The Known (ex ante) and the Unknown (ex post):

Common Principles in Economics and Natural Sciences.

Jürgen Mimkes, Physics Department, Paderborn University, Germany

Abstract

In the first part, the present article discusses a model of the known and unknown elements in science, by which it is possible to select or exclude various mathematical approaches to social and natural sciences. As a result, economics and physics may be formulated by various mathematical fields: differential forms, closed integrals, stochastic theory, non-linear (differential) equations and chaos theory. All these mathematical fields contain known and unknown elements and they are not competitive, but complementary approaches to science.

The second part applies the results to economics and natural sciences: differential forms in double entry accounting are the basis for the laws of macroeconomics and correspond to the laws of thermodynamics. Closed integrals explain the mechanism of economic cycles and the Carnot cycle in mechanical engineering. Both cycles run on oil! In stochastic theory, entropy leads to the laws of statistical mechanics, microeconomics and finance. Nonlinear Lotka-Volterra equations and chaos theory are the basis of complexity in economics and natural sciences.

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Introduction

Prof. Masanao Aoki was an outstanding teacher, an excellent scholar and a fighter against the walls of thought in science. In his spirit, the following contribution tries to focus on a topic that is common to all sciences: the known and the unknown. This topic has been addressed at several recent economics conferences (Mimkes, 2019, 2017). The paper has two different parts:

The first part discusses the known and the unknown in general science and investigates ways to model science of the past and the future by mathematical fields. As the methods for natural sciences are well established, the main object is to find methods to handle social sciences by the proper mathematical fields. The results are compared to the existing mainstream economics theory and to the methods of natural sciences.

The second part uses suitable mathematical fields to discuss economic problems and compares the outcome with data, with standard economics and with natural sciences. This will be the main part of the paper. Few mathematical fields are presented in more detail; other fields are only mentioned.

The final outlook shows the possibilities to apply the future model to many branches of social sciences, to economics, to sociology, to politics, to history and other fields.

1. The U-V Model of Science

We teachers may ask ourselves, why we are teaching the knowledge of today, when the students need the knowledge of tomorrow. Is teaching the knowledge of the past useful for the future?

The reason for teaching the known past is hope, the hope that some parts of today's knowledge will still be valid in the future. These parts of knowledge may be called the V-elements of the future. Of course, in the future students will also encounter new and unknown things; these may be called U-elements of the future. Accordingly, the future will consist of the interaction W (V, U) of known V- elements and unknown U-elements. W (V, U) is the general structure of all sciences, we teach the V- elements and we do research for the U- elements.

However, how useful is it to define the U and V elements and the interaction W (U, V), if we cannot look into the future? The answer is simple: Today is the future of yesterday! We may look at our present data and find out what is different from yesterday.

Finally, we must ask whether it will be possible to model the future in social or natural sciences by mathematical theories. How do we solve the contradiction to calculate the future and not to know the outcome for the future?

Examples for the U – V Model of Science

A closer look at different fields of science will show that the U – V model is incorporated in science in general:

Science: teaching the known (V) and doing research for the unknown (U)

The U - V model is common to all sciences. In each science we have

V: Teaching the known facts

U: Research for the unknown

Economics: Ex Ante (V) and Ex Post (U)

In economics, we find all economic terms are either presently known (ex ante), or they are presently unknown and will perhaps be known in the future (ex post).

V: Ex ante terms like a function F(x, y) are valid (V) in the past and future, we may calculate functions at any time. Another example is a contract. If we have an annual contract for our savings account, we may calculate the interest years in advance.

U: Ex post terms like income or profit are the most common terms in economics. They are only known after we have finished an action: We can file our income tax only at the end of the year, not in the beginning.

In neoclassical theory, there is a widely accepted economic theory, the *Solow Model*:

The Solow model is based on income (Y) as a function of capital (K) and labor (L):

Y = F (K, L). The function F (K, L) is the production function. However, this approach contradicts the U-V model: Income (Y) is an ex post or U term, the function F (K, L) is an ex ante or V term. One cannot calculate an unknown term Y by a known function F! Accordingly, Y and F cannot be equal! The neoclassical theory cannot be valid. We will discuss this point various instances.

Natural science: Conservative (V) and not conservative (U) forces

In natural sciences, we have two different kinds of forces. They are either conservative or non-conservative.

V: conservative systems have no friction; the future is predictable.

U: Non- conservative frictional forces make the future unpredictable. Friction creates heat and leads to the laws of thermodynamics, W (U, V). Thermodynamics is a very general theory and applies in many natural sciences like physics, chemistry, biology, metallurgy, meteorology or civil engineering.

