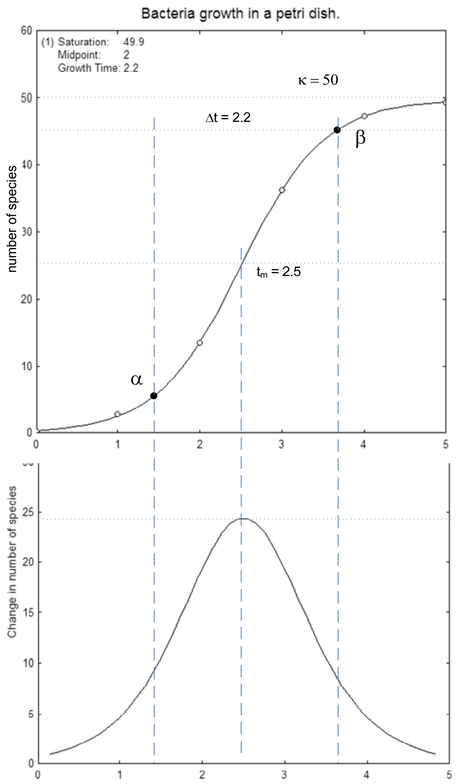
LOGISTIC S-CURVE

"... with enough parameters anything can be fit..."



$$N(t) = \frac{\kappa}{1 + e^{-\alpha t - \beta}}$$

α – growth rate parameter, time required for "trajectory" to grow from 10% to 90% of limit κ
characteristic duration (Δt);
β – parameter specifies the time (t_m) when the curve reaches 0.5κ
midpoint of the growth trajectory;
κ – is the asymptotic **limit of growth**.

Image source: www.cbsnews.com

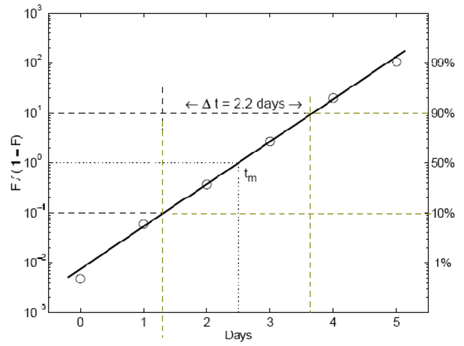
FISHER-PRY TRANSFORM

$$FP(t) = \left(\frac{F(t)}{1 - F(t)}\right)$$

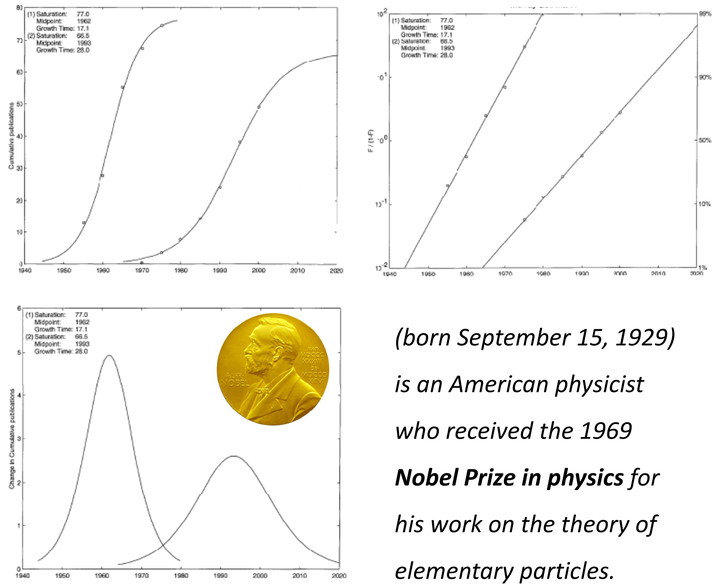
where

$$F(t) = \frac{N(t)}{\kappa}$$

Logistic growth of a bacteria colony plotted using Fisher-Pry transform that renders the logistic linear



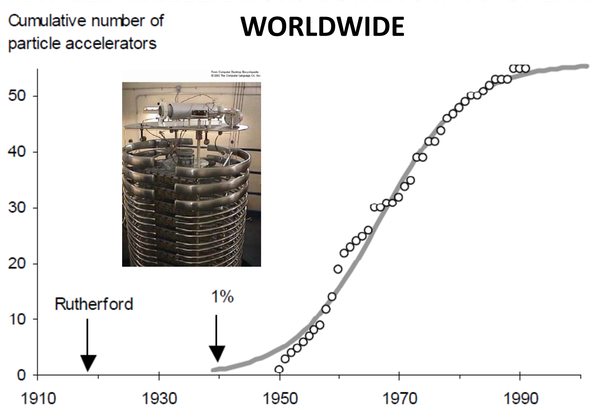
MURRAY GELL-MANN productivity versus ages*



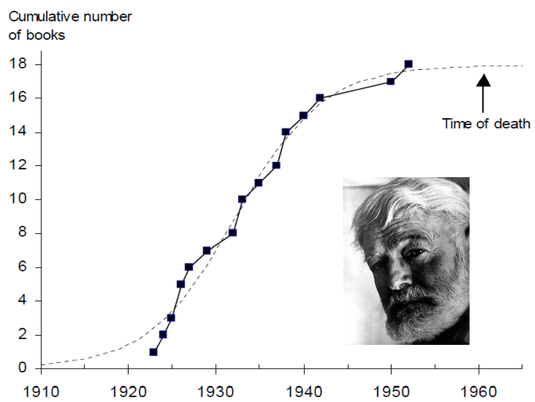
*(born September 15, 1929) is an American physicist who received the 1969 **Nobel Prize in physics** for his work on the theory of elementary particles.*

* Source: Marchetti, C. Productivity versus Age. p. 117 (International Institute for Applied Systems Analysis, Laxenburg, Austria, 2002).

