureates, we also construct the fraction of important years for the laureates in that group that fall within the first 10 years of their careers. As shown in Table 12, 45% of the important years for the extreme conceptual laureates occurred within the first 10 years of their careers. By contrast, only 19% of the moderate conceptual laureates' important years were in the first 10 years of their careers. The χ^2 statistic indicates that the difference between the extreme conceptual laureates and the moderate conceptual laureates is statistically significant. No experimental laureate had an important year in the first ten years of his career. Thus, Table 12 shows that the extreme conceptual laureates tend to have their important years earlier in their careers than the moderate conceptual laureates.

Table 12 furthermore shows that 75% of the extreme conceptual laureates had their single best year within the first ten years of their careers. In contrast, only 17% of the moderate conceptual laureates had their single best year during that stage of their careers. The χ^2 statistic indicates that this difference is statistically significant. As predicted, the difference between the extreme and moderate conceptual groups is larger for the single best year than for the important years. While the extreme conceptual laureates are 2.4 times more likely than the moderate conceptual laureates to have an important year in the first 10 years of their career, they are 4.4 times more likely to have their single best year in the first 10 years of their career.

Finally, for each group of laureates table 13 compares the probability that the single most important year is in the first 10 years of the career to the probability that the important years other than the single best year are in the first 10 years of the career. For the extreme conceptual laureates, the single best year is three times as likely to occur in the first 10 years of the career than the important years other than the single best year, with the difference statistically significant. There are no significant differences in the probability that the single best year and the important years other than the single best fall in the first 10 years of the career for the moderate conceptual or experimental laureates.

Our analysis shows marked differences in creativity over the lifecycle. Among the important innovators in economics in our sample, those whose work was conceptual tended to do their important work earlier in their careers than those whose work was experimental. A similar pattern emerges when we distinguish degrees of abstractness among the conceptual innovators in our sample – the conceptual laureates whose work was more abstract tended to do their most important work earlier than the conceptual laureates whose work was less abstract. Moreover, the gap between the extreme conceptual laureates and the moderate conceptual laureates is greatest for their most important contributions.

Conclusion

The empirical analysis of this paper provides strong support for the proposition that there have been two very different life cycles of creativity for important scholars in economics. As in the arts, conceptual innovators in economics have tended to produce their most important contributions considerably earlier in their careers than their experimental counterparts. It appears that the ability to formulate and solve problems deductively declines earlier in the career than the ability to innovate inductively. As scholars age, they accumulate knowledge related to their fields of study, and become increasingly accustomed to particular habits of thought about their disciplines. Both of these effects may increase the creativity of inductive scholars, since the power of their generalizations will tend to be greater as the evidence on which they are based increases. As experimental scholars age their efficiency in analyzing and accumulating useful information may increase, and the empirical base for their research may consequently grow at an increasing rate over extended periods. In contrast, at a relatively early stage both the accumulation of knowledge and the establishment of fixed habits of thought may begin to reduce the ability to create radical new abstract ideations that is key to important conceptual innovations. This difference in the impact of experience on the two different types of innovator may explain why some great scholars are most creative early in their careers, and others late.

Although some academics appear to believe that creativity is exclusively associated with youth, others understand that there are two different life cycles of creativity, and that which a scholar follows is related to his approach to his discipline. When Harvard’s president vetoed job offers to two 54-year-old scholars, government professor Michael Sandel observed that “a prejudice for younger over older candidates amounts to a prejudice for mathematical and statistical approaches - such as those reflected by Mr. Summers's own economics background - over historical or philosophical approaches, where people often do their best work in their fifties, sixties or beyond." (Golden 2002)

Endnote

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Table 1. Classification of Laureates.

