Extension of the descriptive framework of economic theories by the introduction of knowledge functions

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Summary: Knowledge is treated as a fundamental cause of economic success. Up to now we have been lacking quantities which would allow knowledge to be taken into consideration in mathematical economic theories. In order to remedy this, knowledge functions are introduced here from which a whole series of quantifiable knowledge characteristics can be derived. On the microeconomic level, the example of a company is used to illustrate the quantitative new insights which can be gained into the knowledge structures of companies when each employee is allocated his own individual knowledge function. On the macroeconomic level, the importance of a wide educational basis of the economic individuals for the competitiveness of a market economy can be proven. The relationship between national income and innovation can be registered and expressed in quantitative terms.

Keywords and Phrases: Bit of knowledge, economic temperature, entropy, evolutionary economy, human capital, human potential, information, innovation, intangible assets, knowledge, knowledge matrix, knowledge perspectives, microeconomics, macroeconomics, profit and loss account, prosperity, Basel II, national income, wealth.

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1 Introduction

Terms such as human capital, intangible assets or intellectual property are attempts to make the knowledge of humans accessible to quantitatively based economic theories. A glance at a speech by the young Hayek in 1936 to the London Club of Economy [2] shows what significance attaches to the "bit of knowledge" and how long the necessity of a quantification of knowledge characteristics has been a recognised but unsolved problem. This problem has far-reaching consequences. For example, we do not know how much knowledge underlies a US dollar or a Euro. This means that we are lacking an important criterion for the comparison of currencies.

The situation in which economic science finds itself regarding the quantification of knowledge was analysed by the American scientific theorist, Thomas S. Kuhn, as early as 1962 . He proved on the basis of numerous historical examples that scientific breakthroughs in a discipline are always preceded by what Kuhn called "puzzle phases". In such a puzzle phase, known definitions or proposals are put together to form new constellations to describe hitherto inexplicable aspects of reality. In this sense, the terms cited at the outset are "puzzle results". Kuhn proves that ultimately it is not possible to eliminate the contradictions, and irreconcilabilities between "puzzle data" and observation data. This puzzle phase thus becomes a preliminary stage for a new paradigm which – if it is found – resolves the irreconcilabilities on a new level of insight, the paradigm. The studies carried out by Kuhn also show how breakthroughs lead to new paradigms (world views): some influential scientists have to make a leap to gain a new view, leaving their familiar scientific foundations and taking a risk. If Kuhn is taken seriously, then economic science is standing before a decisive breakthrough. A look into documents as given in [1,7,8] shows the strong need for the expected break through.

In this sense, the unsolved problem of the quantification of knowledge represents an opportunity for a change of paradigm and we are attempting to make a contribution towards this. The basis for the theory presented under the heading of humatics (compound of HUman science and matheMATICS) is scientifically founded on mathematical methods. An overview is given here. In the meantime a wide range of complementary articles, books and studies is available regarding the practical results of the theory which are dealt with in more detail in [3,4,5]

2 Knowledge functions and operable knowledge characteristics

First it is illustrated which analogies can be drawn between familiar Euclidian spaces of vectors and spaces of functions. Then, on the basis of this, the operator concept is used to show how spaces of functions can be used for the quantitative assessment of complex reality characteristics. Finally, knowledge functions are introduced from which some quantitative characteristics of knowledge are derived with the aid of the operator concept.