Astronomy: The Kepler laws of planets are an example for W (0, V): Kepler observed the movement of planets in space without friction, U = 0. Accordingly, the Kepler laws of planets are valid in the past and in the future.

Mathematics: Calculus with exact (V) and not-exact (U) differential forms

In two-dimensional calculus, differential forms are either exact or not exact.

(V): Exact differential forms (d F) are complete and have a stem function (F), which we may calculate any time.

(U): Not exact differential forms (δ M) are incomplete and do not have a stem function (M). A not-exact differential form (δ M) may be linked to an exact differential form (d F) by an integrating factor λ: δ M = λ d F.

Thermodynamics: The first law of thermodynamics is always given by exact and not exact differential forms: δ Q = d E – δ W connects heat (Q) to energy (E) and work (W). Heat and work are not exact; they do not have a stem function. They cannot be calculated unless more information is obtained. In the second law of thermodynamics: δ Q = T d S the not exact heat (δ Q) is linked to an exact function (d S) by an integrating factor (T). The function (S) is called entropy; the integrating factor is the temperature of the economic system.

Mathematics: Closed line integrals by Riemann (V) and Stokes (U)

In two-dimensional calculus, we have closed Riemann and closed Stokes line integrals.

(V): Riemann integral: The line integral of an exact differential form (d F) is a Riemann integral. The integral does not depend on the path of integration and we may calculate the Riemann integral for any boundaries A and B. The closed Riemann integral is always zero, the integrals from A to B and from B to A cancel, as the Riemann integral is path independent. The closed Riemann integral corresponds to a ring.

(U): Stokes integral: The line integral of a not-exact differential form (δ M) is a Stokes integral, which depends on the path of integration. The closed Stokes line integral is not zero, the path dependent integrals from A to B and back from B to A do not cancel.

The closed Stokes integral corresponds to a spiral.

Magnetism: The magnetic field is a Stokes integral and spirals around an electric wire.

Accounting: An account is a Stokes integral: A savings account spirals up to higher profits. A permanently depleted account spirals down to deficit.

Mathematics: Stochastic theory with "real" (V) and "probable" (U) values

In probability theory, real constraints lead to probable results.

(V): Real functions are often the given constraints in a stochastic theory.

(U): The result of stochastic calculations are probability terms.

Mathematics: Linear (V) and non-linear (U) differential equations
Differential equations are either linear or nonlinear.
(V): Linear differential equations may be solved by various methods.
(U): Non-linear differential equations cannot be solved in general.

This list may be extended to nearly all sciences and fields of mathematics. Some examples of the U – V model have been discussed in the literature (Mimkes, 2018).

Mathematical Fields representing Economics/ Natural Sciences

The U-V model of science applies to economics, to natural sciences and to mathematics. This enables us to select proper mathematical fields to represent economics and natural sciences:
V – terms in social or natural sciences must correspond to V – terms in mathematics, and
U – terms in social or natural sciences to U – terms in mathematics.

Line Integrals in economics or natural sciences
Alternatively, we may chose two-dimensional closed line integrals as a mathematical tool in economics or natural sciences: all ex ante/conservative terms are closed Riemann integrals, and all ex post / not conservative terms are closed Stokes integrals.

Differential Forms in economics or natural sciences
We may chose differential forms in two dimensions as a mathematical tool in economics or natural sciences: all ex ante /conservative terms must correspond to exact differential forms, and all ex post/ not conservative terms to not-exact differential forms.

Stochastic theory in economics or natural sciences
If we chose stochastic theory as a base of economics or natural sciences, all ex ante terms must correspond to real functions, and all ex post terms to probability terms.

Non-Linear Differential Equations and Chaos Theory in economics or natural sciences
Economics or natural science theory in differential equations require ex ante and ex post terms to correspond to linear and non-linear differential equations. These equations are the basis of system science, complexity and chaos theory.

There are two important results of this paragraph:
1. Mathematical fields like calculus, stochastic theory, complexity, or chaos theory do not compete for the theories of economics or natural sciences, they are complementary.
2. The mathematical structures of economics and natural sciences are very similar.

Time
So far, we have discussed the past and the future without mentioning time. A V- element may be a function of time, f (t). It is valid in the past and in the future. It typical example is the field mechanics; here all terms are function of space and time. The laws of mechanics without friction, like in space, are always valid; we may calculate the position of the planets at any time t.

This is not true for the unknown U elements of the future. There are at least two ways to handle time in the future model:

1. Thermodynamics as well as mainstream economics do not contain time as a parameter.
2. Statistical mechanics includes time in non-linear equations like the equations by Fokker Plank, Hamilton or Lotka-Volterra. However, these equations have complex solutions.

