INSA STRASBOURG GRADUATE SCHOOL OF SCIENCE AND TECHNOLOGY

ARCHITECTS + ENGINEERS

LOGISTIC SUBSTITUTION MODEL AND TECHNOLOGICAL FORECASTING

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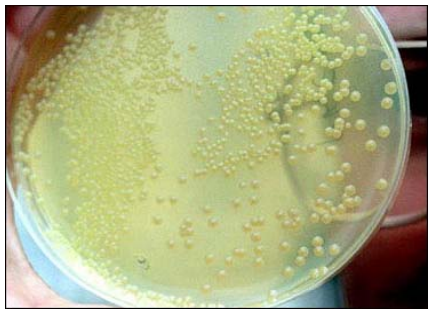
CONTENT

1. Simple logistic model
2. Technology diffusion and competitions
3. Logistic substitution model (LSM)
4. Reliability of LSM

1: simple logistic model

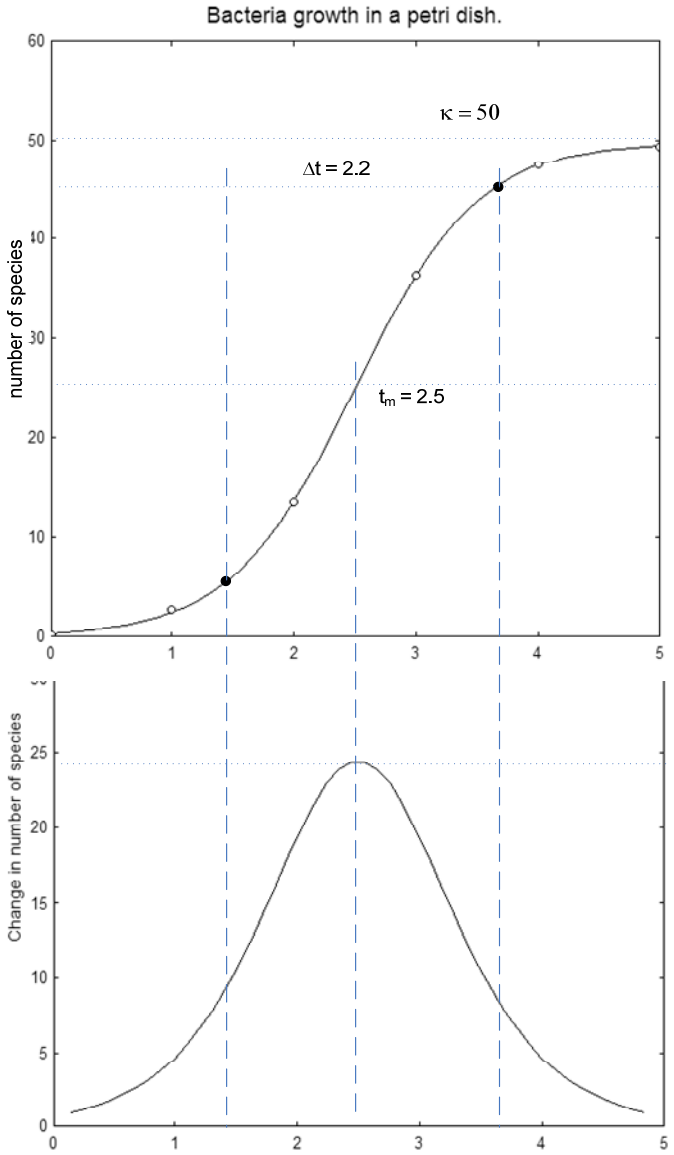
[the natural growth in competition]



•Image source: www.cbsnews.com

$$\frac{dN}{dt} = \alpha N \frac{(\kappa - N)}{\kappa}$$

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



α – growth rate parameter, time required for growth trajectory from 10% to 90% of limit *κ* **characteristic duration** (*Δt=2.2 days*);

β – parameter specifies the time (t_m) when the curve reaches 0.5*κ* **midpoint** of the growth trajectory; (*tm = 2.5 days)*

κ – is the asymptotic **limit of growth**. (*κ=50 species)*

2: Technology diffusion…

[from invention to innovation]

- is the process of obtaining (new) technology adapted through practical use;
- is the a process of transition from ***invention*** to ***innovation***.

