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Summary of "The industrial society's intrinsic dynamics"

Overall abstract: During the longest time of peace on their soil the real GDP and physical capital of Germany, Japan, and the USA converged into a collective evolution. Searching for causes reveals that their mean life expectancy, cost of education, and tradeoff between annual working and spare time were synchronized to this evolution since 1800. Six corresponding generic solutions reproduce all data without extrapolation and fitting parameters. They solve six invariant relations for the incomplete subsystems economics, human nature, and industrial engineering. Together they form a completely quantifiable macro-system with longevity as top demand. The solutions include optimal recoveries from the Great Depression and World War II. All reaction times are directly measured constants of the human species. Reaching its limits is the industrial society's natural goal. The generic solutions saturate accordingly. Resulting negligible to negative interest rates caused the financial and social instabilities observed after 1928 and since 2008.

First page's footnote: This contribution delivers on a promise given to Paul Samuelson as guest of honor at the graduation dinner of the Rutgers MBA class of 1971. The promise was deriving an analytically closed theory of macroeconomic growth from all available data as soon as time would permit. This time came with a series of letters exchanged between 1996 and 1999 with Robert Solow on the limits of the neoclassical paradigm. We thank also Ron Kay for his creative encouragement through the years of completing this work; our medical colleagues of the University of Luebeck for information on human genetics; and AT&T and Siemens AG for professional experience with complex systems, industrial engineering, innovation, and fiscal depreciation.

Section 1 introduces into the neoclassical paradigm of economic growth theory and Robert Solow's list of deficits including our first analytic solutions developed between 1996 and 1999.

Section 2 collects the main data for keeping the per capita leading G7 economies in operational condition: education, law and order, and saving for the technical infrastructure (physical capital). Robert Solow's exponential steady state solution is generalized for allowing increasing capital coefficients (ratio of physical capital to GDP). This allows and specifies just one family of analytic solutions named generic functions. They quantify growth by removal of two kinds of obstacles in their denominator. The first removes the technical obstacles with the effective lifetime of physical capital as constant parameter; the data show that this describes the recovery of physical capital from disasters without adjustable parameters. The second removes the individual obstacles with the effective reaction time of the educated and inherited human capacity as constant parameter; the data show that this describes the industrial society's collective evolution above all financial and martial disasters without adjustable parameter.
Both time constants are directly measureable since the generic solutions saturate with the removal of both obstacles so that they can be normalized to the same height. Then the data show these time constants with constant time shifts for all national recoveries and one constant time shift for the evolution between the storing GDPs and the nation's stored physical capital. Such time shifts are for irreversible processes the counterparts of the phase shifts observed for periodic processes between storing values and their charging flows. This decisive information was always in the data but could not be collected since the neoclassical paradigm's exponential steady state growth features unlimited exchangeability between value and time.

Section 3 replaces all approximations for quantifying production with an analytic invariant of the macro-system. The microeconomic labor variables employment or cost of work cannot be used for macroeconomic equilibrium since successful nations stabilize employment and the cost of labor buys the GDP. Fortunately the annual working time is a good macroeconomic variable for labor. It decreases smoothly from the agrarian maximum of 96 hours per week in 18th century to about 40 hours per week. The data show only short traces of disasters. Industrial engineering decided on medium term economic equilibrium by fixing the inevitable tradeoff between annual working time and the annual spare time required for enjoying G7 level affluence. From our industrial experience we knew that the professional pride of industrial engineers consists in designing the annual working time required for operating or supervising production lines irreversibly and optimally according to technical progress into these lines. The data show now that about half of physical capital is designed for housing, i. e., for generally unpaid reproduction and homework with a corresponding trade-off between annual working and spare time. The other psrt of the physical capital is designed for production, but that half is not just a mathematical input factor: it organizes and amplifies annual working time in power, speed, and/or precision. Linear amplification results in the simplest possible production function when the same calendar unit of 1 p.a. is used for measuring the flow of time for the GDP and the sum of annual spare and working time. This invariant agrees with the data without adjustable parameter.
The neoclassical phenomenon of diminishing returns designed with fractional exponents into neoclassical production functions does not exist for the macro-system. The saturation of all macro-variables is caused with their natural exponent of 1 just by the inevitable and limited tradeoff between decreasing annual working time

and the increasing annual spare time required for enjoying G7 affluence. Dynamic details that were incomprehensible to date are now quantitatively understood as convergence crises in the transition from fast recoveries after disasters into the smooth industrial evolution.