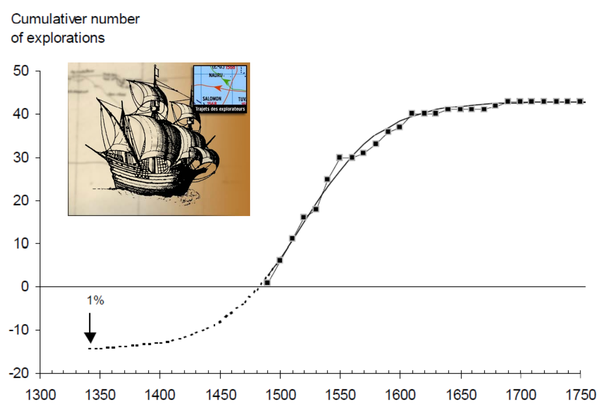
PARTICLE ACCELERATORS COMING INTO OPERATION WORLDWIDE



ERNEST HEMINGWAY (1899-1961)



WESTERN HEMISPHERE EXPLORATIONS



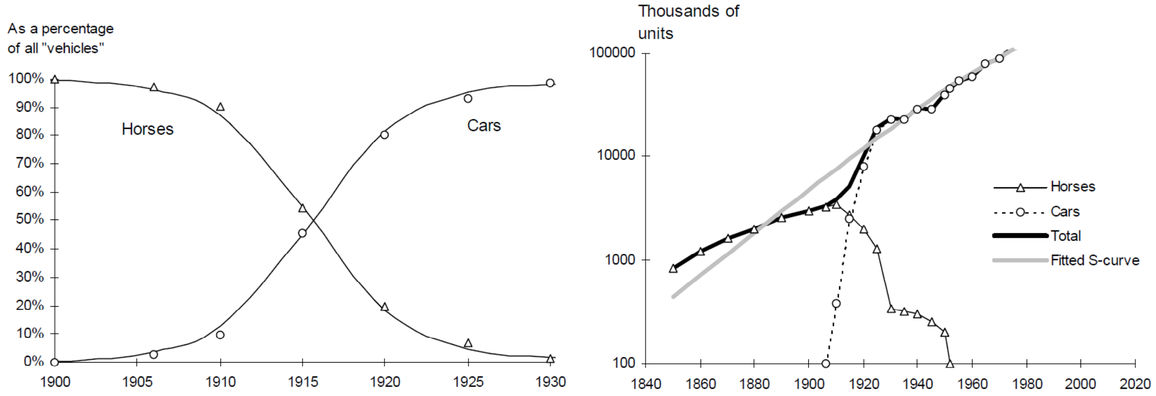
* Source: Modis, T. Predictions - 10 Years Later. (Growth Dynamics, Geneva, Switzerland, 2002), 335. ISBN 2-9700216-1-7.

TECHNOLOGICAL FORECASTING (PREDICTION OF A TECHNOLOGY CHANGE)

LOGISTIC SUBSTITUTION MODEL

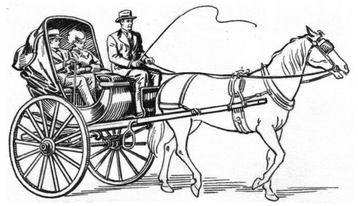
TECHNOLOGICAL FORECASTING (PREDICTION OF A TECHNOLOGY CHANGE)

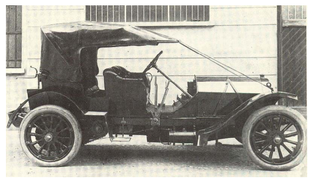
THE SUBSTITUTION OF CARS FOR HORSES IN PERSONAL TRANSPORTATION



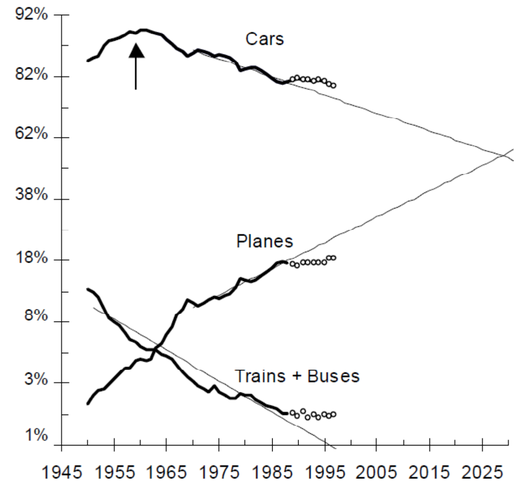
original graphs : Nebosja Nakicenovic, "The Automobile Road to Technological Change: Diffusion of the Automobile as a Process of Technological Substitution," Technological Forecasting and Social Change, vol. 29: 309–40.

* Source: Modis, T. Predictions - 10 Years Later. (Growth Dynamics, Geneva, Switzerland, 2002), 335. ISBN 2-9700216-1-7.



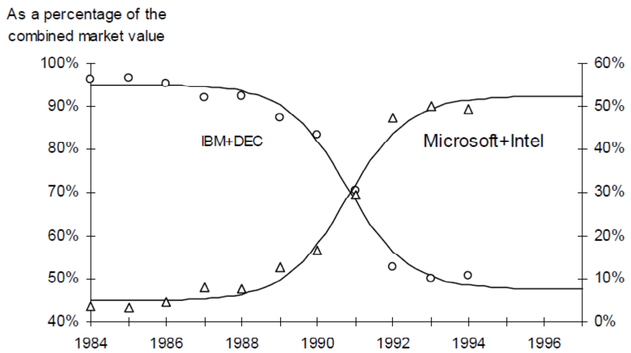


Percentage of total passenger-miles traveled (US)

