Quadratic prosperity growth instead of stagnation

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Foreword

Today’s world economy is threatened by stagnation. The conventional fiscal instruments to counter this are exhausted. High national debts and sustained low interest rates will no longer suffice to encourage economic growth.

With this, and a growing world population we face the following threats:

- increased unemployment,
- the collapse of the many overindepted national economies ,
- an increasing gap between rich and poor within nations and between nations.

If no new economically convincing solutions are found to avoid these risks, we are faced with increasing distribution struggles between nations. The ensuing economic crisis threatens to destabilize political systems because humans lose faith in the market economy and the democracy it supports.

This article presents a new mathematically formulated superstructure for economic theories. It shows how market economies can avoid economic stagnation.

To achieve this, new cybernetic methods are applied to economic processes. It is shown that economic success has a quadratic dependency to the success of the education system. This means that when the education level increases by 1%, economic income increases by 2%. This economic growth is an internal not external expanding one since higher educated individuals live inside their national frame. The quadratic economic grow would allow nations to service or pay down their national debt.

All these positive effects occur when learning performance is rewarded with income. In other words, the economic system promotes and supports the education system and visa verse. With this, unemployment loses its trepidation because now, not only employed workers are paid an income also individuals who further their education are compensated for their learning efforts. Furthermore, individuals of the social underprivileged class can generate income by their own means. That, in turn, stabilizes the political system.

The objective of this article

The T-h-Diagram

In 1936 economist Friedrich Hayek in his presidential address to the London Economic Club held a speech titled "Economics and Knowledge" [2]. In his address he introduced the term "bit of knowledge" and urged his guild to search for said „bit of knowledge" as otherwise the science of economics could not be developed further.

The objective of this article is to present the quantification of the bit of knowledge. For this cause we will step by step derive and arrive at a diagram as depicted by **Figure 1.**

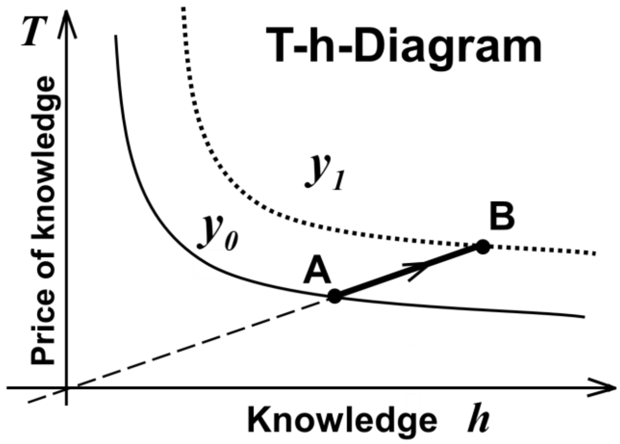

Figure 1: Principle of T-h-Diagram

The diagram shows in general a dependency between the amount of knowledge and its price. The x-axis measures knowledge in a quantity ***h***. The y-axis measures the quantity ***T,*** the price of knowledge. The diagram presents two curves for income levels, the lower level y_0 and a second higher level income y_1. The objective is to derive a formula that shows how we can move from point ***A*** on the curve with the lower income y_0 to point **B** on the curve y_1 with higher income.

To derive the diagram and its describing formula we employ and are open to new methods which are used in information technology, cybernetics and physics and which may give new insights into real economies.

Decision processes and economic systems

The *Φ*-*R* Model.

Figure 2 is an abstract symbolization of how we control economic processes in ***R*** through the control panel ***Φ***.

With **Figure 2** we introduce two systems ***Φ***[1] and ***R*** in which ***R*** (called "economic process") is controlled by ***Φ*** (called "control panel"). We assume that at the ***R*** side well known physical processes are at work which are completely controlled by ***Φ***. These physical processes in ***R*** are necessary for producing goods or services, for example shoes, orange juice or all other products and services which are contained in a standardized market basket etc.

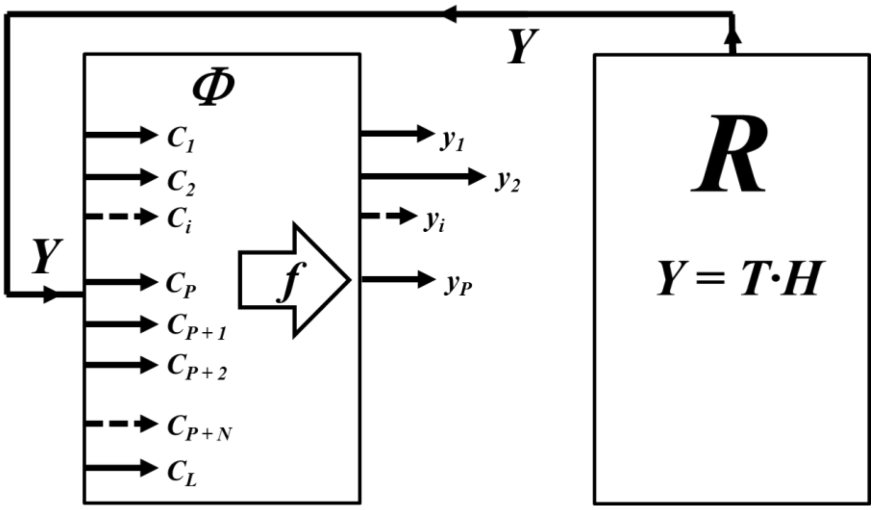

Figure 2: Control panel *Φ* and controlled economic process *R* .

Humans govern the complete system through inputs via the control panel ***Φ*** which in turn control ***R***. The output ***y*** is derived through economic process inside of ***R*** and is counted in energy or money units. At a minimum, humans produce the basic necessities for life at ***R***.

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[1] Spoken "Phi".

The control panel has a number of ***L*** different channels of which ***P*** (y_1, y_2 .. y_P) influence the economic or production processes at ***R***. Imagine that each of the ***P*** channels is controlled by a dial which we can adjust on a scale from zero to one hundred. At zero, there is a negligible control output from Φ to ***R***. One hundred represents the maximum control output. In particular, two parameters determine the control output: The selection of the right channel ***L*** and its value y_x.

The following analysis will show that the human decision processes which are necessary at the Φ-side can be described by borrowing well known mathematical methods commonly used in the information technology, physics and cybernetics. This concept establishes a mathematical relationship between what is intellectual (logical) selected on the channel side Φ to process the physical output at ***R***.

The important point is, that up to now only humans are able to compose ex ante a selection of relevant channels and adjust the appropriate control output (turn the dials). Selecting the right channels means to set in action those physical processes that produce the desired economic output at ***R***. As such, we as scientists rely upon the ex-ante concept of "sufficient reason"[2] of philosophy for selecting the right channels. After humans have selected the right channels, physicists are ex post able to identify and explain all the physical processes that result from human input on the control panel side. In other words, all physical processes at work ex post in ***R*** to produce economic output are known and can be explained with the laws of physics.