Conceptual			Experimental
Arrow	Hicks	Samuelson	Fogel
Buchanan	Klein	Simon	Kuznets
Coase	Leontief	Solow	Myrdal
Debreu	Lewis	Stigler	North
Friedman	Markowitz	Stone	Schultz
Frisch	Meade	Tinbergen	
Haavelmo	Miller	Tobin	
Harsanyi	Modigliani	Vickrey	
Hayek	Ohlin		

Table 2. Summary Statistics.

	Conceptual	Experimental	Combined
Age	54.2	57.4	54.7
	(17.1)	(17.2)	(17.2)
Observations	1493	278	1771

Note. Standard deviations reported in parentheses.

Table 3. Age and the Probability of an Important Year.

	Point Estimate	Standard Error
Intercept	-12.763	5.102
Experimental*Age	.378	.172
Experimental*Age^2	-.0031	.0014
Conceptual	9.649	5.151
Conceptual*Age	.0783	.0296
Conceptual*Age^2	-.0009	.0003

Note. Estimates from a probit model. Sample includes 1771 laureate-years.

Table 4. Peaks of the Age Profiles, by Type.		
	Conceptual	Experimental
Implied peak age	42.92	60.78
	(3.25)	(2.59)
Difference	17.86	
	(4.15)	

Note. Estimates based on those in table 3. Standard errors in parentheses.

Table 5. Further Classification of Conceptual Laureates.

Extreme Conceptual	Moderate Conceptual	
Arrow	Buchanan	Miller
Debreu	Coase	Modigliani
Frisch	Friedman	Ohlin
Haavelmo	Hayek	Simon
Harsanyi	Klein	Stigler
Hicks	Leontief	Stone
Samuelson	Lewis	Tinbergen
Solow	Markowitz	Tobin
	Meade	Vickrey

Table 6. Comparison of Mean Age of Important Years across Types.

	Extreme Conceptual	Moderate Conceptual	Experimental
Mean Age	42.55	47.85	60.64
(Standard Deviation)	(10.63)	(12.88)	(8.79)
Sample Size	20	48	11
Difference Across Groups		5.30	12.78
(Standard Error)		(3.02)	(3.24)

Table 7. Comparison of Mean Age of Single Best Years across Types.

	Extreme Conceptual	Moderate Conceptual	Experimental
Mean Age	35.75	44.67	56.00
(Standard Deviation)	(5.34)	(9.74)	(10.0)
Sample Size	8	18	5
Difference Across Groups		8.92	11.33
(Standard Error)		(2.97)	(5.02)

Table 8. Comparison of the Mean Age of Single Best Years and Important Years other than the Single Best Years, by Type.

	Extreme Conceptual	Moderate Conceptual	Experimental
Mean Age of Single Best Years	35.75	44.67	56.00
(Standard Deviation)	(5.34)	(9.74)	(10.00)
Sample Size	8	18	5
Mean Age of Important Years other than the Single Best Years	47.08	49.77	64.50
(Standard Deviation)	(11.01)	(14.26)	(5.92)
Sample Size	12	30	6
Difference between Mean Age of Single Best Years and Important Years other than the Single Best Year	11.33	5.10	8.50
(Standard Error)	(3.70)	(3.47)	(5.08)

Note. The data reported in the first row are from Table 7.

Table 9. Objective Characteristics of Works.