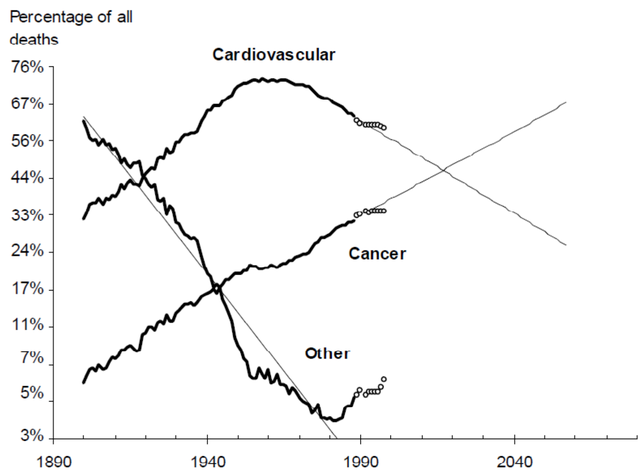


* Source: Modis, T. Predictions - 10 Years Later. pp. 201

TRANSFER OF MARKET VALUE*

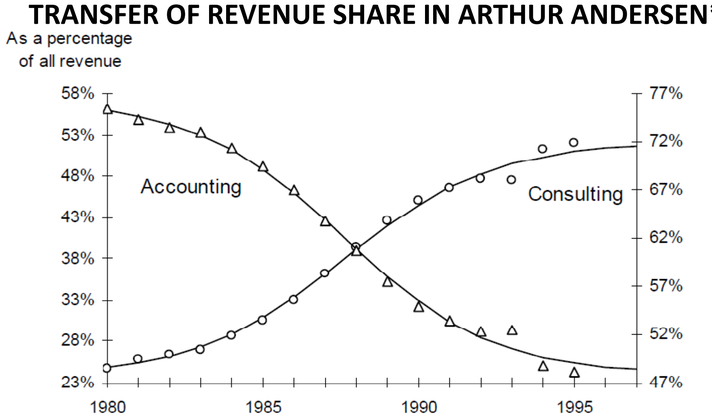


Competition between diseases (US)



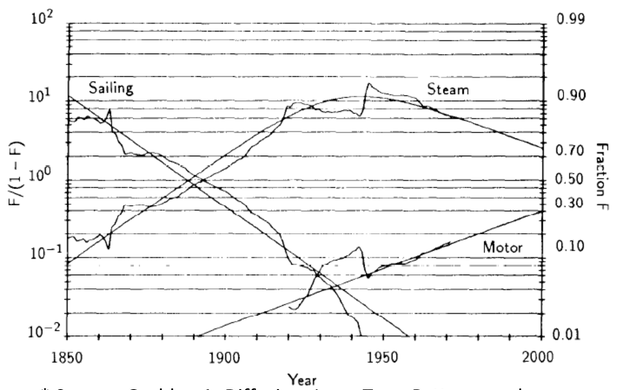
* Source: Modis, T. Predictions - 10 Years Later. pp. 309.
The data come from the Historical Statistics of the United States, Colonial Times to 1970, vols. 1 and 2, Bureau of the Census, Washington DC, and from the Statistical Abstract of the United States, U.S. Department of Commerce, Bureau of the Census.

TRANSFER OF REVENUE SHARE IN ARTHUR ANDERSEN*



* Source: Modis, T. Conquering Uncertainty - Understanding Corporate Cycles and Positioning Your Company to Survive the Changing Environment. (McGraw-Hill, New York, 1998), 204.

Successive replacement of propulsion system in merchant marine fleet of the USA



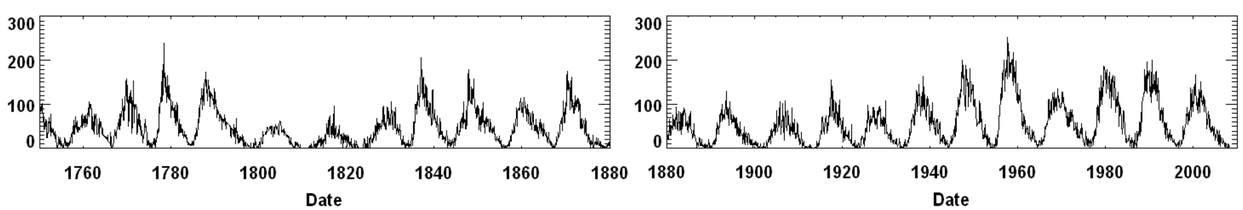
* Source: Grubler, A. Diffusion: Long-Term Patterns and Discontinuities. Technological Forecasting and Social Change, 1991, 39, 159-180.

PHYSICAL FACTORS OF THE HISTORICAL PROCESS

SCHEMATIC SUMMARY OF DATA FOR COMPLETE HISTORIOMETRICAL CYCLE*

Sun-spot activity of Sun				Social activity of the masses (people)								
Time for one cycle of sun-spot activity, years	Time for periods of a cycle, years	# of period	Relative number of sun-spots	Time for one historiometrical cycle, years	Time for period of historiometrical cycle, years	Name of period	Relative number of historical events appearance	Distribution of historical events in each cycle, %	Distribution of historical events by years in each cycle, %	Socio-psychological characteristic of the masses behaviour within each period of cycle	Comments	Historical events in scope of each period of cycle
In the arithmetical mean – 11.124 years	5.16	I	Minimum	In the arithmetical mean – 11 years	3 years (on average)	Minimum excitability period (discharge epoch)	Minimum appearance of mass social movements	5%	1.7%	Differentiation of masses; indifference to social problems; peaceful attitude of masses; compliance, tolerance, depression, statics of mass etc.	These phenomena are under development in presents of military, political or others exciting factors.	Signing of peace treaties; military campaigns are not popular; capitulations, occupations; maximum decrease of parliamentarism, reinforcing of autocracy.
		II	Number of sun-spots and their groups gradually increases		2 years (on average)	Growth of excitability	Gradual increase in numbers of mentioned movements	20%	10%	1) Appearance of social order and beginning of some collective concentration; 2) grouping of ideas and masses; 3) appearance of one dominant idea and consolidation of masses.		Uncertainty and vacillation for military and political questions; preparation to war; increase of tension for international relations; beginning of conspiracies; definition of military and political trends.
	5.96	III	Maximum		3 years (on average)	Maximum of excitability (Concentration epoch)	Maximum	60%	20%	a) pronounced effect of leaders, commanders, mass media, speakers on the masses; b) high influence of ideas circulating in masses. II. a) mass movements evolve very fast; b) high territory coverage; c) masses integration; d) individualization of collectives; e) dynamics of masses.		Promotion of leaders, commanders, and politicians; triumph of ideas supported by masses; maximum of parliamentarism; social and democratic reforms; democracy; limitation of autocracy. Revolutions, rebellions, political distempers, wars, military campaigns, expeditions, emigrations, persecutions, and other types of mass activities of humanity.
		IV	Number of sun-spots and their groups fades		3 years (on average)	Decline of excitability	Gradual decrease in numbers of mass social movements	15%	5%	Society response on irritations becomes slower and slower; degradation of the focused activity, enthusiasm, inspiration, and so on.		Collapse of military and political organizations; separatism; recession from international or state claims; dispersal or collapse for popular assembly; easy neutralization of revolts; completion of occurrence from previous period.

