Technology and Investment, 2026, 17(2), 150-155
https://www.scirp.org/journal/ti
ISSN Online: 2150-4067
ISSN Print: 2150-4059

Human Capital and the Nature of Humans: Epochal Turning Points over the Neurological Life Span?

Frank Peter Stafford

University of Michigan, Ann Arbor, USA
Email: fpsannarbor@gmail.com

How to cite this paper: Stafford, F. P. (2026). Human Capital and the Nature of Humans: Epochal Turning Points over the Neurological Life Span? *Technology and Investment, 17,* 150-155.
https://doi.org/10.4236/ti.2026.172010

Received: March 17, 2026
Accepted: April 14, 2026
Published: April 17, 2026

Abstract

Labor economists have been active students of the life cycle of market work and non-market time (such as training, and other non-market time—such as leisure, retirement and housework). This life cycle research has been studied for decades both theoretically and empirically. Theoretical work and empirical relationships and literally thousands of papers using this empirical estimation approach with both cross sectional and panel data are remarkably robust. The theoretical and empirical results align in important ways with recent work in neuroscience as discussed below.

Keywords

Human Capital, Life Course, Neuroscience Epochs

1. Introduction

A recent paper in Nature (Mousley et al., 2025) develops a conceptual and empirical study around the theme of topological[1] turning points across the human lifespan or epochs, defined as distinct age-specific phases of cognitive function. The work supports the theme of turning points defining 5 Epochs with childhood and youth up to age 32, and age 32 - 66 as Epoch 3, with a rather protracted duration of 34 years up to age 66, as "adulthood," with downward movement at older ages in the study (up to age 90).

The research aligns with the economic theory (Becker, 1964; Ben-Porath, 1967; Heckman, 1974; Blinder & Weiss, 1976; Ryder, Stafford, & Stephan, 1976; Shaw, 1989) and robust evidence on the topic of human capital (Mincer, 1964; Card,

[1]Stable or continuous in form within a phase as with boundaries in a phase diagram.

1999). Is this a conceptual analogy, a shared dynamic structure, or a causal link between neurological change and human capital profiles? Perhaps some of each. Both approaches are motivated to study distinct life phases as a way to frame a range of topics, such as what induces normal life course behavior as a baseline and how do interceding events lead to more favorable or less favorable outcomes. The economic approach presumes underlying optimization.

The neuroscience view could possibly be seen as nature acting as if there is some main pattern shaped by a form of optimizing. Both approaches of suggest an element of early investment, giving a longer time to realize the benefits. Both show the decline induced in a finite time setting. Both have human evolution as a setting, and both appear to feature potential distinct departures from a smooth baseline path—consistent with the theory of a catastrophe sets found in dynamic models. While the term "catastrophe" suggests a form of error, this may be a form of natural experiment in the process of evolution.

The empirical pattern in neuroscience generally aligns with the framework in life cycle studies of early development and life course activity. Many empirical studies in social science are framed by age ranges that are similar to those in the neuroscience paper[2]. There is early childhood development age 0 - 12 (compared to age 0 - 9), 12 - 18 – later childhood and 18 - 25 or transition to adulthood (compared to age 10 - 32), longer mid years of 30 - 60 (compared to 32 - 66), retirement age 60 - 80 (compared to 66 - 83), and age older than 80 (compared to age older than 83).

Notably, there is reported support in their work and that of others which indicates an inverted "U" shape and blending which "intersects with other developmental and aging milestones". The protracted Epoch 3, at least in a simple way, aligns with basic data descriptions often referred to as "prime age workers" age 25 - 54[3]. The inverted "U" appears in both theoretical and empirical work. While there are basic recurring patters both types of studies, there can be disruptive factors such as macroeconomic conditions (Oreopoulos, von Wachter, & Heisz, 2012), health shocks (Wagstaff, 2005), or institutional and cultural factors such as occupational exclusion (Bergmann, 1986; Goldin, 1990; Johnson & Stafford, 1998; Anaya, Stafford & Zamaro, 2022). The cross-disciplinary perspective can add to the human capital interpretations.

2. Conceptual Framework

In theoretical work, the earnings models used are commonly based on the Pontryagin Maximum principle (PM) (Athans & Falb, 1965). The basic model is solved for an extremal and a companion phase diagram. The early PM phase is devoted primarily to non-market activity of learning and of training[4] and "lei-

[2]In the Panel Study of Income Dynamics there is a special module, the Child Development Supplement, capturing non-market learning and time use https://simba.isr.umich.edu/ Related conceptual work has been developed by Inhelder and Piaget, 1958.