	Invention	Adapting time	Innovation
Photography	1727	112	1838
Steam locomotive	1769	55	1824
Television	1907	26	1936
Zipper	1891	32	1923
Incandescent light bulb	1800	79	1879

2: …and competitions

[struggling for resources]

Malthusian case: **competition for resources**			Simple S-curve
Models for **two competitors**:			
Pure	☹	☹	Lotka-Volterra model[1]
Predator-Pry	☺	☹	Lotka-Volterra model
Symbiosis (Mutualism)	☺	☺	Lotka-Volterra model[2]
Parasitic (Commensalism)	☺	😐	Logistic S-curve
Symbiotic (Amensalism)	☹	😐	Logistic S-curve
No-competition (Neutralism)	😐	😐	Simple S-curve
Models for **multiple competitors**:			
Spatial arrangement *Time arrangement*			Can be reduced to two competitors

2: Invention to innovation …and competitions

[natural selection ?]

Overwhelming majority of inventions will never become innovations thanks to the phenomena of competition and adaptation.

3: Logistic Substitution Model (LSM) #1

[problem: numerous relationships… over 50 years]

The forecasting models should

<capture and simulate numerous relationships >, in order

- to represent changes in energy market, in energy use, and in energy technology;
- to characterize the activity of an economic system;
- to imitate the feedback characteristics.

However, **the forecasting model** should
<apply minimum characteristics>, in order

- to minimize errors owing by data (e.g. synergy effect);
- to minimize inaccuracy of results due to model complexity;
- to provide a clear unambiguous interpretation of results.

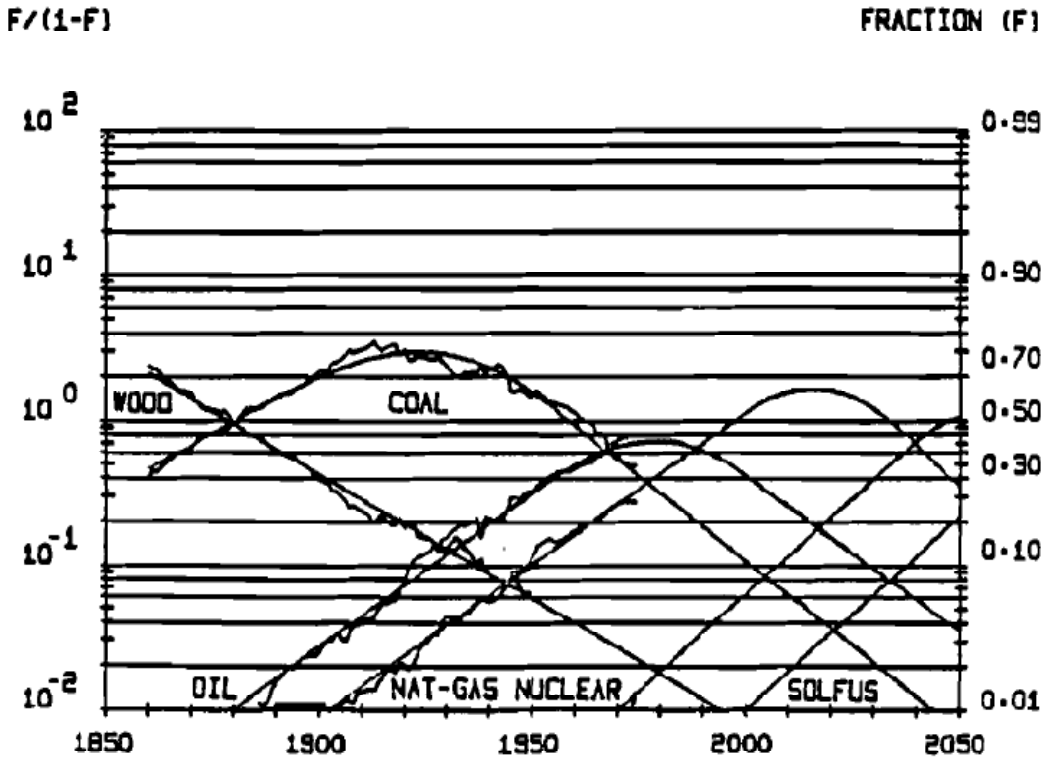
3: Logistic substitution model (LSM) #2

[competitors' niche market]

The life cycle of competitive technologies is subdivided into three periods: growth, saturation and decline, where the growth and decline stages are logistic growth processes.