2. Applications to Economics

We will now apply the four mathematical fields to model economics and compare the outcome to standard economic theory and to natural sciences. The first two fields, closed integrals and calculus will be applied to macroeconomics, the third field, stochastic theory to microeconomics and finance and finally non- linearity to special economic problems.

The laws of macroeconomics in closed integrals

According to the U - V model the laws of macroeconomics are given by W (U, V), where V and U may be presented by closed Riemann and Stokes integrals. The problem is now to find the proper equations. A recent paper has derived the integrals of macroeconomics from Luca Pacioli's laws of double entry accounting (Mimkes, 2017).

Double entry accounting and macroeconomics

In double entry accounting Luca Pacioli considers two accounts, the monetary account and be productive account. Accounts can never predicted, they are ex post terms and may be written as closed Stokes integrals.

The monetary account is the surplus or profit (M), the difference between income (Y) and costs (C). The monetary account is ex post and must be presented as closed Stokes integral,

$$\oint \delta M = Y - C = \Delta M \qquad (1)$$

The monetary account belongs to a household, a company or an economy and is given in monetary units, in €, US $, £, ¥ or any other currency.

The productive account (P) is the difference between output of goods (G) like food and input of labour (L). The output of the productive account is also ex post and must be presented as closed Stokes integral,

$$\oint \delta P = G - L = \Delta P \qquad (2)$$

Labor and food are measured in energy units, in kWh, mega joules or kcal..

However, in double entry accounting Luca Pacioli measures labor and food in monetary units and initiates a new science, economics: *The monetary account measures the productive account in monetary units, both accounts add up to zero,*

$$\oint \delta M + \oint \delta P = 0 \qquad (3)$$

This law is the basis of economic theory.

Differential Forms in macroeconomics

According to the U - V model the laws of macroeconomics may also be given by W (U, V), where V and U are presented by exact and not exact differential forms.

First Law of Economics

The first law of economics in differential forms reads

$$\delta M = d K - \delta P \qquad (4).$$

Eq. (4) is this solution of Eq. (3). The closed integral of the exact differential d K is zero. Eq. (4) contains three differential forms with the common dimension money:

1. The not exact monetary term (δ M) stands for money, for surplus or losses and relates to a person, a household, a company, a country or any economic system.
2. (δ P) is the ex post term of production or labour input of persons, households, companies, countries or any economic system.
3. (d K) is an exact term with the dimension "money". (K) refers to money or capital.

All economic terms in eq. (1) are measured in €, US $, £, ¥ or other monetary units.

The second law of economics

According to calculus, we may link a not exact differential form (δ M) with an exact differential form (d F) by an integrating factor λ,

$$\delta M = \lambda d F \qquad (5).$$

(δ M) is the inexact or ex post profit, surplus or loss. The function (F) is the production function and eq. (5) is the proof of existence of production functions in economics. The dimension of the integrating factor (λ) depends on the production function (F). We will find the production function to be a number (N), and then the integrating factor (λ) has a monetary dimension: (λ) will be the standard of living or the GDP per capita of a country

Production, price and amount

According to calculus, we may link a not exact differential form of production or labour input (δ P) with an exact differential form (d V) by an integrating factor p,

$$\delta P = - p d V \qquad (6).$$

(δ P) is the inexact differential of production or work, and (d V) the exact differential of volume or amount of the produced item. The integrating factor (p) will be the price of the product (Yakovenko and Rosser, 2009).

Differential forms in natural sciences

We can turn Luca Pacioli's law around and measure both accounts in energy units:

The monetary account measures the productive account in energy units, both accounts add up to zero,

$$\oint \delta Q + \oint \delta W = 0 \qquad (7)$$

This law is now the basis of economic theory in energy units. Q is the monetary account in energy money. The oil price converts money into energy. W is the work input in energy units.

The First Law of Economics in Energy Units

The first law of economics in differential forms reads

$$\delta Q = d E - \delta W \qquad (8).$$

Eq. (8) contains three differential forms with the common dimension energy:

1. The not exact monetary term (δ Q) stands for profit in energy units.
2. (δ W) is the ex post term of work input in energy units
3. (d E) is an exact term and refers to capital in energy units.

All terms in eq. (7) are identical to Eq. (4), but they are now measured in Joule, calories, kWh or other energy units.