Properties of the Shannon formula

We now analyze some properties of the Shannon formula [3].

The arrows y_i at the control panel, through their length and composition, establish a diagram well known in mathematics (statistics). It is called a distribution function.

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[2] By this concept philosophers have explained the difference between physical causality and human reasoning for choosing specific processes to achieve objectives.

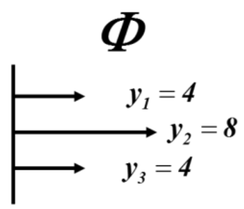
Economists refer to this diagram more commonly as a “bar chart”. We can apply the well-known Shannon formula to these bar charts. It produces varying results when we alter the controlling parameter $\boldsymbol{y_i}$ inside of $\boldsymbol{\Phi}$.

Formula 1 shows how the Shannon formula is applied:

$$h = -\sum_{i=1}^{P} \lambda_i \, ld \lambda_i \qquad \text{mit}: \lambda_i = \frac{y_i}{y}; \quad y = \sum_{i=1}^{P} y_i$$

Formula 1: Shannon formula

As common in information technology, we use the binary logarithm ***ld*** in the formula. The quantity ***h*** represents a measure of information (entropy), which depends on the values of $\boldsymbol{\lambda_i}$ which is given by the quotient $\boldsymbol{y_i / y}$ (see middle part of the formula). ***y***, in turn, is the sum of all scaling values of the dials at the control panel side (see the right part of the formula). Since humans are necessary for choosing the channels and set the dial values, we measure this specific result of the Shannon formula by the unit (physical dimension) ***hbit*** for “human bit”. We can interpret the quantity ***h*** as a measure of the control input information which is provided by $\boldsymbol{\Phi}$ for managing the output of ***R***.



Row 1: $y = y_1 + y_2 + y_3 = 16$

Row 2: $\lambda_1 = 4/16; \quad \lambda_2 = 8/16; \quad \lambda_3 = 4/16;$

Row 3: $h = -\sum_i \lambda_i \, ld \lambda_i = -\left(\frac{4}{16} ld \frac{4}{16} + \frac{8}{16} ld \frac{8}{16} + \frac{4}{16} ld \frac{4}{16} \right) = 1.5 \quad (hbit)$

Figure 3: Example for the use of the Shannon formula

Figure 3 illustrates a simple example for determining a human bit value by using the Shannon formula. There are three channels $\boldsymbol{y_1, y_2, y_3}$ with their specific control parameters 4, 8, 4. We therefor arrive at their sum $\boldsymbol{y = 16}$ (Row 1). We use this sum to determine the quotients $\boldsymbol{\lambda_1}$, $\boldsymbol{\lambda_2}$, $\boldsymbol{\lambda_3}$ (Row 2) and apply them in the Shannon formula (Row 3) for a result of 1.5 hbit.

Of special importance is that the λ-quotient in the Shannon formula eliminates any dimension. For example, whether we say $\boldsymbol{y}$ is measured in energy units like Joule or in amounts of any money, currency or income value, the quotient λ is always dimensionless. The Shannon formula uses pure ratios for λ that are smaller than 1. Since logarithms of ratios smaller than 1 are negative, the Shannon formula needs the negative sign for converting results into a positive number. This is only a convention, since humans prefer positive numbers.

This flexibility of the Shannon formula is of significant importance for harmonizing the physical and economic view in general. From a physics standpoint we can say that we send a small amount of energy from the control panel to the production process $\boldsymbol{R}$ through channel $\boldsymbol{y_i}$ **(Figure 2**). Similarly, we can substitute energy units with different amounts of currency (€, US-$ or any other currency unit) to pay for the required processes at the $\boldsymbol{R}$-side of our model. In this case, there is no direct physical interaction between $\boldsymbol{\Phi}$ and $\boldsymbol{R}$. It is only necessary that each $\boldsymbol{y_i}$ is proportionally reflected in the sum of all $\boldsymbol{y_i}$.

In summary: The measure of human bit is free of scaling. It is determined only by the "decisions" through which humans influence reality by choosing channels.

We are now close to reconcile the abstract system $\boldsymbol{\Phi}$ of **Figure 2** to how humans make economic decisions. Let us assume that the complete control panel of **Figure 2** is contained within the human brain (ore in a community of human brains). We don't need to know how the decision processes are established. It is sufficient to see that human decision making influences the world by having some economic effects.

We now arrived at the threshold where economics becomes its own science and close to the point of determining the x-coordinate measure of our **T-h** diagram.

For the following analysis we shall differentiate between knowledge and competences.

Knowledge is the human ex ante ability to select some specific skills from a number of possible skills and to decide how much of each skill is needed to achieve a certain economic outcome. Therefore, knowledge is necessary to select the channels discussed as part of **Figure 2** and decide on their intensity by adjusting the "dials".

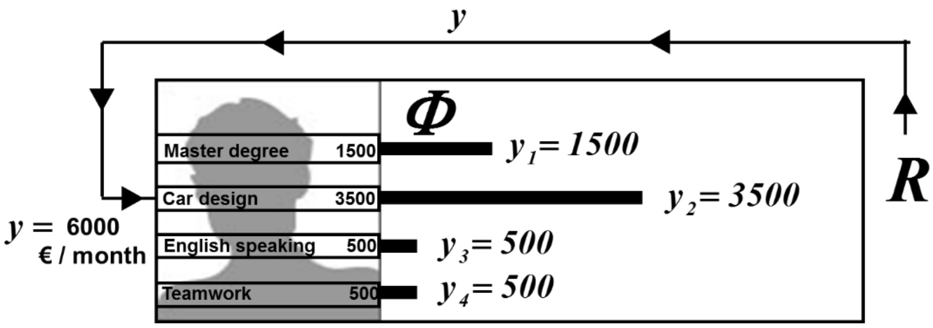
Since the term knowledge is rather general, we refer to the specific form of knowledge used in our ***Φ*-*R*** model as “operable knowledge”. Operable knowledge denotes the knowledge required to selecting the necessary competencies to achieve a desired economic outcome. It is this form of knowledge that is the basis for our Shannon formula analysis.

Competence is the human ex post ability to control different processes. As such we can say that the output channels y_P of the control panel ***Φ*** are in fact competencies since they control what acts on ***R***. By applying the Shannon formula to it we derive a measure of the operable knowledge which has ex ante been necessary for choosing the competences.

The human bit (hbit)

The Shannon formula results in the measure ***h*** representing the unknown decision making processes that take place in the control panel ***Φ***. We know that we are free to use any unit-measure for evaluating the channel outputs $y_1, y_2 .. y_p$. In economics the return humans get for their decision making process is measured as income (wages) ***y***. In other words, the resulting measure for human economic activity is “money units per time period”.