* Source: Tchijevsky, A., Physical factors of the historical process. 1922: Kaluga, Russia. p. 72. Translated and adopted by Kucharavy D. (2007)



* Source: http://solarscience.msfc.nasa.gov/SunspotCycle.shtml

100 000-Year Eccentricit Cycle: eccentricity or ellipticity of the Earth's orbit.

41 000-Year Tilt Cycle: "The tilt of the Earth's axis relative to the plane of its orbit varies from 21.8 to 24.48° over a regular period."

21 000-Year Precession Cycle: "The third cycle, which is superimposed on the other two, arises because the gravitational pull of the Sun and Moon on the Earth's equational bulge causes the Earth's axis of rotation to vary and the north pole to follow a circle around the axis that takes 26,000 years to complete…"

. . .

6 100-Year Heinrich Cycle: "…is associated with Heinrich events, pulses marked by the expulsion of large numbers of icebergs from the ice caps surrounding the North Atlantic and rapid melting of adjacent continental ice"

1,450-Year Cycle: "…is associated with rapid and dramatic changes in climate over periods of years to decades…"

2,300-Year "Little Ice Age" Cycle: the solar wind magnetic field has fluctuation period…

~211-Year Suess Cycle: "…prolonged episodes of sunspot minima that reappear in clusters along the ~2,300-year period…"

88-Year Gleissberg Period: …due to variations in solar output that result from tidal forces of the planets operating on the sun…

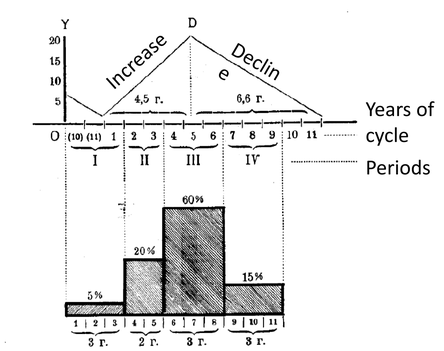
~11-Year Schwabe Sunspot cycles: …varies in length from 8.5 to 14 years between minima, and from 7.3 to 17 years between maxima over time spans of ~88 years, averaging ~11 years… During a sunspot cycle, solar luminosity varies systematically by about 0.1% and the energy reaching the Earth by ±0.04%...

~22-Year Hale Sunspot Cycles encompasses two successive Schwabe cycles, varying in accordance with the lengths of its positive and negative halves… a magnetic process that amplifies the impact of solar variability on the weather…

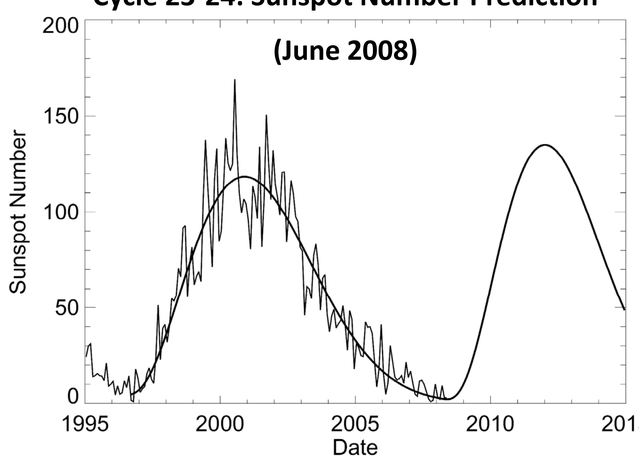
18.61-Year lunisolar cycle: Sun, Moon, and Earth interaction; …tidal accelerations also modify the precession of the Earth's equinoxes by a process called nutation.

55.83-Year cycle: …three periods (18.61-year) for the longitude to be repeated and the eclipse to occur at the same location, a time span the Greeks termed the exeligmos period.

* Source: Berry, B.J.L. A Pacemaker for the Long Wave Technological Forecasting and Social Change, 2000, 63(1), 1-23.

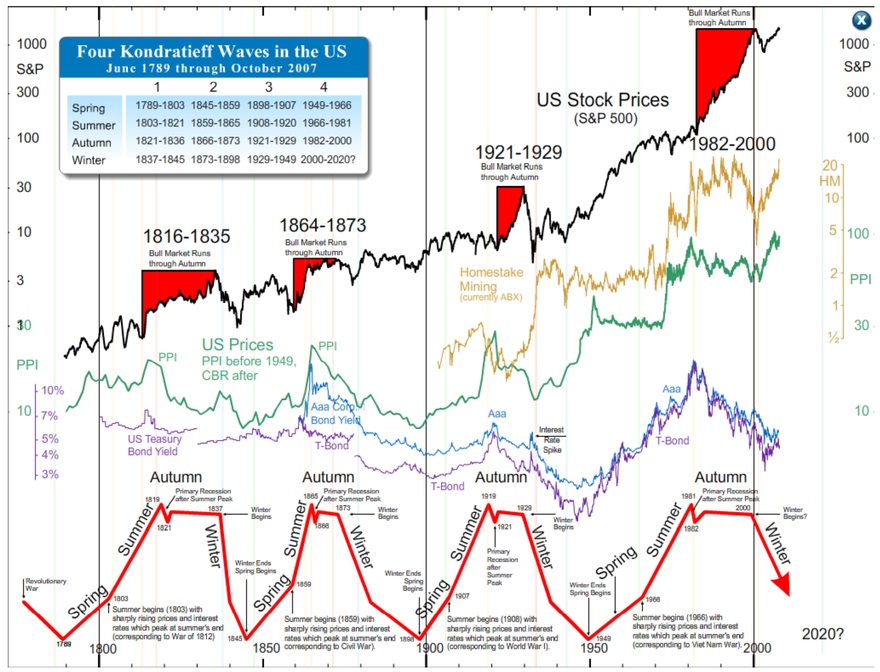


Percentage of historical events to years and period of cycle. Average conclusion for 500 years data.(Fifteenth – Twentieth Century)