The second law of economics in energy units

According to calculus, we may transform a not exact differential form (δ Q) into an exact differential form (d S) by an integrating factor T,

$$\delta Q = T d S \qquad (9).$$

Eq. 9 is identical to Eq. 5, but is now measured in energy units. (δ Q) is the inexact or ex post profit, surplus or loss in energy units. The function (S) is the production function. The integrating factor (T) has a monetary dimension. Eqs. 7 and 8 are also called the first and second law of thermodynamics.

Work, pressure and volume

According to calculus, we may link a not exact differential form of work (δ W) with an exact differential form (d V) by an integrating factor p,

$$\delta W = - p d V \qquad (10).$$

(δ W) is the inexact differential of work, and (d V) the exact differential of volume. The integrating factor p will be the pressure of the thermodynamic system.

Equivalence of macroeconomics and thermodynamics

As predicted by the U–V model, economics and natural science have the same mathematical structure (Richmond et al., 2013).

Macroeconomics corresponds to thermodynamics and vice versa. In thermodynamics, we call the function S entropy. The laws of macroeconomics and thermodynamics are equivalent.

The sum of capital (K) and amount of goods (V) like houses, property or other commodities times the price (p) of the goods is the wealth (W) of a person or company:

$$W = K + p V \qquad (11)$$

The difference of capital (K) and production function (F) times mean capital (λ) in Table 1 is the Lagrange function (L)

$$L = K – \lambda F \qquad (12).$$

Table 1 shows the close relationship between economic and physical terms. Each term in economics corresponds to a term in thermodynamics.

Symbol	Economics	Unit		Symbol	Thermodynamics	Unit
M	Profit, loss	€, $, £. ¥	↔	**Q**	Heat	kcal, kWh
K	Capital	€, $, £. ¥	↔	**E**	Energy	kcal, kWh
W	Wealth	€, $, £. ¥	↔	**H**	Enthalpy	kcal, kWh
P	Production, Labour	€, $, £. ¥	↔	**W**	Work	kcal, kWh
λ	Mean capital	€, $, £. ¥	↔	**T**	Mean energy	kcal, kWh
F	Production function	-	↔	**S**	Entropy	-
N	Number	-	↔	**N**	Number	-
p	Price per item	€, $, £. ¥	↔	**p**	Pressure	kcal / m^3
V	Volume, amount	-	↔	**V**	Volume	m^3
L	Lagrange function	€, $, £. ¥	↔	**F**	Free energy	kcal, kWh
L*	LeChatelier function	€, $, £. ¥	↔	**G**	Free Enthalpy	kcal, kWh

Table 1. Corresponding terms in economics and thermodynamics. Most economic terms are measured in monetary units; the corresponding thermodynamic terms are measured in energy units.

The equivalence of economics and thermodynamics is not only given by theory, it may also be found by experimental data. In Figure 1 the GDPs per capita of 126 countries are compared to the use of energy per capita. GDP and energy run parallel for nearly all coutries. This confirms the equivalence of capital and energy in Table 1.

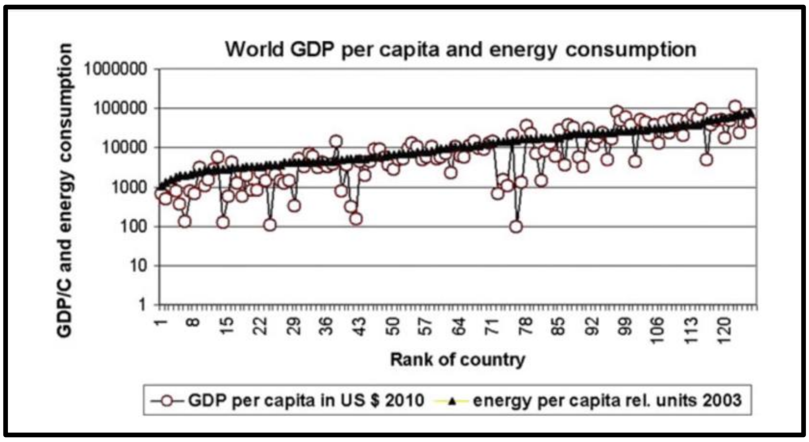

Fig. 1: GDP per capita and energy use per capita have been plotted for 126 countries. Both curves are equivalent for nearly all countries.

The equivalence of economics and thermodynamics raises the question, whether economics is the physics of markets or whether physics is economics of nature (xx).