The outcome of the decision processes in our control panel ***Φ*** are symbolized by y_i. For example, if one helps to build a house he combines ex ante many possible (not actual) physical processes. He should be able to interpret some information from the blueprints, be able to arrange his work with other humans etc. In economic terms we speak of human competencies that ex post are applied to achieve economic results. Usually, competences are evaluated and rewarded through wages. That is the generated income ***y*** that individuals receive for their labor.



Row 1: Money Amount: m = (6000 € / time) * time = 6000 €.

Row 2: Human Potential: h = 1.55 hbit (human bit)

Row 3: Economic Temperature: $T = m / h = \frac{6000}{1.55} = 38.71\, T^E$

Row 4: Used Unit of Economic Temperature: $1\, T^E = 100\text{ €} / 1\, hbit$

Figure 4: Φ -Model used for economic active individuals

With **Figure 4** we show how income could be distributed across competencies and how we can apply the Shannon formula to it.

Figure 4 is related to **Figure 2**. It symbolizes an individual that earns a monthly income of ***y = 6000 EUR / month***. This income is generated from the output of the economic production system ***R*** (which for simplicity reasons is all represented by the letter ***R***). Obviously, the economic production system needs the operable knowledge of the individual to select and combine ex ante the right skills (channels) that lead to the ex post evaluated competencies through wages that produce goods or provide services.

We see in **Figure 4** that the masters certificate contributes 1500 €, the specific design ability $3500, speaking English and team ability each 500 € per month to the individuals' total earning potential. We call the distributed income over competencies a competence profile or operable knowledge profile. Consequently, we may thus refer to it as a knowledge function, which is comparable to the sign ***f*** in **Figure 2**.

The monetary value assigned to each competency is determined by the individual's employer based on the premise that they will best know what each competency is worth to them. The result is shown in **Figure 4** where we distribute the input ***y*** to its individual parts. By applying the Shannon formula to this distribution we get the human potential ***h***. As such, ***h*** is a measure for the knowledge potential that humans can utilize.

In summary, **Figure 4** demonstrates that operable knowledge is a result of human intellect and a process that takes place in the human brain. Human potential is a measure of its output and therefore a representation of its ex ante cause. We have found a measure ***h*** of operable knowledge for the x-axis of our *T*-*h*-Diagram (see **Figure 1**, page 4).

The economic temperature

By combining the human potential ***h*** - as a new economic quantity – with known economic quantities we gain new economic insights. We start with the quotient of money to human potential.

Conventionally, the quotient of money per product or service is referred to as its price. We say: Supply and demand determines price. That is a typical ex-post situation. Supply and demand have settled the price.

These ex-post situation of a settled price is preceded by its ex-ante use of operable knowledge. For example, the products and services in a standardized market basket of products and services as defined by Wicksell [1], are evaluated by their ex-post prices. The basket's composition is determined by humans' ex-ante ability (knowledge).

The quotient of money to operable knowledge is a new economic relationship between the ex-ante potential of knowledge and its ex-post measurable output (monetary value) and is referred to as "Economic Temperature".

This term has strong ties to physics (see page 29) and is the desired y-axis quantity of our diagram in **Figure 1**, page 4.

If we use the newly introduced unit economic temperature $\mathbf{T^E}$ in **Figure 4** we get 233.5 $\mathbf{T^E}$ (233.5 economic degrees). We thus have a comparable basis to measure the value of human decision processes (human knowledge). We can apply this measure internationally by using official exchange rates for currencies.

Income and economic temperature

Row 1 of **Formula 2** shows the three different ways to write the formula $\boldsymbol{T = m / h}$. Since it combines the fundamental economic measures money and knowledge we call it the second fundamental law of economics. The first law from our context is the distribution of income to consumption and savings ($\boldsymbol{Y = C + S}$).

Row 1's formulas always result in a hyperbola if m = constant. Such a hyperbola is shown in our T-h diagram of **Figure 1**, page 4 and on the right side of **Figure 5**, page 13.

$$\textbf{Row 1:}\quad m = T \cdot h \quad \leftrightarrow \quad T = \frac{m}{h} \quad \leftrightarrow \quad h = \frac{T}{m}$$

$$\textbf{Row 2:}\quad \frac{y_1}{y_0} = \frac{\frac{m_1}{year}}{\frac{m_2}{year}} = \frac{m_1}{m_2} = \frac{T_1 \cdot h_1}{T_2 \cdot h_2} \quad \leftrightarrow \quad \frac{y_1}{y_0} = \frac{T_1 \cdot h_1}{T_2 \cdot h_2}$$

Formula 2: Quotient and time development of income

The formula in Row 2 sets the income $\boldsymbol{y_1}$ in relation to the income $\boldsymbol{y_0}$ of the preceding period and thus establishes a time dependency of income $\boldsymbol{y}$. The quotient eliminates the time basis of the income (year) and we can use the right side expression in row 2 for income development. Keeping $\boldsymbol{y_0}$, $\boldsymbol{y_1}$ constant, results in the two related hyperbolas of row 2. That is shown in **Figure 5**, page 13 on the lower right side diagram. In relation to our defined objective we have to analyze the mathematical relations between these two hyperbolas.

For this, it helps to look at sharp and broad distributions as illustrated on the left side of **Figure 5**.

A sharp distribution is shown in the upper part (left side) of **Figure 5**. A sharp distribution means that some specific competences dominate the appearance of the distribution with their large values. The economic interpretation is that such a distribution characterizes individuals as experts, like it is the case for scientists, football-players etc. Highly valued competence profiles commonly appear with economically active individuals. Free market economies prefers sharp distributions as they need specific competencies. **Figure 4** is an example of a sharp distribution.

A broad distribution is shown in the lower part (left side) of **Figure 5**. A broad distribution means that all the competencies are valued similarly. No specific competence dominates the appearance of the distribution. The economic interpretation is that such a distribution represents an individual who is a generalist or who has not yet fully developed newly acquired competences. Broad competences appear when individuals undergo a longer education where they learn new competencies.