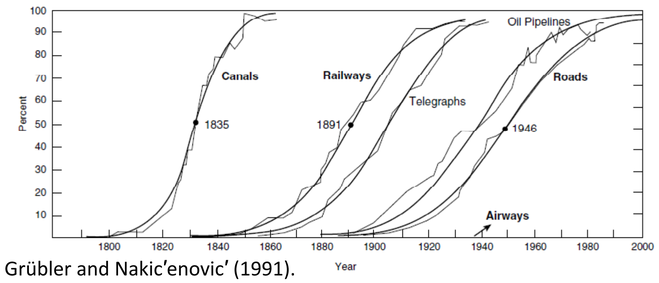
TECHNOLOGICAL FORECASTING (PREDICTION OF A TECHNOLOGY CHANGE)

LONG WAVES AND CYCLES



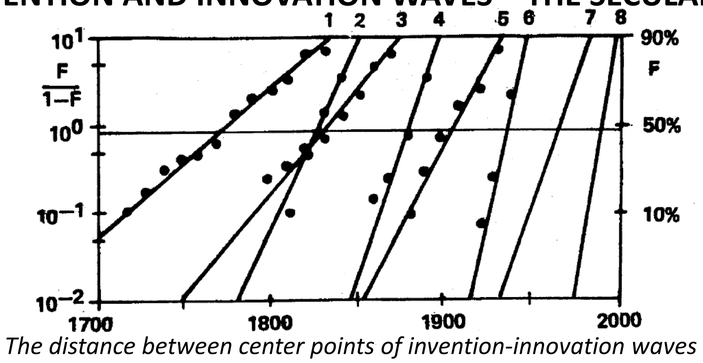
* Source: http://www.thelongwaveanalyst.ca/cycle.html

Growth of infrastructures in the US as a percentage of their maximum network size



Source: Grübler and Nakic'enovic' (1991).
Grubler, A. Time for a Change: On the Patterns of Diffusion of Innovation. in Technological Trajectories and the Human Environment. 1997. Washington, DC: National Academy Press.

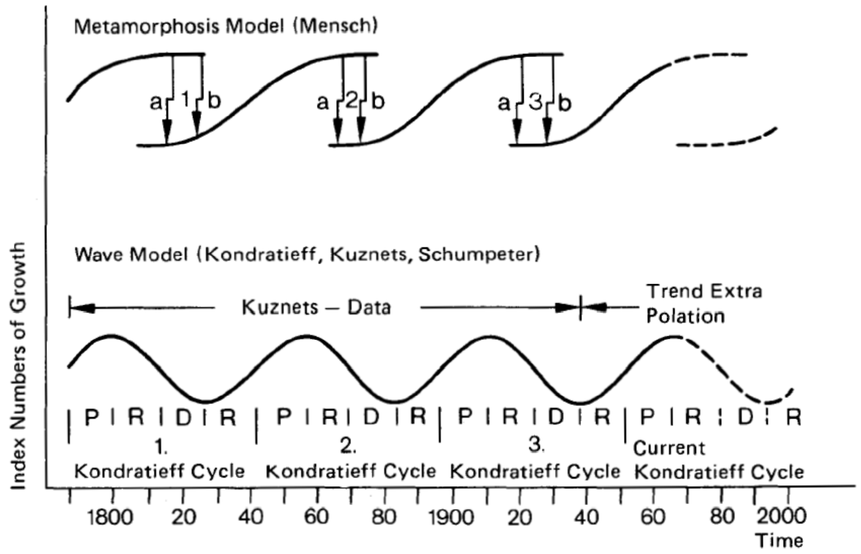
INVENTION AND INNOVATION WAVES – THE SECULAR SET



The distance between center points of invention-innovation waves (1-2; 3-4; 5-6; 7-8) is always 55 years, one Kondratiev cycle.

* Source: Marchetti, C. A Forecasting Model for Research and Innovation Activities in Selected Areas: A Support for Strategic Choices. (1991)

THE METAMORPHOSIS MODEL OF INDUSTRIAL EVOLUTION



[P] – prosperity; [R] – recession; [D] – depression; [R] - recovery

* Source: Mensch, G. Stalemate in Technology: Innovations Overcome the Depression (Ballinger Pub Co, Cambridge, Massachusetts, **1978**), 241. ISBN 088410611X.

Theoretical Explanations for Long Waves in Socioeconomic Development (1939 - 2000)