Stokes integrals: Trade Cycle

The trade cycle of a sales company has four parts: Buying products at a cheap market or producer, e.g. in China, bringing goods to an expensive market, e. g. Europe, sell goods expensively. The productive cycle is linked to the monetary cycle: Cheap production leads to low costs. Expensive sales lead to high income. One can look either at the monetary cycle or at the productive cycle, fig. 2.

$$\oint \delta M = -\oint \delta P = \oint p \, dV \qquad (13).$$

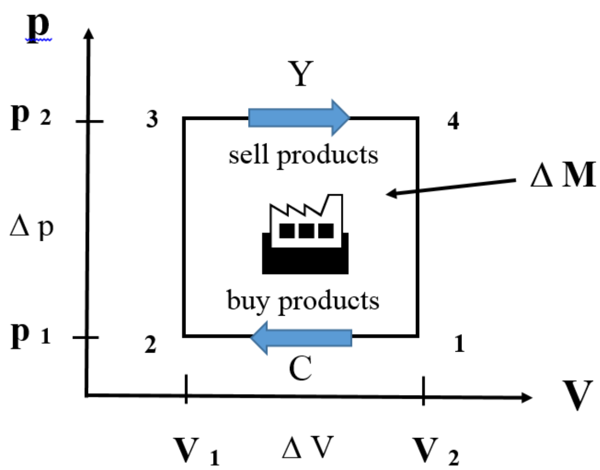

Figure 2. Trade is a two level process: The merchant buys products cheap at price (P_1) from a wholesale market or by importing directly from a low price country like China, and sells the product more expensively at (P_2) in his shop in Europe. The profit (ΔM) of the merchant is based on inequality of prices. In order to make a profit the merchant has to keep up the difference in prices by separating wholesale and retail prices. Trade companies accomplish the price difference by separating producers and customers by a long trade distance or by market laws. The profit is the inside area of the cycle, eq. (13). The logo indicates the profit of the owner (trade company or merchant).

The merchant brings the products from the farm a market. Here the price of apples (P_2) is higher than at the farm. By changing the location, the merchant has raised the value of the apples. Earning money by trade requires two price levels: cheap – expensive, wholesale – retail, farm – market. Without these two levels, a profit is not possible! In former times, merchants sent ships to far distant places to buy precious goods like spices at a cheap price to sell it back home for a high price. Today merchants buy in China and sell in USA.

Wealth: By trading, the wealth of the merchant (wealth = capital + value of goods) in eq. (11) has not changed. Trade conserves wealth of buyers and sellers; nobody is robbed in a fair trade!

Stokes integrals: Production Cycle and Carnot cycle of motors

The productive cycle of a company has four parts: Cheap production, export, expensive sales, recycling. The productive cycle is linked to the monetary cycle: Cheap production leads to low costs. Expensive sales lead to high income. One can look either at the monetary cycle or at the productive cycle. This corresponds to the Carnot cycle of motors:

The Carnot process of a motor has four parts: Slow (isothermal) compression at low temperature, fast compression, and slow expansion at high temperature, fast expansion. The work cycle is linked to the heat cycle: Slow compression at low temperature leads to low heat generation, slow expansion at high temperature leads to higher heat losses. One can look either at the work cycle or at the heat cycle,

$$-\oint \delta P = \oint \delta M = \oint \lambda \, d F \qquad (14).$$

Productive and monetary circuits are now depending on the production factors (λ) and (F): the factor (λ) is proportional to the mean value or price, and (F) is the entropy: (+d F) corresponds to distributing or selling products and (- d F) to collecting, producing or buying the products: produce cheap and sell expansive. In this way, we obtain four different lines of the line integrals in fig. 2.

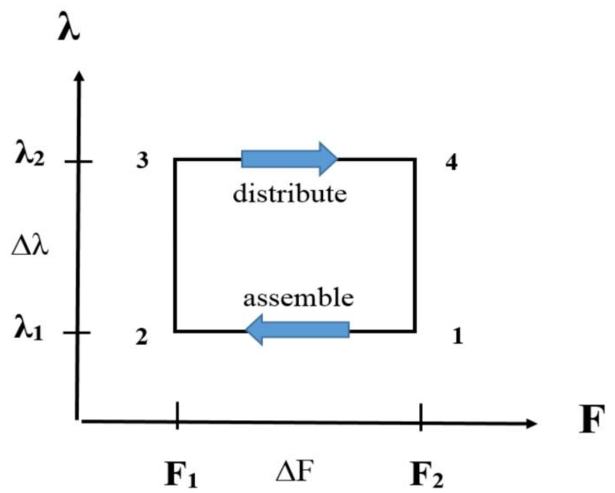

Fig. 3. The production circuit: Assemble products *cheap* and sell (distribute) *expensively*! Carnot cycle in motors: collect *cold* gas before burning and expelled *hot* gas after burning.