Three basic assumptions:

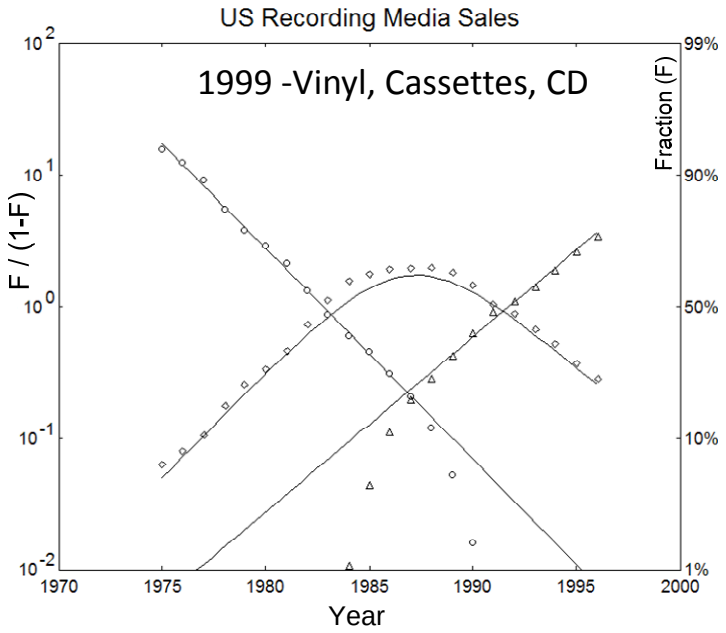
1. New technologies enter the market and grow at logistic rates.
2. Only one technology is in the saturation period at any given time.
3. Declining technologies fade away steadily at logistic rates uninfluenced by competition from new technologies.



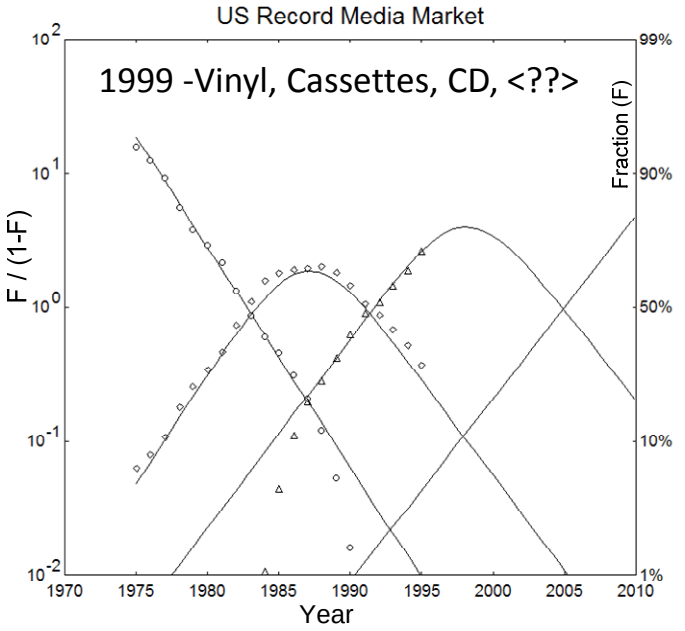
Source: Marchetti, C. and Nakicenovic, N. The Dynamics of Energy Systems and the Logistic Substitution Model. p. 73 (IIASA, Laxenburg, Austria, 1979).

3: Logistic substitution model (LSM) #3

[how does it work?]

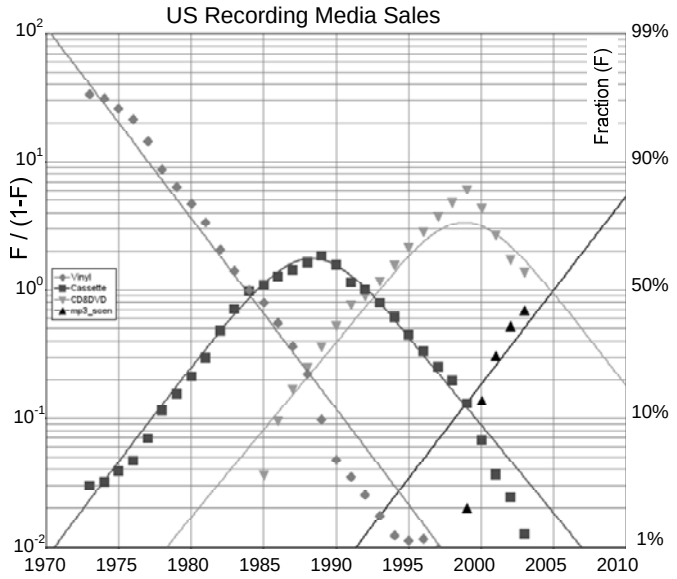


(1)