Section 4 quantifies the parallelism between the industrial evolution and the average life expectancy at birth of the UK, USA, Germany, and Japan from 1800 to date with a simple analytic integral over the industrial evolution. Both are corrected for and evolve above all disasters, respectively. Since this integral represents the top demand for longevity it is the macro-system's decisive invariant. It quantifies the life insurer's complex extrapolations with a simple linear bio-economic transformation. Normalizing the mean life expectancy and the industrial evolution to the same height discloses the genetic limit to the human life expectancy already now with the constant time shift between both evolutions. This calibrates also the inflationary G7 currencies and exchange rates with the biologically stabilized life expectancy.

Section 5 collects the problems of quantifying demand for long-term equilibrium and the costs of G7 education from kindergarten to university. The latter represents capitalism's answer to socialism's orbiting the first satellite. This resulted together with industry's comparable reaction in the industrial society's largest and very successful experiment with technology push. Unfortunately it was followed by the industrial society's largest experiment with performance push after the gold standard was given up. Free monetarism enforced fast return on investments, financial skills replaced technical skills for business and administration, and the top 10 per cent's share of total income increased from 30 to over 50 per cent within the same active generation.
The educational effort allows estimating the economic value of education per capita. When this value amplifies annual spare time for creating demand for G7 affluence like physical capital amplifies annual working time for providing supply one obtains an invariant condition for long-term equilibrium. For the first time all macro-economic variables are known. Comparison with the actually needed value shows that the G7 level nations installed a large safety buffer against a liming role of education for the industrial evolution.

Section 6 explains the stability and predictability of the industrial evolution and its immunity to short-term financial and martial disasters. The differential equation for both the industrial evolution and the life expectancy documents an invariant proportionality between the current growth rate and the system's future gap to be closed. We suggest this protects the human genome from manipulation since it allows the genetic program to unfold from the first cell division to geriatric care without external supervision. Besides being the proportionality constant between current growth rate and future gap to be closed the same evolution constant appears also as initial growth rate and as reaction time to improving existential conditions (including new relevant knowledge) for both quantities. This reaction time was not measurable before 2010 but it was worth waiting since it confirmed the evolution constant's stability for centuries and the predictive power of the new theory.

Overall Conclusion: This introduction into the natural theory of the industrial society is the result of a fascinating interplay between 24 generally available data sets, a comparable number of unexpected discoveries, and finding six invariant relations between 3 incomplete subsystems. That all of them have analytic solutions is a very rare event. But in the end the data left no vacancy for another main variable or natural constant: they supplied all reaction times required for a self-consistent theory without extrapolations and fitting parameters. The discovery of the industrial society's stable evolution and the quantitative explanation of the saturation of all per capita variables are the most important results.
That human nature is the dominant subsystem is not surprising. The information stored in the human genome is priceless by economical and unbeatable by technical standards. Its replication by inheritance is programmed with the stability and predictability required for human life without external supervision. Otherwise no administration or supporting institution could have achieved the formation and defense for centuries of relatively free societies in an open world with very uneven distributions of resources and wealth.
All data show that G7 level GDPs are 2 orders of magnitude above UK's start into the industrial society and only a factor of 2 below reaching the genetic limit of the average life expectancy for the G7 population, its lifestyle, and its distribution of income and wealth. Decisive for long-term equilibrium is human nature's all-inclusive demand for longevity. The late discovery of human capacity as amplifier of spare time for generating the demand for G7 affluence is due to its concealed nature as an indestructible quantity and the fact that long-term equilibrium could not be achieved and confirmed for the leading G7 nations before 2010.
That the constructive role of the monetary subsystem is very modest is also not surprising. Money belongs with law and order to the human brain's most important inventions that are not subject to the laws of nature. The banking system had no alternative to adjusting all interest rates promptly to the observed saturation. But accepting that saturation is here to stay may take more time than is available in an open world with extremely diverging existential conditions.
In the economic perspective the discovery of the quantitative roles of industrial engineering and human nature are important spin-offs. Strong links to other disciplines multiply the opportunity for more unexpected economic discoveries. We hope this stimulates students and researchers to use this natural theory for a wider understanding of economics beyond the per capita leading nations.