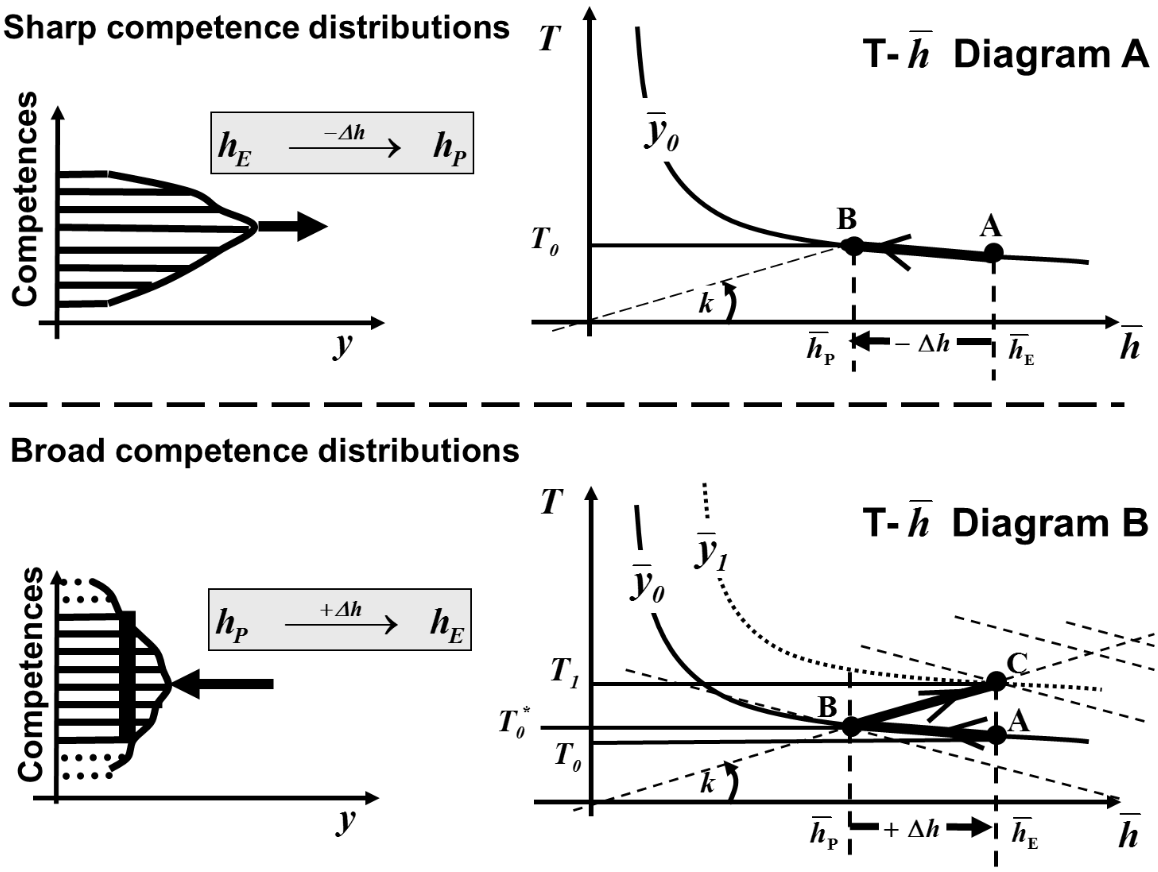


Figure 5: Distributions and T-h-Diagrams

From our T-h Diagrams of **Figure 5** we see that large ***h*** values are situated further to the right of the x-axis where the values of the hyperbola are lower. The opposite is true when moving left on the x-axis: **h** values are lower while the hyperbola values increase.

The largest human potential h_{max} is achieved when competencies equally contribute to the total income. This scenario is symbolized by the thick black line in the left lower part of **Figure 5**. In this case the number of competences L determine the maximal human potential and the Shannon formula is simplified to the expression $h_{max} = ld\ L$. For example, if we determine h_{max} for the distribution of **Figure 4** we get for $L = 4$: $h_{max} = 2\ hbit$. Since the distribution there is sharper we get the lower value of $h = 1.55\ hbit$.

As a direct result of the formula $T = m / h$ (with m = y • year, see **Formula 2**) the value of the temperature increases with decreasing human potential and vice versa. That means sharp distributions present higher temperatures versus broader distributions. The economic interpretation is: Sharper distributions present human bits of competencies that contribute a larger portion to total income than others. In other words: Sharp distributions contain higher human bit values because free market forces value these competencies higher.

In summary: T_{min} for h_{max} and vice versa T_{max} for h_{min}. This is all shown in the **T-h** diagrams.

A deeper analyses shows that the lowest possible value $h_{min} = 1\ hbit$ arises when we only use one competency for controlling a complex system [7]. In this case the economic temperature is directly proportional to its evaluated money output. The individual knows exactly the one competency that is needed to control a complex economic system resulting in output y.

Education and income development

We can now apply our findings to national economies. We achieve new insights into the economic mechanisms at work in societies with market oriented economies. The missing link between work and education of the Keynesian economic framework will be closed. The mathematical results of our model will show that in the long run those market economies that continuously innovate and foster human education (the competences of its individuals) will dominate. This offers new possibilities to overcome stagnation.

The right side of **Figure 5** depict T-$\bar{h}$ -diagrams. The y-axis presents the T-value and the x-axis the average $\bar{h}$ -values. Average values are symbolized by its upper score. We get $\bar{h}$ by adding all the h-values of the N individuals in a society and divide its sum by N. We derive the average income $\bar{y}$ in the same way. In a first approximation we can say, the wealth (prosperity) of a society depends on the high of its average income.

The advantage of such diagrams is that the average income $\bar{y}$ is a constant for the hyperbola as shown for $\bar{y}_0$ in the upper diagram. A higher average income $\bar{y}_1$ curve is shown on the bottom diagram. The points of the hyperbolas represent all the possible combinations of the specific T, h pairs**.** The product of the pairs defines the fixed income $\bar{y}_0$ res. $\bar{y}_1$. With the T-$\bar{h}$ -diagrams we now have a new set of methods for analyzing national economies. The well-known economic diagrams which, for example, appear in the macroeconomic (Keynesian) models have thus to be completed by T-$\bar{h}$ -diagrams to show the connection between knowledge and economic measures.

The question that now arises is: How can we move from a hyperbola with lower average income (Diagram **A**) to one with higher income (Diagram **B**)? A possible path **A**, **B, C** is shown in Diagram **B**. In an initial abstract analysis we describe the path as follows: We start at point **A** which is characterized by constant income $\bar{y}_0$ and all its possible T-h-pairs. From there we move at a constant rate $\bar{y}_0$ from $\bar{h}_E$ to the lower value $\bar{h}_p$ at Point **B** and thus increase the economic temperature from T_0^* at point **A** to T_0 at point **B**.

We now introduce a new hyperbola with the higher average income $\bar{y}_1$ into the diagram (see lower part of **Figure 5**) and determine how we can reach it. We know that the specific values of the average human knowledge potential $\bar{h}_E, \bar{h}_P$ are realistic since they form the foundation for generating the previous (ex-post known) average income $\bar{y}_0$. We assume that they are the limiting values for that society and introduce two vertical lines (the dashed line at $\bar{h}_E, \bar{h}_P$) into the diagram. The intersection at $\bar{y}_1$ marks the point that we can reach. We connect the points **B** and **C** with a straight line which is characterized by a constant rise ***k*** (positive gradient).