[3]The age interval used is partly the result of the mixture of training and work that occurs at ages 19 – 25.

[4]Including possible and important on the job training which is well documented empirically and which seems subject to market disturbances, for example, from AI and a prior history of IT. (information technology).

sure"[5] and moves quite quicky to a phase where the behavior persists near a potential steady state. To meet the endpoint or transversality condition the training in late life slows or stops entirely and can be followed by a span of non-market retirement time and living on prior earnings.

The model has several features and issues. First, an extremal is a necessary but not a sufficient condition for a maximal path, and there may be other extremals that authors may have missed. Conditions which induce a protracted training period are referred to as a production of human capital bias where accumulated human capital has a greater role in producing added human capital with a stronger inverted U or production of human capital period (Stephan 1976).

On the other side of neutral, there are "market bias" conditions where the accumulation of added human capital is more shaped by time allocation to training time, including on-the-job training. The by then accumulated marketable skills increase the opportunity cost of training compared to a previous phase of less acquired human capital. This can induce an earlier shift into market time and away from training time and is referred to as the market bias case. This will make some difference in the duration of a phase or "epoch" of human capital.

A more extreme PM "watershed" condition is shown in Ryder, Stafford and Stephan paper (Figure 9a). There can be a catastrophe set[6] in which an apparently minor perturbation along a smooth topological path may induce a distinctly different shape to the path (Thom, 1984)—such as from one with a substantial human capital "inverted U" peak to a rather flat profile with more non-market time and less market time throughout[7]. The paper in Nature suggests possible DNA tangling as measured by and related disruptions and suggests some of this can connect to the onset of mental health concerns.

3. Empirical Connections

The paper in Nature has an extensive set of references to early human development[8], and is based on a life course sample—much as is the research conducted on human capital. Notably, the sample was of 4216 adults across the full life span and was focused on measuring turning points to characterize cognitive function. In contrast, the theory of human capital was motivated initially by simple descriptive patterns—which suggested an underlying model based on optimizing and an underlying objective function of maximum utility over a finite time horizon.

[5]A term which is a catch all for a wide set of activities which produce direct non-market goods and services or utility benefits rather than being an intermediary to work or human capital formation.

[6]The theory of a catastrophe set was developed by Reně Thom. The set is defined by a boundary at which a stable equilibrium path changes abruptly or disappears. Closely related is topological tangling where an apparent smooth path or transition becomes disrupted.

[7]The idea of dynamic processes in economics has diverse perspectives. Alfred Marshall emphasized a smooth or evolutionary process with his phrase "nature non facit saltum". In contrast, at a granular level, Joseph Schumpeter emphasized "creative destruction".

[8]Consider Piaget's theory of stages of cognitive development.

Framed by human capital theory, a wide range of life course studies emerged (Inhelder & Piaget, 1958). Many have been based on the Panel Study of Income Dynamics (Duncan & Brooks-Gunn 1997) and confirm the importance of the home environment at early ages for lifetime income and well-being. Another illustration is of the life cycle of scholarly research productivity (Stephan, 1996). In terms of methodology shared with the social sciences, the Nature paper references networks and graph theory, which have been used in the study of social networks in social psychology, notably (Harary 1967). A central feature in the modern world manufacturing economy is machine vision, such as from developments at Machine Vision International (MVI), Incorporated of Ann Arbor, Michigan (Chen & Stafford, 1986). Their system was dependent on morphology and topology-based software to control industrial robots and assess product quality.

4. Conclusion

As if by serendipitous coincidence, there are surprising parallels, both theoretical and empirical, between the theory of lifetime human capital and the neuroscience of brain function over the life course. The theory of human capital has been shaped by the use of the Pontryagin Maximum Principle. Neuroscience of the brain function epochs has relied on structural topology to capture the cognitive trajectories over the life span. Both approaches indicate a baseline case of a rather stationary mid-life plateau of a substantial duration. In the human capital model this is defined by a finite horizon setting with a middle period near a potential steady state with movement to a shorter epoch and movement to an endpoint condition.

Even in what can look to be a rather simple optimizing model in human capital can, despite a well-behaved phase diagram, exhibit catastrophe set results. In this case small displacements can induce dramatic shifts to a distinctly different path or paths. Notably, from one of extended training, longer duration work, and late or no retirement being replaced by a simpler life course with less work and training, more non-market time and early retirement. This heuristic result may apply to other dynamic models—even when a phase diagram for the main pattern seems well-behaved. An implication is that dynamic models can serve to indicate some elements of instability at transition points and greater complexity induced by deflections such as economic shocks or labor market exclusion.