We may divide the production process in figure 3 into four sections:

1 → 2: At low labor costs λ, workers in a factory assemble production parts the amount of assembling is (-d F). The low standard of living of the workers (λ) is constant during at least one cycle due to contracts. Assembling at constant (λ) corresponds to an isothermal process in thermodynamics.

2 → 3: Products are transported (exported) to a region, where the products have a higher value λ due to higher labor costs and standard of living (λ), this corresponds to an adiabatic process in thermodynamics.
3 → 4: at higher value the products are sold (distributed) to the customers. At selling or distributing the price (λ) stays constant, this corresponds again to an isothermal process in thermodynamics.
4 → 1: after using the products for some time they will break, and they are transported to recycling centers. The value of the product has declined ($d\lambda < 0$) and this corresponds again to an adiabatic process in thermodynamics.

Efficiency, ROI and EROI
For efficient economic production and trade the ratio of returns over input ((ROI) must be larger than 1. In figure 3 this ratio is given by

$$ROI = \lambda_2 / \lambda_1 > 1 \qquad (15\ a)$$

the ratio of income and costs.
For survival of the human race, the energy of food must be larger than the energy of work to obtain this food. The biophysicist Hall (Hall) has called this energy returns over energy input (EROI), and with figure 3 we obtain

$$EROI = \lambda_2 / \lambda_1 > 1 \qquad (15\ b),$$

the ***e**nergy **r**eturn **o**ver the energy **i**nput.
The same ratio applies to the efficiency of the Carnot process of a heat pump, where heat is pumped from the cold river (T_1) to a warm house (T_2),

$$EROI = T_2 / T_1 > 1 \qquad (15\ c)$$

According to table 1 the mean price λ of economics is now replaced by the temperature T of thermodynamics.

The definition of EROI does not only show the close relationship between economics and thermodynamics, but it also leads to the correct definition of money: We may buy and sell in monetary units, in €, US $, £ or currencies, but we cannot eat money, we must eat energy. Companies may increase their monetary value at the stock market, and they may pay wages in money, but they run on energy, presently mostly on oil.
This has important consequences for economic costs: If we build a new power plant, we must not ask, how much it costs, but how much energy it will produce compared to the energy that has been invested to build it. This is not only important for power plants but for all items, we produce. All products must be valued in energy terms. For the survival of humankind, the EROI is more important than the ROI. We can live without money, like natural societies, but we cannot live without energy. Energy units like Joule, kWh or calories are the hard currency, on which every economy is based.
The principle of the known and the unknown has led to new laws of economics, which are closely related to thermodynamics.

Efficiency of state economies
Efficiency of industry affects the structure of states and countries: Countries may by capitalistic, socialistic or communistic, fig. 4.

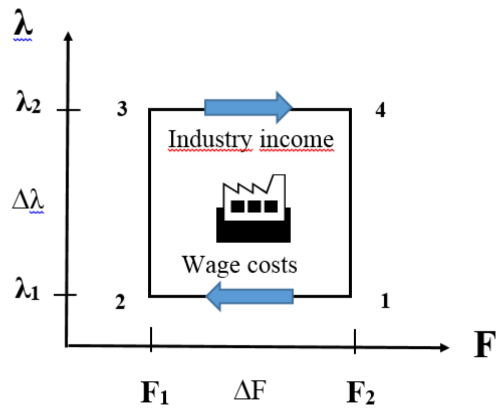

Fig. 4. The efficiency of industrial production income vs. costs (wages) determines the political state of a country.

Capitalism: Capital favors a high efficiency, $\eta \rightarrow$ **max!** This means high industrial prices and low wages leads to a strong economy and to a rising gap between rich and poor. A good example in Europe is Germany. In order to avoid aggressions between high and low income classes, the government of a strong economy can level out differences in incomes by taxes and by support of unemployed and other problem groups.

Socialism (Labour): Labour favors a lower efficiency, $\eta \rightarrow$ **small!** This means lower industrial prices and higher wages. This leads to a weaker economy and a slowdown of the gap between rich and poor. A good example in Europe seems to be France. Lower income classes still have a rather good standard of living, but the state cannot raise enough taxes to support problem groups like unemployed.

Communism: Communism calls for a one-class society in which the capital is owned by the proletarians. In a one class society ($\lambda_2 = \lambda_1$) the efficiency will be zero, $\eta \rightarrow$ **0!**
This has been observed for all communist states, and has led to the downfall of all communist regimes in Europe.
In order to make a refrigerator work we have to close the door, inside and outside have to be separate. In the same way, rich and poor classes have to be separated to make the economic production process work.