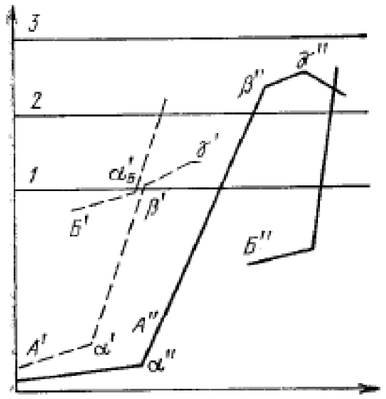
Model/ Theory name	Innovation Waves	Profit Cycle	Commodity Price Movements	Capital Lifespan	Metamorphosis Model	Evolutionary World Politics	Long-term Patterns of Soc. Behav.	Mass Psychology Phenomena	Climatic Cycles	Materials-substituting Technology	Growth Cycles	Cosmic Heartbeat	Koedrative Cycles/ Structure	Historical Generation	Historical-Societal Generation	Chemistry of Social Interactions	Geophysical Pacemaker
Author References	Schumpeter (13)	Mandel (31,32)	Rostow (33,34)	Forrester (15,35)	Mensch (14)	Modelski (34-37), Modelski-Thompson (38)	Marchetti (4,17,21,22)	Beckman (38)	Zaborchak and others (39,40)	Volland (41)	Berry (10,42,43)	Modis (9,23)	De Greene (44,45,46)	Dzerdzeh (47,48)	Mallman-Lamarchand (7)	Duncan (49)	Berry (50)
Origin in Paradigm	Endogenous	Endogenous	Endogenous	Endogenous	Endogenous	Endogenous-Exogenous	None	Deep Endogenous	Exogenous	Endogenous	Endogenous	Exogenous	Endogenous	Endogenous	Endogenous	Endogenous	Exogenous
Approach	Economic	Economic/ Marxist	Economic	Economic	Economic	International Political Economy	Physical/ Social	Social Psychological	Geophysical	Economic	Economic	Physical	Complex systems	Historical	Evolutional (Epigenetic)	Chemistry (rate theory)	Geophysical
Methodology	Rhetorical Empirical	Rhetorical	Rhetorical Empirical	Cybernetic-Computer Simulation	Empirical (Logistic)	Evolutionary theory, tested	Empirical Mathematical (Logistic)	Rhetorical	Empirical	Rhetorical Empirical	Empirical Nonlinear Dynamics	Empirical Mathematical (Logistic)	Rhetorical	Rhetorical	Mathematical (Logistic)	Mathematical (Logistic)	Empirical Mathematical (Eigenanalysis)
Quality/Value of Proof	Strong	None	None	Intermediate	Strong	Strong	Powerful	None	None	None	Strong	Substantiating	None	None	None	None	None
Determinant of 50-60-year periodicity	Suggested (Rise of New Men)	None offered	None offered	Lifespan of Capital Equipment	None offered	Suggested (Replacement interval)	None offered	None offered	Suggested (Ec. drought clock)	None offered	None offered	Suggested (56-year SEM configuration)	None offered	Suggested (Generation Lag)	Historical-Societal Generation	Rate constant of social interactions	18.6 years lunisolar cycle
Order/ Control Parameter	Innovations Clusters	Rates of profit	Time lag of commodity prices	Capital Intensity	Basic innovations bursts	Generational period	Learning Society	Human Behavior	Sunspot Activity Solar System Dynamics	Technology in terms of materials substitution	Infrastructure Kuznets cycles	Solar System Dynamics	Macro-psychological phases	Generational movements	Socio-motivational concerns	Social interaction time	Entrainment of geophysical cycles
Date	1939	1975-1980	1975-1978	1976-1977	1979	1978-1983 1996	1980-1983	1983	1983-1988	1987	1991-1993	1992	1993-1994	1995	1998	1999	2000

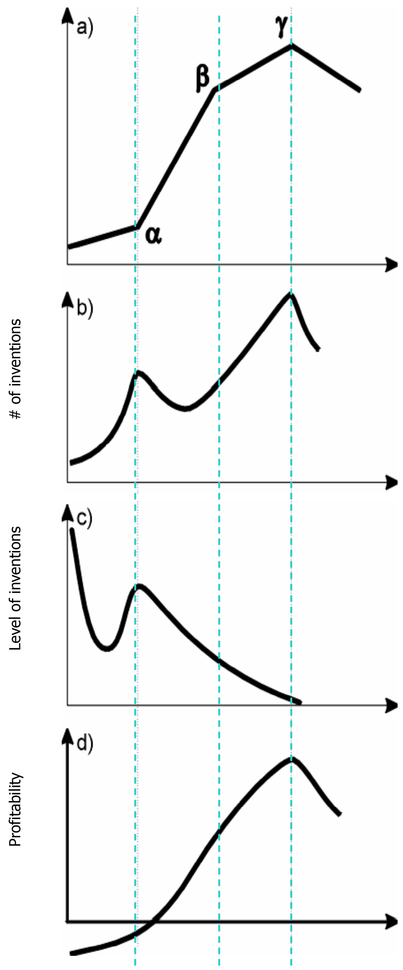
Source: Devezas, T.C. and Corredine, J.T. The biological determinants of long-wave behavior in socioeconomic growth and development. Technological Forecasting and Social Change, 2001, 68(1), 1-57.

TECHNOLOGICAL FORECASTING (PREDICTION OF A TECHNOLOGY CHANGE)