(2)

1. To represent the initial data in millions of US dollars as market shares using the Fisher-Pry transform.
2. To assign the years between in which a logistic should be fitted.
3. To execute the LSM. (1)
4. To assign the characteristic duration Δt and the midpoint t_m for the next (new) technology. (2)



(3)

4: Reliability of LSM #1

[known difficulties]

1. The definition of parameters for the hypothetic (new) technology. The absence of proper procedure to define the parameters (e.g. Δt, t_m) for the given time periods.

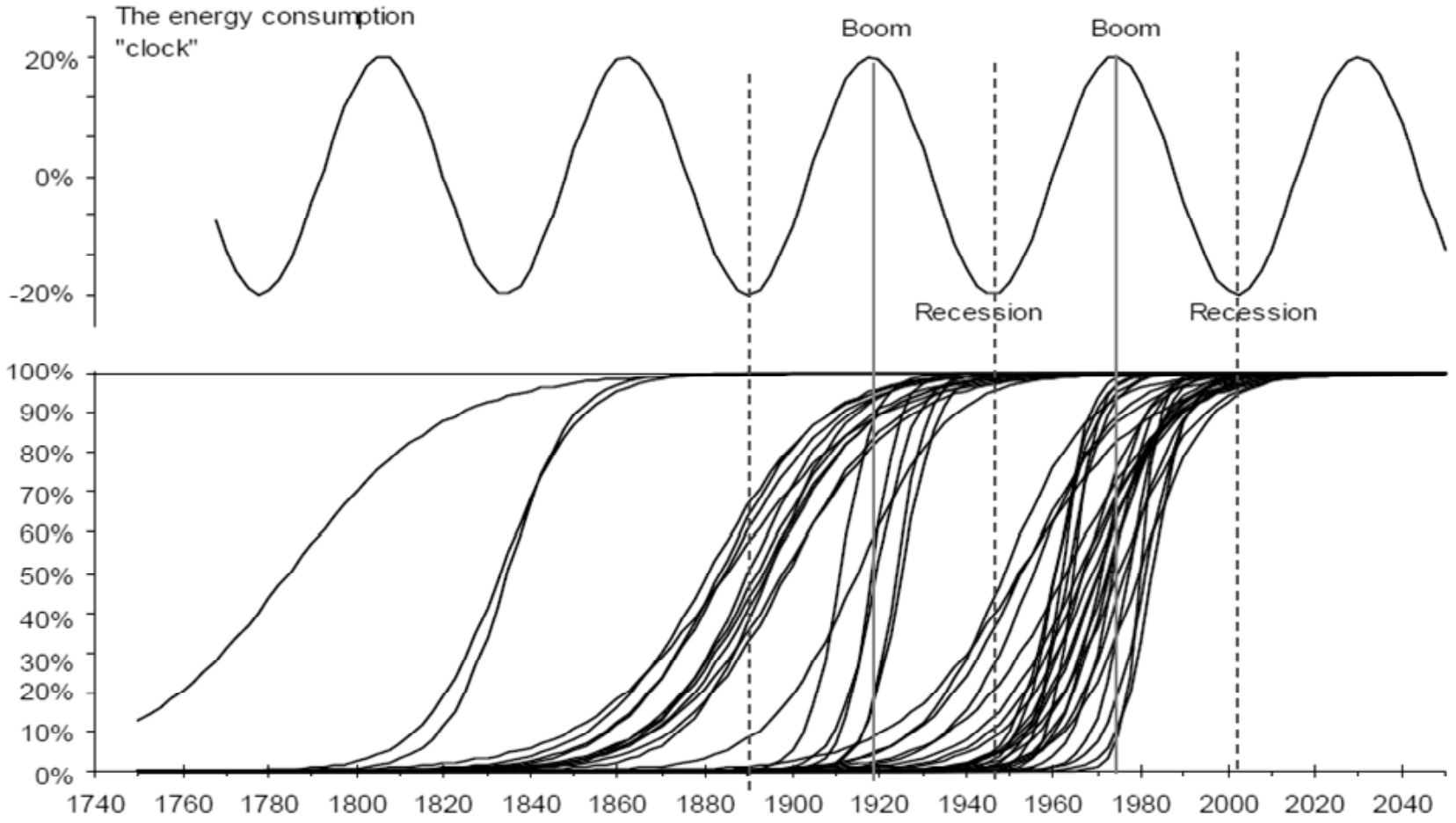
	1999	1999 [8]	2007 [7]
Vinyl	1975-1985	1977-1985	1977-1988
Cassettes	1977-1985	1977-1985	1985-1999
CD	1988-1996	1988-1995	1986-2000
Hypothetic	2005-2018	1998-2012	1999-2016