Stochastic theory in microeconomics
Microeconomic deals with the amount and price of items bought or sold at a productive market. The standard theory of microeconomics applies utility functions and probability calculations for optimal results. However, standard economics has not been able to link macroeconomics to microeconomics. Again, the U-V model will solve this problem.

Markets with large numbers of goods depend on probability (P) and constraints. The constraints of markets are usually the costs (K). Probability (P) has the property to move from an improbable state to a more probable state,

$$P \rightarrow \text{maximum!} \qquad (16)$$

This has led Lagrange to formulate the probability law under constraints (K)

$$L^* = \ln P - K / \lambda \rightarrow \text{Maximum!} \quad (17)$$

With P also the logarithm of P will always grow according to the constraints (K).

Like in standard theory, we may start microeconomics with the Lagrange equation,

$$L = C - \lambda F \rightarrow \text{minimum !} \quad (18)$$

(L) represents the Lagrange function, C denotes the costs, λ is the integrating factor and F is the utility function. However, in contrast to mainstream economics, F is not the *Cobb Douglas* utility function, but according to table 1, the entropy function S. In probability theory entropy is closely related to the natural logarithm of probability **P**,

$$F = S = \ln \mathbf{P} \quad (19)$$

This corresponds to the free energy approach to statistical mechanics.

Eqs. (13, 14) link the Lagrange function (L) and probability (**P**) of microeconomics to the Lagrange- and entropy functions of macroeconomics in Table 1. In contrast to mainstream economics, eq. (13, 14) are free of any adjustment to elasticity.

Stochastic theory in finance: long-term, short-term, strategies

According to the first law in eq. (4), profits (δ M) are the result of capital gains (d K) and production input (δ P). In closed integrals eq. (4) now reads

$$\oint \delta M = \oint d K - \oint \delta P \quad (20)$$

Profit (δ M) comes from production, from labour input (δ P). Investing only in capital (dK) will lead to zero output, as capital (d K) is ex ante.

$$\oint d K = 0 \quad (21).$$

Capital alone cannot create capital. Figs. 4 and 5 demonstrate profit from long and short-term investments in the (US) stock market.

Long-term investment e. g. in (US) stocks corresponds to investment in production (δ P) and has led to more than 7 % annual growth between 1940 and 2010 in fig. 5.

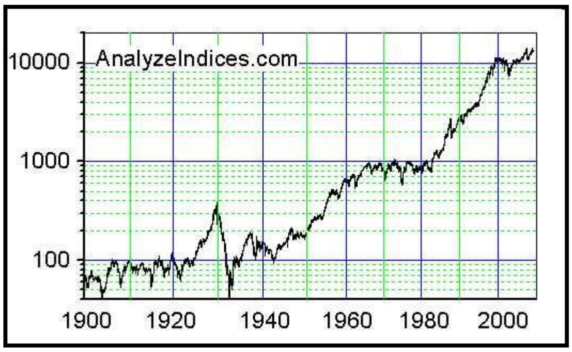

Fig. 5. A long time investment in the (US) stock market corresponds to an investment in production (δ P) and shows mean positive returns. [Department of Statistics, Carnegie Mellon University Pittsburgh, PA, 15213, USA (2011)}

Short time investment corresponds to capital investment (d K). In fig. 4 this may seem more appealing, as much higher returns are possible, like between 1920 and 1929. However, these high growth bubbles finally burst like in the depressions of 1929 and 2009.

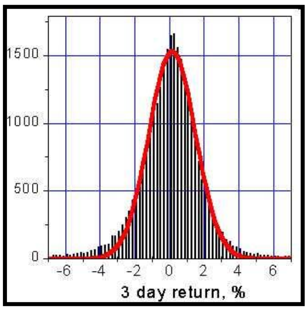

Fig. 6. A short time investment in the stock market corresponds to an investment in capital (d K) and shows a Gauss distribution with symmetric gains and losses. There is no profit in short time investments. [Department of Statistics, Carnegie Mellon University Pittsburgh, PA, 15213, USA (2011)}

Fig. 6 shows the even distribution of gains and losses of 3-day returns by a bell shaped function with fat tails. Short-term capital investments are similar to gambling and do not contribute to general growth, they only redistribute wealth. A short-term stock market is a legal casino. The only permanent winners are the banks, which collect transfer fees, whether the player wins or loses. Only when banks start investing in financial markets, they will become risky players as well, and they will risk the stability of financial markets.

Strategies try to overcome the risk in financial investments. Without strategies, the investor would lose and win without much profit at the end. Strategies seem to be able to overcome the possibility of losses. A typical example:
Banks start giving credits to risky investors at a high interest. If the investment fails, the next credit to a new investor must be bigger than the first credit, in order to cover the losses. If a bank runs out of money, it will try to borrow more from other banks. This strategy is continued until a successful investor finally pays all the losses.
Another strategy is "betting on growing house prices", which led to the world financial crisis in 2008.