The following analysis of ***k*** will reveal the quadratic dependence of average income ***y*** (prosperity, wealth) to the average ***h***-values.

Let us look back to **Figure 2.** We observe additional channels called y_{P+1} up to y_P in the control panel which thus far had no relevance in our analysis. Let us assume that some of them will open new possibilities for increasing the output of ***R***. These additional channels represent unrealized innovative potential. If we experiment with more channels we can test if those channels will increase output by simply introducing more elements into the Shannon formula which in turn increases the human potential ***h***. Some of the competences will not survive in the ***R***-System. As such, ***h*** will decline based on competitive market principles. Some of the new competences, on the other hand, will be adopted as they contribute to a higher output of ***R***.

Individuals who want to increase their human potential ***h*** have to add new competencies to their old ones. That means, they have to learn. The new competencies have to prevail the competitive market forces by resulting in the production of better, cheaper, newer products or services. This is represented by the path **A** to **B** to **C**.

At **A** we start with a high average human potential of $\bar{h}_E$. We assume this value is established by the education system of a society. The high value is given by the Shannon formula since there are many additional competences available. These new competences appear in the market economy where they will be tested. Only the effective competencies will survive. Thereby, the high human potential $\bar{h}_E$ brought about by the education sector is reduced by market competition to the value $\bar{h}_P$. In the ***T-h*** diagram we have followed the path from **A** to **B**.

We call the path from ***A*** to ***B*** the rationalization path since we achieve the same economic output (the average income) by reducing the required human potential.

We call the path from ***B*** to ***C*** the innovative pass since we introduce new competences (add new channels) which increases the human potential and as a result leads to higher income.

In real economies, both processes are intertwined and we have not been able to separate them. Both processes can be clearly analyzed with the methods presented here.

The quadratic dependence between income and operable knowledge.

In row 1 of **Formula 3** we see the formula for the constant gradient ***k*** with two expressions taken directly from diagram **Figure 5.** page 13. In the right side of row 1 we use equations of **Formula 2** (page 12) and take into account constant time periods. That means we can use the expression $\bar{y} = \boldsymbol{T} \cdot \bar{\boldsymbol{h}}$. It presents for constant $\bar{y}_0$ resp. $\bar{y}_1$ all the possible combinations of the pairs $\boldsymbol{T}, \bar{\boldsymbol{h}}$. That means, through our T-h diagram we know all the values of economic temperature ***T*** and average human potential $\bar{\boldsymbol{h}}$ that fix a constant average income $\bar{\boldsymbol{y}}$. Combining these formulas with the expressions for ***k*** leads to the formulas in row 2 and 3. In row 4 we combine the right side of the expression in row 2 and 3 to arrive at the ratio ***u*** which is the measure of average income growth. Some simple mathematical transformation leads to the quadratic expression on the right side of row 4. In row 5 we have simplified the formula to the expression $\boldsymbol{u} = \boldsymbol{v}^2$. Resulting Row 6 shows that: If income ***y*** shall grow by 3%, the human potential ***h*** must grow by 1.5%.

$$1: \quad k = \frac{T_0}{\bar{h}_P} = \frac{T_1}{\bar{h}_E} \quad ; \quad \bar{y}_0 = T_0 \bar{h}_P \quad ; \quad \bar{y}_1 = T_1 \bar{h}_P \quad \textbf{per period!}$$

$$2: \quad k = \frac{T_0}{\bar{h}_P} = \frac{\frac{\bar{y}_0}{\bar{h}_P}}{\bar{h}_P} = \frac{\bar{y}_0}{\bar{h}_p^2} \quad \rightarrow \quad \bar{y}_0 = k\,\bar{h}_p^2$$

$$3: \quad k = \frac{T_1}{\hat{h}_E} = \frac{\frac{\bar{y}_1}{\bar{h}_E}}{\bar{h}_E} = \frac{\bar{y}_1}{\bar{h}_E^2} \quad \rightarrow \quad \bar{y}_1 = k\,\bar{h}_E^2$$

$$4: \quad u = \frac{\bar{y}_1}{\bar{y}_0} = \frac{k\,\bar{h}_E^2}{k\,\bar{h}_p^2} = \frac{\bar{h}_E^2}{\bar{h}_p^2} = \left(\frac{\bar{h}_E}{\bar{h}_P}\right)^2$$

$$5: \quad \bar{y}_1 = v^2 \cdot \bar{y}_0 \quad ; \quad \bar{h}_E = v \cdot \bar{h}_P \quad ; \quad \textbf{with}: \quad v = \frac{\bar{h}_E}{\bar{h}_P}$$

$$6: \quad u = v^2 \qquad \bar{h}_E = \bar{h}_P \sqrt{u}$$

$$7: \quad h_E = h_P \sqrt{u} \quad ; \ \textbf{for} \quad u = 1.03 \quad \rightarrow \quad v = \sqrt{u} = 1.015$$

Formula 3: Development of quadratic income growth

What does this result tell us?

The quadratic dependency is true for the condition $\boldsymbol{k}$ = constant (see diagrams in **Figure 5**, page 13). The gradient $\boldsymbol{k}$ is defined by the expression $\boldsymbol{k = T / h}$. If we move from **B** to **C** to achieve a higher income level, the value of $\boldsymbol{T}$ (the value or price of our competencies) must also grow. So, the constancy of $\boldsymbol{k}$ says, the price of a human bit (its temperature) shall be constant for all used human bit. Or in other words: The new incoming human bits should be as valuable as the old ones. This results in the quadratic relationship shown in Rows 2 and 3 of **Formula 3**. In other words, the growth of $\boldsymbol{y}$ is developing quadratic in relation to the constant $\boldsymbol{k}$.

We try to visualize the effect. Imagine a water well. If the radius $\boldsymbol{h}$ of the well opening increases linear, the increase of the opening area grows quadratic by $\boldsymbol{\pi h^2}$. We can imagine water pouring out of the well by dividing its flow $\boldsymbol{y}$ into many thin strings, each contributing a constant flow of water. Each string is characterized by a constant $\boldsymbol{k}$, which is given by $\boldsymbol{k = y / \pi h^2}$. So, we get $\boldsymbol{y = k \cdot \pi h^2}$. That means the well output increases quadratic to $\boldsymbol{h}$. We call $\boldsymbol{k}$ the viability. A constant viability always produces a quadratic increase of water output of the well by increasing its radius.

Economically speaking, we can say: Our human operable knowledge measured by ***h*** is like a well of money. If we extend the well by adding new human potential units (hbits) the money output will increase quadratic with the additional units. In other words, humans with their knowledge are the wells of values measured in money units.