Acknowledgements

I thank Paula E. Stephan, David E. Card and John A. Laitner for remarks on an earlier exploration of the topics. Thanks for valuable suggestions which were provided by a reviewer.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Anaya, L., Stafford, F., & Zamarro, G. (2022). Gender Gaps in Math Performance, Perceived Mathematical Ability and College STEM Education: The Role of Parental Occupation. *Education Economics, 30,* 113-128. https://doi.org/10.1080/09645292.2021.1974344

Athans, M., & Falb, P. L. (1965) *Optimal Control*. McGraw Hill.

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis and Special Reference to Education*. Columbia University Press. https://www.nber.org/books-and-chapters/human-capital-theoretical-and-empirical-analysis-special-reference-education-first-edition

Ben-Porath, Y. (1967). The Production of Human Capital and the Life Cycle of Earnings. *Journal of Political Economy, 75,* 352-365. https://doi.org/10.1086/259291

Bergmann, B. (1986). *Sex Segregation as the Root Cause of Women's Wage Disadvantage*. New York Basic Books.

Blinder, A. S., & Weiss, Y. (1976). Human Capital and Labor Supply: A Synthesis. *Journal of Political Economy, 84,* 449-472. https://doi.org/10.1086/260454

Card, D. (1999). The Causal Effect of Education on Earnings. In *Handbook of Labor Economics* (pp. 1801-1863). Elsevier. https://doi.org/10.1016/s1573-4463(99)03011-4

Chen, K., & Stafford, F. P. (1986). *The Employment Effects of High Technology: A Case Study of Machine Vision. Research Report Series 86-19*. National Commission for Employment Policy. https://files.eric.ed.gov/fulltext/ED328777.pdf

Duncan, G. J., & Brooks-Gunn, J. (1997). *Consequences of Growing up Poor*. Russel Sage Foundation.

Goldin, C. (1990). *Understanding the Gender Gap: An Economic History of American Women*. Oxford University Press. https://www.nber.org/books-and-chapters/understanding-gender-gap-economic-history-american-women

Harary, F. (1967). *Graph Theory*. Addison Wesley.

Heckman, J. J. (1974). Life Cycle Consumption and Labor Supply: An Explanation of the Relationship between Income and Consumption over the Life Cycle. *American Economic Review, 64,* 183-194. https://www.jstor.org/stable/1814894

Inhelder, B., & Piaget, J. (1958). The Growth of Logical Thinking from Childhood to Adolescence. Basic Books. https://doi.org/10.1037/10034-000

Johnson, G. E., & Stafford, F. P. (1998). *Alternative Approaches to Occupational Exclusion*. The Economics of the Family and Gender, Arne Ryde Foundation, University of Lund, Lund Sweden.

Mincer, J. A. (1964). *Schooling, Experience and Earnings*. Columbia University Press.

Mousley, A., Bethlehem, R. A. I., Yeh, F., & Astle, D. E. (2025). Topological Turning Points across the Human Lifespan. *Nature Communications, 16,* Article No. 10055. https://doi.org/10.1038/s41467-025-65974-8

Oreopoulos, P., von Wachter, T., & Heisz, A. (2012). The Short and Long-Term Career Effects of Graduating in a Recession. *American Economic Journal: Applied Economics, 4,* 1-29. https://doi.org/10.1257/app.4.1.1

Ryder, H. E., Stafford, F. P., & Stephan, P. E. (1976). Labor, Leisure and Training over the Life Cycle. *International Economic Review, 17,* 651-674. https://doi.org/10.2307/2525794

Shaw, K. L. (1989). Life-Cycle Labor Supply with Human Capital Accumulation. *International Economic Review, 30,* 431-456. https://doi.org/10.2307/2526656

Stephan, P. E. (1976). Human Capital Production: Life-Cycle Production with Different Learning Technologies. *Economic Inquiry, 14,* 539-557. https://doi.org/10.1111/j.1465-7295.1976.tb00441.x

Stephan, P. E. (1996). The Economics of Science. *Journal of Economic Literature, 34,* 1199-1235.

Thom, R. (1984). *Mathematical Models of Morphogenesis*. Ellis Horwood Limited.

Wagstaff, A. (2005). *The Economic Consequences of Health Shocks. World Bank Policy Research Working Papers*. https://doi.org/10.1596/1813-9450-3644