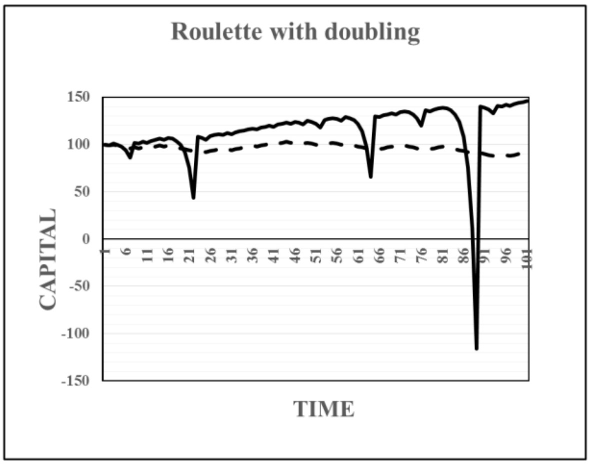

Fig. 7. "Winning strategy" of doubling the stake after losses. In the simulation the capital permanently grows, except for a few spikes.

We may model these strategies by probability calculations. Fig. 7 shows the strategy of doubling the stake after loss in a simulated roulette game.
Without strategy, wins and losses are nearly even (dotted line). With strategy, the financial market keeps always growing, except for a few spikes. The market may handle small spikes, if the starting capital is high enough. However, eventually the spikes will be deep enough to let the market crash. This may take some time, but the crash will come to keep the statistics right. The last financial crash took 80 years between 1928 and 2008. However, the time until the crash may come at any time.

Non-linear differential equations in complexity and chaos theory

Many financial data, however, do not show a Gaussian distribution of stocks. In contrast to figure 4, many stock market data show non-Gaussian distributions, so-called fat tails, fig. 8.

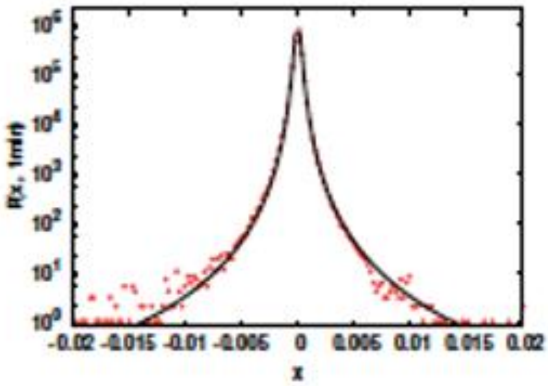

Fig. 8. Plot of the probability density distribution for log price returns [Richmond]. For low probability densities, the data show a so-called fat tail and deviate from data in fig. 6.

The calculation for this non-Gaussian curve is based on time dependent non-linear Fokker-Planck calculations, which leads to a power law instead of an exponential Boltzmann law for the probability function, fig. 9.

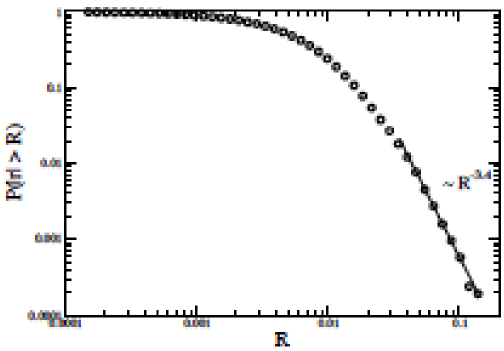

Fig. 9. Power law of probability of price returns in a log – log plot [Richmond]. The linear tail indicates a power law and a higher probability of rare events than predicted by a Boltzmann distribution.

This power law has first been found for British income distributions by Pareto, and has been discussed more recently for the US incomes by Yakovenko. Many researchers have labeled this field of non-linear thermodynamics and statistical mechanics "econophysics" or "complexity".

Outlook

So far, we have applied the future model of science to economics and natural sciences, using only the fields of calculus and probability. We have presented nonlinearity and chaos theory only in a short paragraph. These fields have been presented in more detail, elsewhere (Giovanni (2008), Gleick (1988), Guckenheimer et al. (1983).

In addition, we may also apply the future model to social sciences [xx]. This leads to an insight into the structure of societies, the collective, individual or global state, which corresponds to the political structure of hierarchy, democracy and globalism. Moreover, we may look into the states of integration, segregation and cooperation, one of the biggest issues of present-day politics.

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