In **Formula 4** we repeat the formula of line 6 of Formula 3 and rid it of all unnecessary mathematical symbols.

$$\boldsymbol{h_E = h_P \cdot \sqrt{u}}$$

Formula 4: Income and knowledge development in societies

The formula is interpreted as follows: If a society wishes to increase its average income by the factor u (for example 3%), the economically used human potential $\boldsymbol{h_P}$ has to be increased by the factor $\sqrt{\boldsymbol{u}}$ (in this example 1.5%). Thereby, we have formulated a general law that shows the dependency between income and knowledge development for societies.

Considering the entire economic system of a society

The completion of the fundamental economic formulas.

In a next step we consider the entire economy of a society, which is its national economy. The sum of the total output of goods and services is known as the Gross National Product (**GNP**) and must be equivalent to the national income: ***Y = GNP***[3]. For

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[3] We do not consider aspects of savings, investments etc. We concentrate on the fundamental economic relationships which are always true independent of specific aspects.

simplicity we consider a closed market system where ***Y*** of the global market is equivalent to total production output (no export, import). On the global level we only get what we have produced. As such, if we add all individual incomes of a society we derive the national income ***Y***. We can also add individuals' human potential and get the total amount ***H*** of human potential in a human society. By dividing both values by the number of the relevant individuals we derive the average values $\bar{y}, \bar{h}$.

With this last step we can complete the first fundamental macroeconomic formula $y = c + s$ which are used in nearly all analytical models for national economies.

$$\begin{aligned} 1: &\qquad y_0 = c_0 + s_0 \\ 2: &\quad y_1 = u \cdot y_0 = v^2 \cdot (c_0 + s_0) \end{aligned}$$

Formula 5: Extending the description frame of economic formulas.

In **Formula 5** the small letters represent the respective averages of the values. The first line shows the known formula where the subscript indicates a fixed period (also time point). It tells us nothing about the time development of income. It only shows us how income in a fixed economic period is distributed to consume and savings. This is a typical ex post situation. In row 2 we expand the formula by its time development. That means we are looking for the time dependency of income. Therefore, we use the derived expression in line 5 of **Formula 3** (page 18). The left side of row 2 is the typical ex-ante view, it shows the possible future average income y_1. The right side shows how it dependents on its previous (ex-post) income y_0. The factor v^2 indicates the influence of knowledge.

With row 2 of **Formula 5** we have, for the first time, formulated the equation which extends the macroeconomic theoretical frame by including knowledge as the driving potential of economic development.

By looking back to our ***Φ-R*** Model of **Figure 2** we can describe our findings in the following way: There are ***L*** available channels to control ***R***. Only ***P*** of these channels are in use. A potential of ***L-P*** competencies are thus available to test.

It is obvious that the larger the potential of ***L-P*** competences, the higher the probability of selecting the appropriate competencies for controlling the economic system ***R*** to achieve a higher income level. In other words, the broader the educational background of the individuals in a society, the better the chance that the right knowledge can be applied inside the Φ construct.

A look back to **Figure 2**, page 5 shows what national economies of today lack. The Φ-**R** model represents a closed feedback loop (see page 25). That is, the outcome of **R** impacts the control panel side Φ which also includes the unused **L - P** Channels. In today's economies those (students, scholars etc.) who provide additional competencies which enlarge the difference (***L-P***) are excluded from the feedback loop. In our today's economies the required ex-ante competencies are not promoted through economic success. This practice is contradictory to market economic principles and socially unfair.

Balancing between education and stagnation

In most western economies, a portion of a person's wage is deducted for government run social services (unemployment insurance etc.). In case of unemployment, individuals receive money from this pot to bridge the time between jobs. If this money was instead used to pay individuals to acquire new competencies, it would foster a dynamic exchange between the economy and the education sector to drive quadratic income growth.

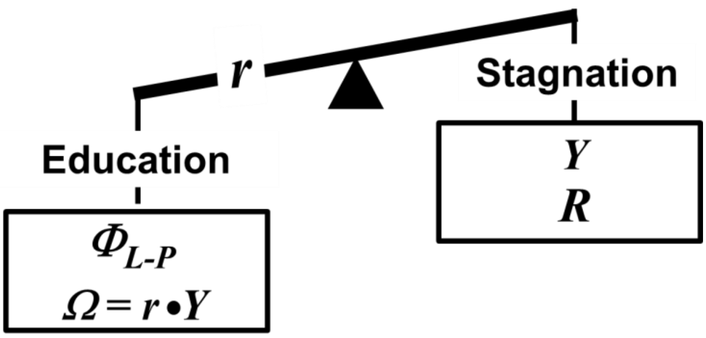

Figure 6: Balancing between education and stagnation

Figure 6 symbolizes a balanced system. It shows how we can counteract stagnation. On the right side of the scale is our economic production system ***R*** (see also **Figure**

2). On the left side is our known **Φ**-System. Here we try to enlarge the number ***L*** of available competences and skills. **R** produces the total income ***Y***. Thereof the $\boldsymbol{\Omega = r\,Y}$ part is fed into the education sector as a part of the **Φ**-System in which we pay the education of individuals which acquire (learn, train, test ..) new competencies. Thereby, we enlarge the amount ***L*** of testable new competencies and skills (see **Figure 2**). The length ***r*** of the scale beam in **Figure 6**symbolizes how much of the total income ***Y*** is feed into the education system to counterbalance an upcoming stagnation. The feedback parameter ***r*** determines how much of the income is used for education efforts. It is set through negotiation between the different social stakeholders (employees, unions, entrepreneurs, students …) which are represented by their respective social organizations. Our derivation of the quadratic dependency between the income and education measures shows that a feedback loop between the education system and the market economy is of advantage.

We can reach the following advantages for real national economics:

- The economic success is regulated by the breadth of competences offered in the education sector of societies.
- The broader the educational background of individuals – at least the broader the cultural background – the greater the chance to achieve higher income levels.
- Individuals who through a formal learning process acquire new competencies that are relevant in the market economy are rewarded through income.

We can say: Education and work are two sides of the same coin.

A thus far unknown consequence becomes apparent: An educated society will develop more diversified products.

This is true because educated individuals, for example educated in music, demand higher quality instruments etc. The same is true for the food industry; knowledgeable individuals will demand higher quality and healthier food. On the other hand, consider the production of dog food. Diversification of dog food could be minimal. As such, dog food is an excellent example of a product ideally suited for mass production. The more educated individuals are, the more they will demand diversified products and services and thus foster internal economic growth.

It is possible to achieve sustained internal economic growth of 3% based on the formula derived above. As a result of the generated internal growth, we can pay down national debts. The current reliance on external growth will not enable us to maintain the levels of national debt today.