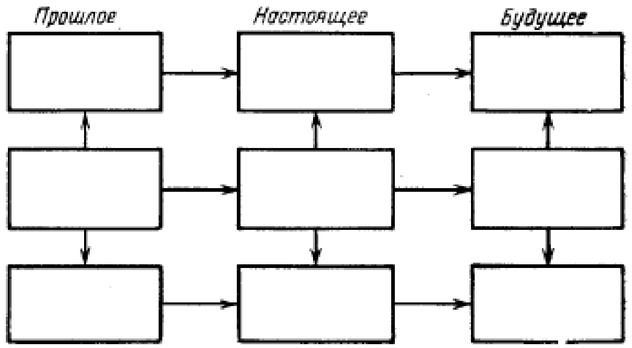
TRIZ-INSTRUMENTS

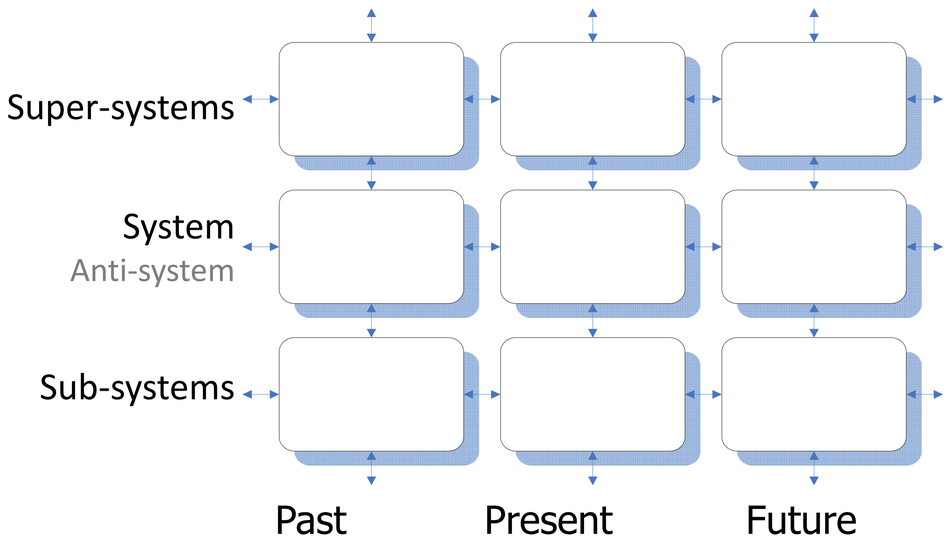
G. Altshuller (April 18, 1975):
S-curve of system evolution





G. Altshuller (1979):
System operator or
Multi-screen scheme of advanced thinking





G. Altshuller (1977-1979):
System of laws of technological system evolution

1. law of System Completeness
2. law of Energy Conductivity in systems
3. law of Harmonization
4. Law of Increasing Ideality
5. law of Irregularity of the Evolution of a System's Parts
6. law of Transition to the Super-system
7. law of Transition from Macro- to Micro-level
8. law of Increasing Substance-Field Interactions
9. law of Dynamics Growth (added in 1985)

TRIZ-INSTRUMENTS

Altshuller G.S., Zlotin B.L., and Philatov V.I. (1985)*:

Ways for increasing rate of Ideality (patterns)

1. Towards *differentiation*: special-purpose engineering systems with better efficiency for particular purpose (customization).
2. Towards *versatility*: many-purpose system perform many functions.
3. New deployment of existing properties and parts of system.
4. Transition to *self-adjusting* systems: many-purpose specially adjusted system. Towards adaptability for effective operation.
5. Towards increasing *harmonization* of system and external changes without changing working principle.
6. *Transition to super-system* when no other ways.
7. Transition *from macro- to micro-level* when no other ways.
8. Increasing system completeness towards *pushing out human* as a part of system.

G.S. Altshuller:

Science-fiction and Advanced Imagination

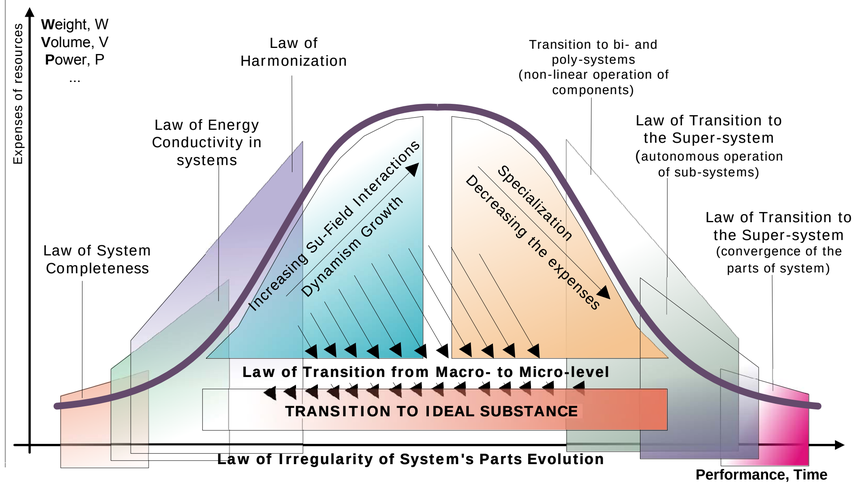
1. 1964-1997
   Register of contemporary ideas from science-fiction literature
   [http://www.altshuller.ru/rtv/sf-register.asp in Russian]
   - 11 classes,
   - more than 1000 typescript pages.
2. Methods and techniques to design and develop science-fiction ideas
   - **'Four levels' scheme**,
   - '**Fantogramma**' (1971);
3. **Scale Fantasy-2** (mid of 80's) is a technique to measure science-fiction ideas (metrics).
4. Analysis of science-fiction ideas from literature as support for long-term technological forecasting.

Altshuller G.S., Zlotin, B.L., Zusman, A.V. and Philatov, V.I. (1989)*:

1. Basic principles of technological forecasting based on TRIZ.
2. Forecasting procedure
   4 stages; 26 steps:
   1. express forecast;
   2. preparation to forecast;
   3. forecasting using laws of technical systems evolution;
   4. aggregate forecast.
3. *22 lines* of evolutions the engineering systems were presented.

Salamatov Y.P (1984-1991)*:

wave model (bell-shaped running curve)



FROM INVENTION TO INNOVATION

Basic Innovations in the First Half of the Nineteen Century

NAME	INVENTION	INNOVATION	YEARS LEAD TIME
High voltage generator	1820	1849	29
Electro-medical stimulator	1831	1846	15
Deep sea cable	1847	1866	19
Electricity production	1708	1800	92
Insulated conductors	1744	1820	76
Arc lights	1810	1844	34
Pedal bicycle	1818	1839	21
Rolled rails	1773	1835	62
Rolled wires	1773	1820	47
Pudding furnace	1783	1824	41
Blast furnace with coke	1713	1796	83
Crucible steel	1740	1811	71
Locomotives	1769	1824	55
Telegraph	1793	1833	40
Lead chamber process	1740	1819	79
Pharmaceutical industries	1771	1827	56
Quinine industries	1790	1820	30
Hard rubber	1832	1852	20
Portland cement	1756	1824	68
Potassium chloride	1777	1831	54
Photography	1727	1838	**111**

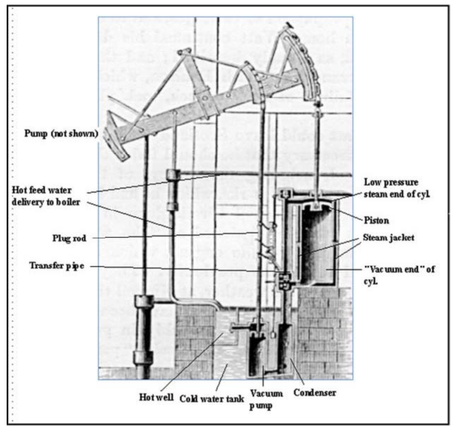
Basic Innovations :
a technical event is a technological basic innovation when the newly discovered material or newly developed technique is being put into regular production for the first time, or when an organized market for the new product is first created."