2. The definition of the new technology itself.
3. Preparing the time-series data sets (selection, cleaning, transformation) and the assumptions made to fit logistics into data.
4. The interpretation of obtained results.

4: Reliability of LSM #2

[how to be reliable? #1]

...the system had a schedule, a will, and a clock...

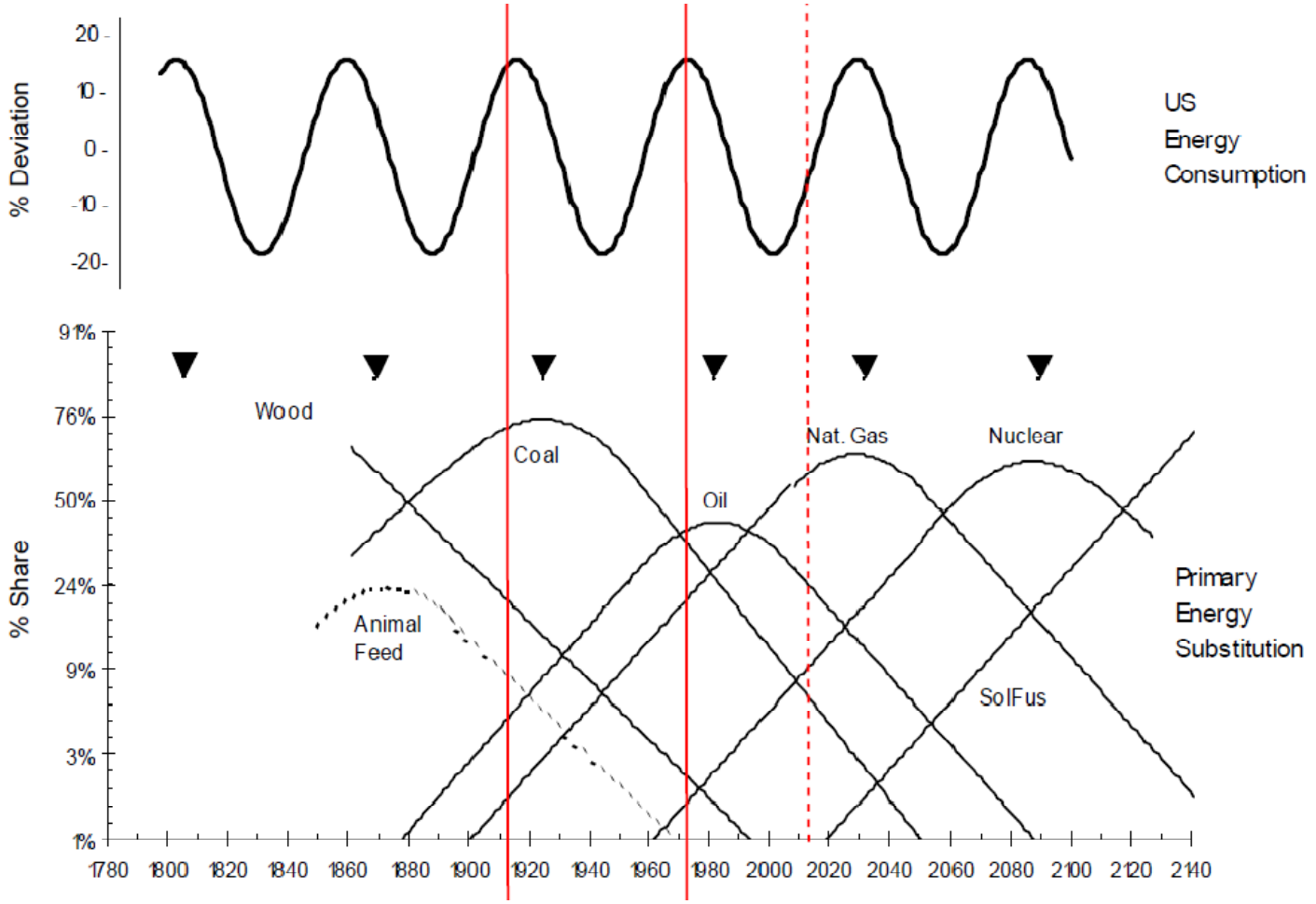


S-curves describing technological growth (invention-innovation, maturity, decline) and all normalized to reach 100% when they are completed. Adapted from [2].