The zig zag walk

The practical concept of increasing income is like a zig zag walk through the ***T-h***-diagram. This is shown in **Figure 7.**

We start our walk at point $\boldsymbol{A}$ with a large amount of learned competences $\bar{\boldsymbol{h}}_E$ available for testing. After sharpening the competency profiles on this rationalization path we reach point $\boldsymbol{B}$ with a reduced human potential $\bar{\boldsymbol{h}}_P$. Point $\boldsymbol{B}$ lies on a line with gradient $\boldsymbol{k}_0$. By testing additional new competences which are offered through the education system we walk the constant gradient $\boldsymbol{k}_0$ up (we use a constant viability) to the right until we reach point $\boldsymbol{C}$. New competences made available through the education sector enlarge $\bar{\boldsymbol{h}}_P$ to $\bar{\boldsymbol{h}}_E$ (innovative path). We thus created a competence hub. Once again, we sharpen our competencies and reach point $\boldsymbol{D}$. We found a new density of income at $\bar{\boldsymbol{h}}_P$. From point $\boldsymbol{D}$ we follow the line with gradient $\boldsymbol{k}_1$ (we use a higher viability) and start a new zig zag walk to an even higher level of income. Again, our competence hub has worked.

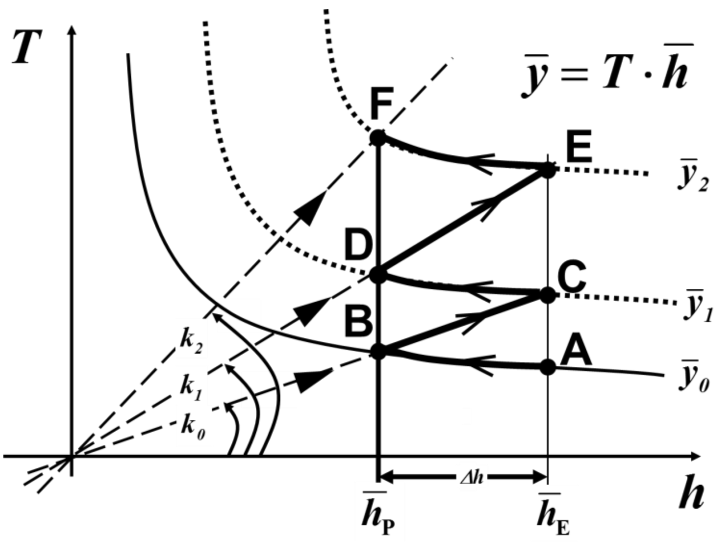

Figure 7: Zig-Zag-Walk of economic income development in T-h-Diagrams.

We can sum up our results: If there is a broad base of competences in a society we will find new Zig-Zag-Walks to increase our income step by step. The competence hub causes a quadratic increase in income. To find higher income levels, we need to promote the education system by allowing it to share the success of the economic system. In other words, since economic success is dependent upon a broad education system (large competence hub) there should be a feedback from the economic system to the education system.

Advantages for developing countries

The increasing gap between rich and poor countries can be reduced if efforts to acquire new competencies by young individuals in developing countries is rewarded with pay. This is funded with foreign hard currencies that the countries exchange to local currency to in turn pay the individuals. Financing the education of young people in developing countries provides that economy a source of hard currency. This will stimulate further investment in their local economy. Instead of funding the construction of a new bridge directly, it makes more sense to pay this money to individuals furthering their education directly. The country can finance the bridge itself through the exchange of the hard currency income from education.

Ultimately, the funds used to finance individual education in developing countries flows back into the system of the industrialized nations since investive products can be purchased with it.

The side effect is, that political systems are stabilized through education. It would be difficult for autocratic leaders to prevent a broader education of their population. Merely religious despots would be opposed to present broader knowledge to their followers.

Remarks about the used feed back system

Figure 2 (page 5) shows the ***Φ-R***-system as a feedback system in which the feedback unit is money. This feedback loop was missing in the general cybernetic models of the 1970s [9]. The emphasis of cybernetic models was on their direct feedback.

This article introduces a uniform cybernetic feedback model that applies to physical, biological and economical (human) systems.

Overview of cybernetic models

During the Second World War, physical feedback processes were intensively analyzed to help with air defence [4], [9].

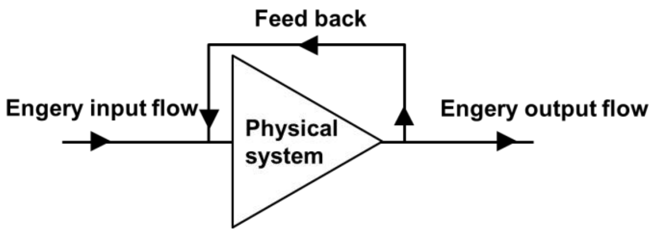

Figure 8: Pure physical feedback system.

The principal of physical feedback systems is illustrated in **Figure 8.** A flow of energy is introduced to the physical system form the left side (i.e. electric current). The energy flow transfers through the system and appears as an output on the right side.

If some part of this energy flow is used to manipulate the input side, we speak of a pure physical feedback system. These physical feedback systems shaped cybernetics in its earliest form.

Figure 9 illustrates a feedback system in which no direct energy output is used to control the physical system. Instead, information is extracted from the output and is combined with external data to produce a feedback for controlling the input of the system. Assume the physical system is a cruise missile which appears on a radar screen. A second missile is launched in defence to destroy the first missile. This missile uses no part of the energy flow output from the first cruise missile. Only information from the radar screen possibly linked with other external data like wind speed, direction, temperature is used to steer the defence missile. Software may be used in the informal system part of **Figure 9** to combine all relevant information in the feedback loop to destroy the attacking cruise missile.

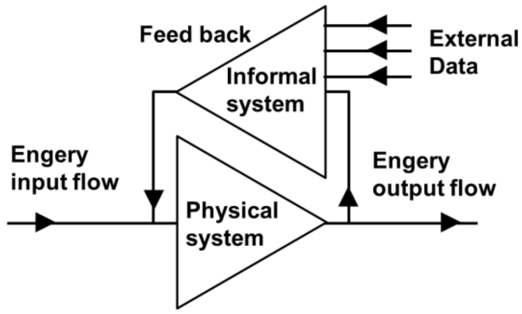

Figure 9: Informal feed back system.

Figure 9 represents also a large number of biological systems. For instance, a lion hunting a gazelle does not utilize the energy flow output from the gazelle. The lion rather takes the information input of the running gazelle (what he sees with his eyes) and processes it in his brain to determine the path he will take to tackle the gazelle. A bee processes information from a plant blossom (color, scent) in its brain to feed on its pollen. As such, **Figure 9** represents all biological systems in which information gathered and assembled through the nervous system to generate feedback.

All biological systems are stimuli driven. If these stimuli are simulated, the system behaves in a predictable manner. Similarly, software controlled systems are driven by data. If such systems are fed with data in a certain manner, identical feedback loops are created.