Characteristic	Description	Extreme Conceptual	Moderate Conceptual	Experimental
References to Specific Items	The sum of: • The number of pages with references to specific places • The number of pages with references to specific time periods • The number of pages with references to industries or commodities	2.250 (3.059)	14.556 (12.724)	34.200 (3.033)
Data Tables	The number of tables reporting data.	0.125 (0.354)	0.778 (1.396)	2.000 (2.550)
Assumptions, Equations, and Proofs	The sum of: • The number of pages with formal proofs • The number of pages with explicit statements of assumptions, axioms, lemmas, postulates, theorems, formal definitions • The number of pages with formal proofs	32.875 (17.324)	17.111 (22.226)	0.000 (0.000)
Mathematical Appendix	A binary variable equal to 1 if the work has a technical appendix or introduction	0.500 (0.535)	0.278 (0.461)	0.000 (0.000)
Statistical Methods	The sum of: • The number of pages with regression results • The number of pages with standard errors • The number of pages with R^2 statistics • The number of pages with explicit hypothesis tests • The number of pages with cross-tabulations • The number of figures with data.	0.625 (1.188)	2.278 (3.322)	0.400 (0.894)
Non-Proof, Mathematical Methods	The sum of: • The number of equations • The number of theoretical figures • The number of theoretical tables, including payoff matrices	30.750 (16.219)	18.444 (23.299)	0.000 (0.000)
All Empirical Methods * Non-Proof, Mathematical Methods	The sum of: • References to Specific Items • Data Tables • Statistical Methods Multiplied by Non-Proof Theoretical Methods	5.557 (5.223)	9.168 (9.743)	0.000 (0.000)

Note. Standard deviations in parentheses.

Table 10. First Stage Equations.

	Moderate Conceptual or Experimental	Experimental
References to Specific Items (Square Root)	0.067	0.199
	(0.049)	(.031)
Data Tables (Square Root)	-0.094	0.107
	(0.071)	(0.044)
Assumptions, Equations, and Proofs	-0.191	0.142
(Square Root)	(0.073)	(0.045)
Proofs and Equations	0.188	-.005
	(0.008)	(.005)
Mathematical Appendix	-0.166	-.315
	(0.105)	(0.066)
Statistical Methods (Square Root)	0.055	-0.118
	(0.049)	(0.030)
All Empirical Methods * Non-Proof,	0.021	-0.024
Theoretical Methods (Square Root)	(0.007)	(0.005)
R^2	0.492	0.691
F-statistic	9.84	22.63
Observations	78	78

Note. Standard errors in parentheses. The 95% critical value for an F-distribution with 7 and 70 degrees of freedom is 2.14.

Table 11. Instrumental Variables Estimates.

Important Years					
	Extreme Conceptual		Moderate Conceptual		Experimental
Difference Across Groups		6.753		13.629	
(Standard Error)		(4.749)		(5.036)	
Implied Mean Age	41.350		48.103		61.732

Single Best Years					
	Extreme Conceptual		Moderate Conceptual		Experimental
Difference Across Groups		13.102		11.587	
(Standard Error)		(6.124)		(6.210)	
Implied Mean Age	32.604		45.706		57.293

Table 12. Comparison of the Probability that Important Years and the Single Best Years occur in the First 10 Years of the Career across Types.

	Extreme Conceptual		Moderate Conceptual		Experimental
Percentage of Important Years Occurring in the First 10 Years of the Career	45%		19%		0%
Sample Size	20		48		11
$\chi^2(1)$ for Equality Across Types		4.99		2.43	
Percentage of Single Best Years Occurring in the First 10 Years of the Career	75%		17%		0%
Sample Size	8		18		5
$\chi^2(1)$ for Equality Across Types		7.44		.96	