	Type of innovation (according to degree of radicalness)	Weighting (according to degree of radicalness)	Frequency (in the period 1953-1973)
1.	Basic innovation	32 to 35	7
2.	Radical innovation	28 to 31	29
3.	Very important improvement innovations	24 to 27	62
4.	Important improvement innovations	20 to 23	145
5.	Mundane improvements	16 to 19	239
6.	Minor product or process differentiation with new technology	0 to 15	760
	Range of weights	0 to 35	
	Total frequency		1242*

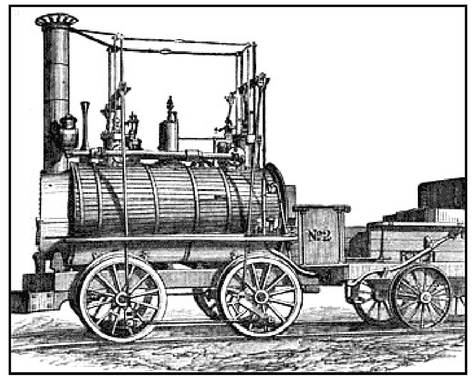
** The lower classes of innovation are increasingly underestimated in quantity*

The case of Locomotive

1769	Watt: Low pressure machine
1770	Cugnot: Steam gun vehicle
1790	Read: Steam road vehicle
1800	Watt's: Patent on steam engines expires
1801	Trevithick starts work on locomotives
1804	Evans: Road locomotive
1811	Blenkinskop: First toothed gear locomotive
1813	Hadley: Locomotive on rails
1814	Stephenson: starts work
1824	Stephenson: built first locomotive plant
1825	Stephenson: open Stockton-Darlington line

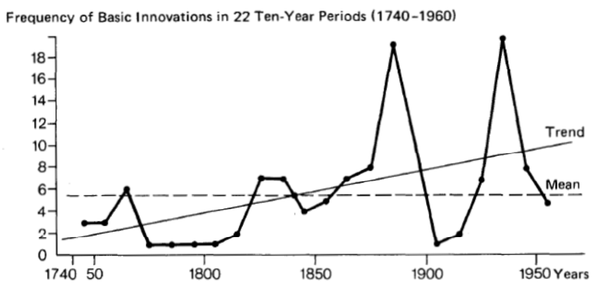


Early Watt pumping engine.

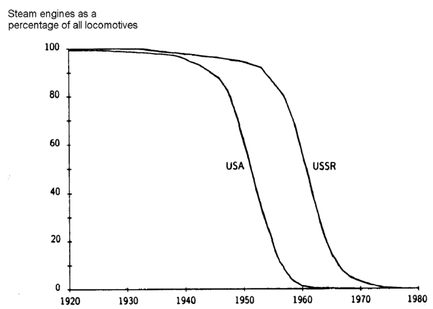


Locomotive built in 1814 by George Stephenson

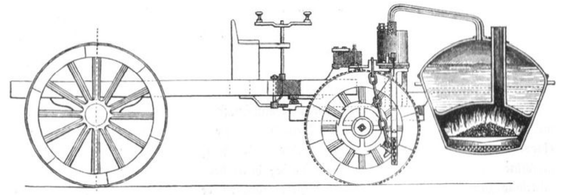
SWELLS OF BASIC INNOVATIONS



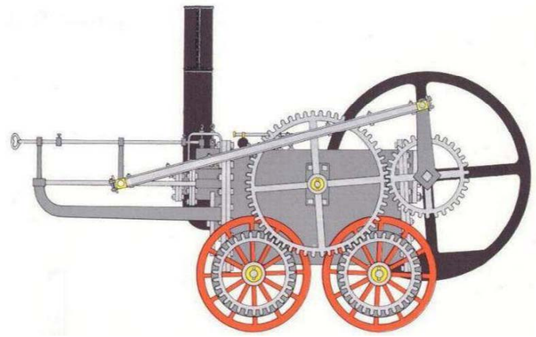
THE EXIT OF STEAM ENGINES



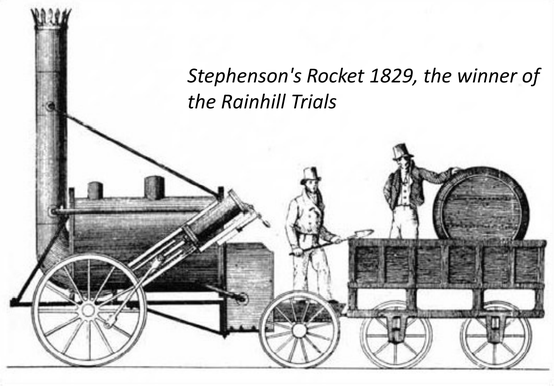
Source: Modis, T. Predictions - 10 Years Later. (Growth Dynamics, Geneva, Switzerland, 2002),



Cugnot's three-wheeled fardier à vapeur (1770)



Trevithick's locomotive, 1804 the first successful steam locomotive



The last steam locomotive to be built by British Railways: Standard Class 9F 2-10-0 no. 92220 Evening Star

Source of images: www.wikipedia.org

* Source: Mensch, G. Stalemate in Technology: Innovations Overcome the Depression (Ballinger Pub Co, Cambridge, Massachusetts, 1978), 241.

TECHNOLOGICAL FORECASTING (PREDICTION OF A TECHNOLOGY CHANGE)