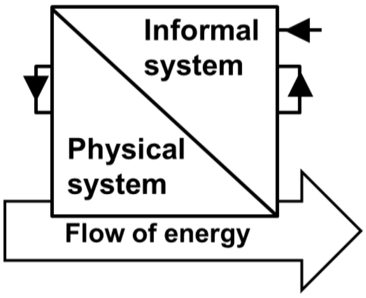

Figure 10: Simplified informal feedback system.

Figure 10 illustrates a simplified version of **Figure 9.** The pure physical system is depicted on the left, the informal on the right side. The flow of energy which is necessary for each physical system is depicted in the bottom of **Figure 10**. The flow of energy shall be influenced by the informal system. These physical-informal feedback systems are governed through their determined nature. The same input scenarios result in like outcomes.

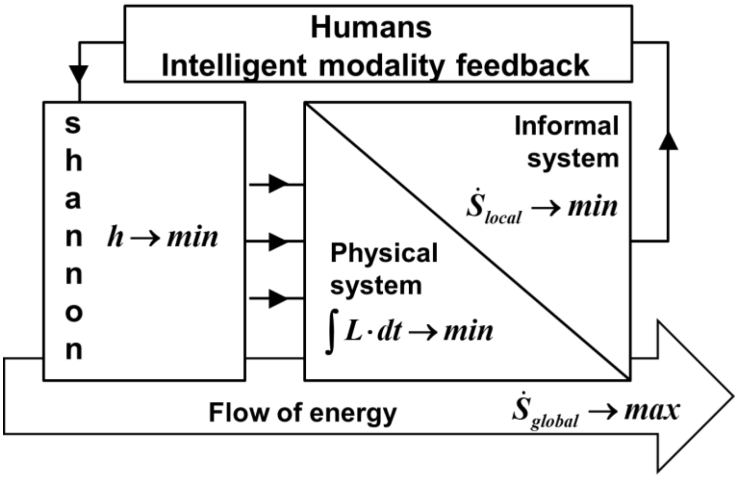

Figure 11: Intelligent modality feedback.

Figure 11 also includes human intelligence in cybernetic feedback models. We call it „Intelligent modality feedback“

The right side depicts the described informal feedback system. In its simplest form, as in our example from **Figure 2**, page 5, only one unit value, i.e. money flow, is maximized. This model is unique in that it allows the use of previously unknown modalities to control the output (engergy flow) throug the feedback loop. This model explains how humans form the world around them in a non predictable way. That is in contradiction to a software that picks one alternative from a pool of many alternatives. Such a software reacts to specific data inputs in much the same way a biological system does in relation to stimuli.

Neural computers, as in development in 2016, venture beyond the structured software previously described. Neural software was used in 2016 to produce unique moves to beat a master GO player.

Since each neural system creates its own neural link structure by learning through its respective task (i.e. GO game), many different neural link structures can be created. As a result, system A would respond to a certain GO board constellation differently than system B. Similarly, system B has a different learning history and has therefore created a different neural link structure which would not produce the same solution as system A. This is because its solution was not ascertainable through the neural link structure of system B. The previously mentioned constraint “similar causes have similar effects” is no criteria for neuronal structures. This is also true for human intelligence. The only criteria that remains to distinguish between the human neuronal system and the digital neuronal system is the control of the flow of energy on which both systems physically rely. Humans can act in the complete surrounding of their local world.

The question arises: how capable are neural intelligent systems in “their world” of digital systems (information technology) in utilizing feedback independent of human input? That means, the neural system should be able to use the web as its “hunting ground” to find information and insight (such as this article) [10].

The model introduced in **Figure 11** allows to specify four of its characteristic formulas.

1. For the flow of energy applies the formula $\dot{S}_{global} \rightarrow max$. It is named the second law of thermodynamics: ***S***, entropy increases. Simplified, this law states that energy moves from higher levels (higher temperature) to lower levels.

2. For the physical system, the formula $\int L \cdot dt \rightarrow min$ holds. The formula applies to all physical systems. Each physical system minimizes ***L***, the difference between its

kinetic and its potential energy (***L*** = ***T*** – ***V***) . That is, a system can only distribute energy over time by reaching a minimum. For this reason water flows down a hillside from higher elevations to lower elevations etc.

3. For the informal systems the formula $\dot{S}_{local} \rightarrow min$ holds true. The formula applies to all biological systems. They concentrate energy locally, whereby the entropy ***S*** is locally minimized. I.e. animals can store food in their stomachs or build nests. The special effect of informal feedback arises by filtering out those possibilities with a specific required energy (to run, fly, hunt etc.) that produce the exact surplus of locally concentrated energy (the nest, stomach, etc.) to maintain the feedback loop. This principle arose from the random process of evolution.

4. For the humans intelligent modality feedback the Shannon formula $h \rightarrow min$ holds true. As described, for each selected channel to influence the feedback system we must determine a value (for example money flow) through which the feedback takes place. The value used is the human bit as determined by the Shannon formula. As previously described (see left side of **Figure 11**) minimization principle applies.

Relationship between economics and physics

Formula 6 shows the relationship between physical und economic values.

$$T_{phy} = \frac{E}{S} \quad ; \quad T_{eco} = \frac{M}{H}$$

Formula 6: Definition of physical and economic temperature

The left side of **Formula 6** defines the physical temperature T_{phy} by the quotient of energy ***E*** to entropy ***S.*** The right side defines the economic temperature T_{eco}. It is the quotient of an amount of money ***M*** to human potential ***H***. In physics, energy ***E*** (more exact the usable difference of energy ΔE) is the potential necessary to bring about an action. In other words, something happens by the transformation of energy from a higher to a lower level. If we assimilate this concept to economics we can say that money ***M*** is also a potential to bring about an action, since we pay for a service or get a product. So, money is similar to energy, both cause actions.

The respective temperature shows how concentrated this potential is. The economic temperature is high with sharp distributions. A sharp distribution means: one (or few) competences are valued high (have a lot of monetary value (income) attached to them), ***H*** is small, the economic temperature T_{eco} is high. If ***S*** the physical entropy is small its usable energy ***E*** is concentrated at a specific location, the physical temperature T_{phy} rises. As such, human potential is comparable to the unit entropy in physics. The smaller the values of ***S, H*** in the denominator of **Formula 6**, the higher the respective temperature.

We can summarize as follows: If money for competences is used in a concentrated fashion, the higher the economic temperature, the more action can be achieved. Similarly, in physics: The more concentrated energy is used (car engine), the higher the physical temperature.

Our mathematical derivation of the human potential by using the Shannon formula is strongly correlated to how it is used in physics and information technology.

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1996, Helsinki: ESCAT-European SmartCard Price.

1997, Darmstadt: SmartCard-Price of the society for mathematics and computer science (today Fraunhofergesellschaft).

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