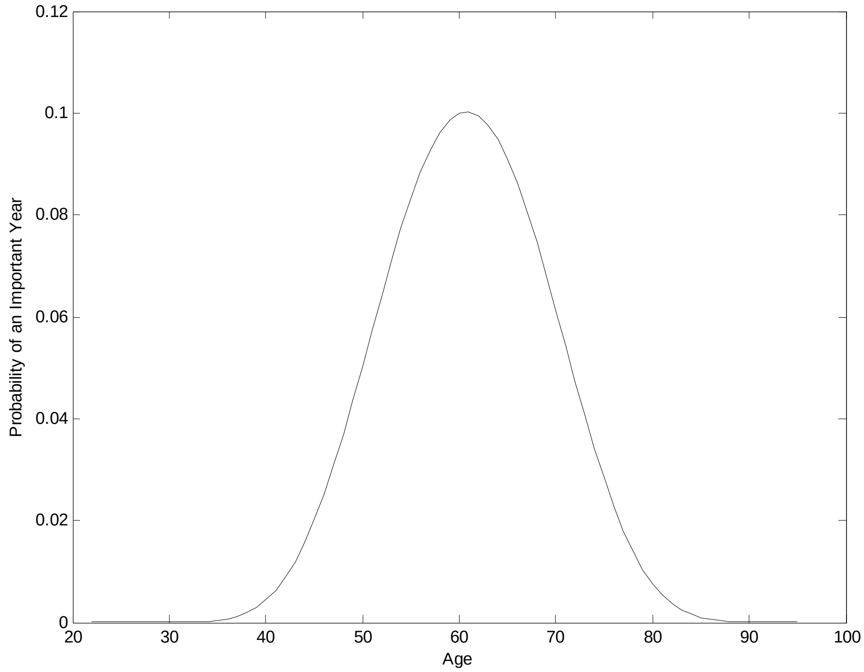
Note. The 95% critical value for a $\chi^2(1)$ is 3.84.

Table 13. Comparison of the Probability that the Single Best Years and the Important Years other than the Single Best Years occur in the First 10 Years of the Career, by Type.

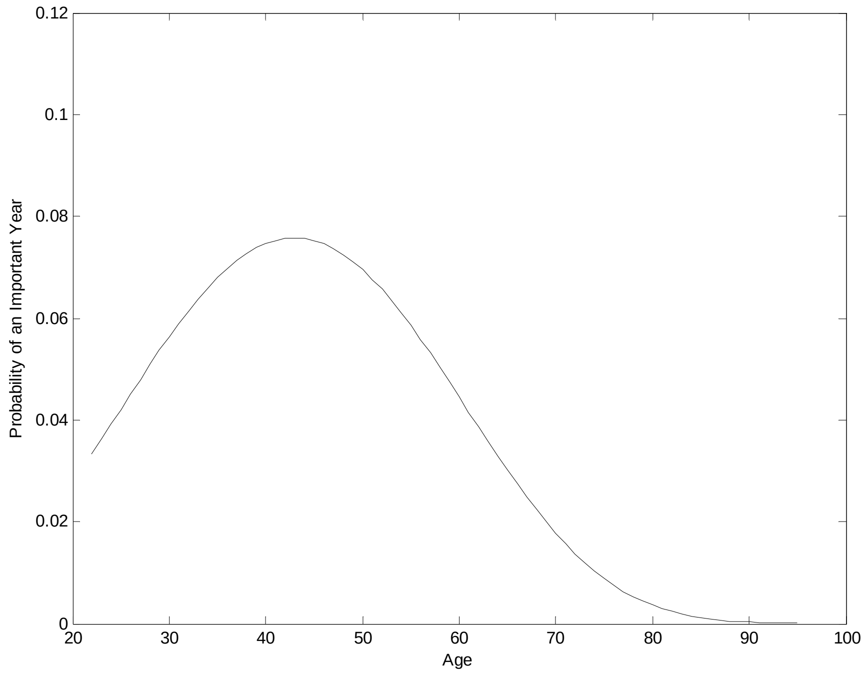
	Extreme Conceptual	Moderate Conceptual	Experimental
Percentage of Single Best Years Occurring in the First 10 Years of the Career	75%	17%	0%
Sample Size	8	18	5
Percentage of Important Years other than the Single Best Years Occurring in the First 10 Years of the Career	25%	20%	0%
Sample Size	12	30	6
$\chi^2(1)$ for Equality of the Probability that the Single Best Years and Important Years other than the Single Best Years occur in the First 10 Years of the Career	4.85	.082	0

Note. The 95% critical value for a $\chi^2(1)$ is 3.84. The data reported in the first row are from Table 12.

Figure 1. Age and the Probability of an Important Year, by Type.
a. Experimental



b. Conceptual



Note. Curves give the probabilities predicted from the probit models in table 3.