4: Reliability of LSM #2

[how to be reliable? #1]

...the system had a schedule, a will, and a clock...



Primary energy sources substitution and cycles of energy consumption. Adapted from [2].

4: Reliability of LSM #2

[how to be reliable?]

2. *Hypothesis*: the definition of prospective competitive technology
   - artificial evolution (e.g. genetic algorithms, evolutionary strategies, genetic programming)
   - *problems flow technology;*
   - X-element (ARIZ), the Ideal Final Result (IFR),
   - the element-name_of_feature-value_of_feature (ENV) models.
3. *Supposition*: The issue about data sets and fitting techniques demands :
   - research about logistic growth models
   - the development of software with rigorous analysis of data and *residuals*.
4. The interpretation of obtained results. *Proposition*: proper initial estimation of a upper limits κ
   - with help study about *limiting resources*
   - the *network of contradictions* approach.

So what?

[summary]

1. Forecasting of changes through study of super-systems – naïve method via *logistic substitution models* (LSM) and
2. Forecasting of changes through sub-systems – causal method via component logistic models and *measuring the knowledge growth*.
3. Laws of technical systems evolution, logistic growth, and cycles as the basic patterns of technological changes are *invariant*.
4. Competition takes place only in *common infrastructure*.
5. **The reliable method alone is not enough for accurate long-term forecasting: *crucial role of forecasters*.**

Efficiency is doing things right;
Effectiveness is doing the right things.
Peter Drucker

Thank you for your attention :)

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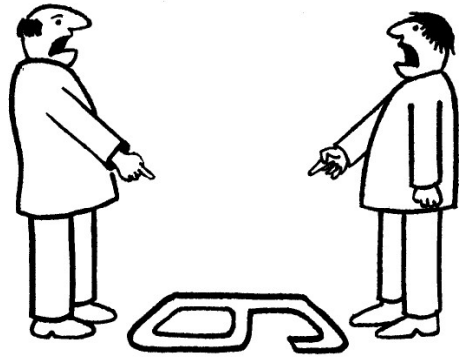

[technology change and forecasting]
[knowledge management for problem solving]

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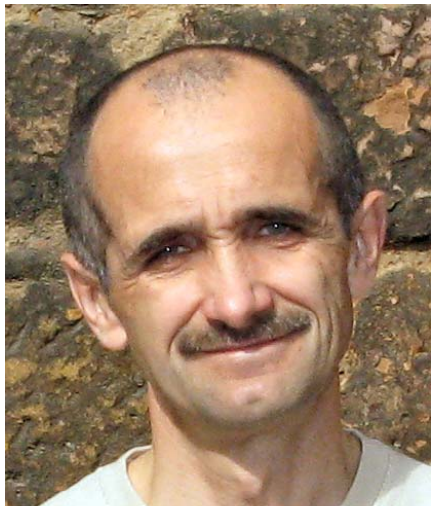

More than 18 years experience in TRIZ as engineer, researcher, consultant, and instructor.

1987-1988: the first acquaintance with TRIZ as mechanical design engineer;

1989-1993: research engineer at IMLab, Minsk, Belarus;

1994-1998: freelance TRIZ-consultant, entrepreneur;

1997-1998: invited instructor in SADT, IDEF0, and TRIZ at Belarusian state and private universities;

1998-2001: professional TRIZ consultant & instructor at LG-Production and Research Center (LG-PRC, Pyeongtaek, S.Korea);

2001 - : research engineer, instructor, adviser and consultant at LGECO, INSA Strasbourg, France.

2003 - : doctoral student (Reliable Technological Forecasting methods) at the University of Louis Pasteur.

2004 - : OTSM-TRIZ instructor for educational Program “Advanced Master of Innovative Design” (AMID).

References

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