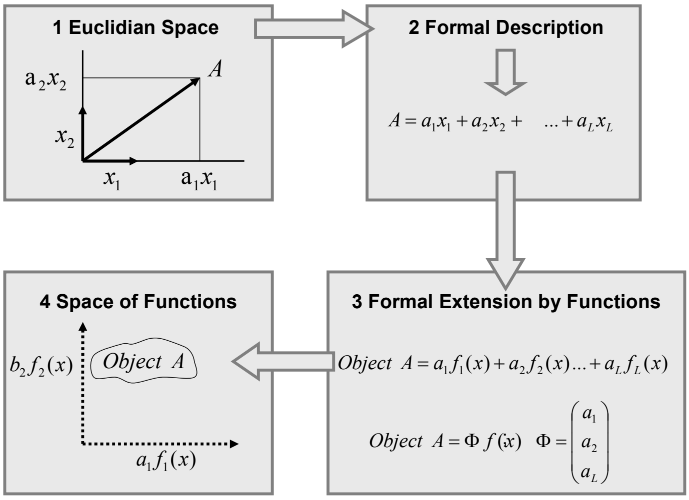


Figure 1: From the graphical Euclidian space to the space of functions

Leaving aside some of the finer mathematical points, the four boxes of Figure 1 represent the analogy between the Euclidian space 1 and the space of functions 4. Box 1 shows how a vector A is represented as a mathematical object in a Euclidian two-dimensional space. It arises as the sum of its axis components (axis projections) which are products of the unit vectors of the axes x_1 and x_2 with numbers a_1 and a_2. This formation of a vector by addition of its components is shown in box 2 in mathematical notation. This can be extended to any number of axes (e.g. L axes in box 2). This results, for example, in a vector in L-dimensional space.

Instead of the coordinate axes with their unit vectors x_1, x_2 .. x_L, functions $f(x_1)$, $f(x_2)$ .. $f(x_L)$ are used as the carrier elements of a space. If these functions are multiplied by numbers – as illustrated in box 3 – the analogy to box 2 is immediately obvious. If, for example, in the simplest case $f(x_1) = x_1$, $f(x_2) = x_2$, .. $f(x_L) = x_L$, the formula in box 2 results as a special case of that in box 3. The mathematical objects (e.g. Object A) which result by addition of functions in accordance with box 3, are also referred to as vectors even though these objects can no longer be represented so graphically as the vectors in box 1. We have hinted at this by the use of the expression Object A in box 3. Mathematicians can now prove that these mathematical objects can be used for calculations in a space of functions in a similar way to vectors in the Euclidian space. This is illustrated symbolically in box 4.

But how can this formal extension of the Euclidian space be used for economic purposes?

Let us assume that each of the functions $f(x_1)$, $f(x_2)$ .. $f(x_L)$ in box 3 is a complicated and indeterminate supply/demand function for some human performances. We could, for example, assume that the human skills and abilities deployed in companies stand in some kind of functional relation to the profits of the company. We can substantiate this in economic terms by pointing out that companies seek out certain skills and abilities in employees and harmonise these in corporate processes in such a way that they can achieve profits on the free market, i.e. win competitions. Accordingly, the salary received by an employee can be regarded as a function of the evaluation of his skills and abilities with which he contributes to the company's profits. On the basis of this principle we can draw up a mathematical object for an employee by evaluating and adding his skills and abilities in terms of the turnover shares u_1 to u_L. We shall see below that such a mathematical object already represents a knowledge function. Instead of taking this microeconomic perspective, the space of functions introduced above could also be used to select a macroeconomic perspective. For this purpose we assume that there is a stock exchange for the evaluation of skills and abilities. This would show the market value of skills and abilities as a function variable in time u(t). By evaluating and then adding the skills and abilities of a person with these time-dependent stock exchange values $u_1(t)$ to $u_2(t)$, we are assessing the time-dependent function of the value of the skills and abilities of a person in terms of the macroeconomic perspective. This would be analogous to the determination of the stock exchange value of a company. As we can see, the addition of functional relationships results in mathematical objects. The important thing is that these objects can be used for calculation. What this actually means is to be illustrated briefly.

Up to now we have stated functions $f(x_1)$, $f(x_2)$ .. $f(x_L)$ as carriers of the space for mathematical objects. How do we interpret the factors a_1, a_2 .. a_L before the functions (see box 3)? Again we leave aside the finer mathematical points and determine that when these functions are enlarged they expand function values and cause them to shrink when they are reduced. Such effects on functions (and many others including rotations and shifts in space) are caused by operators. If we write the factors a_1, a_2 .. a_L in a special form (ultimately matrix form), as shown at the bottom right of box 3, we can say: matrices have the effect of operators on mathematical objects (vectors) in the space of function. This is expressed concisely in the abbreviated form "Object $A = \Phi\ f(x)$". In this case, Φ (Phi) is an operator which influences the function f(x). This formula, stated at the bottom of box 3, says the same as the explicit formulation above it. We can express this formula graphically in this way: if operators (in this case the operator is Φ) influence the space of function, this results in special effects (e.g. expansions, rotations, shifts etc.). We will observe below the special case of a rotation which, in economic terms, turns out to be a change in perspective.

In this brief outline we have described the characteristics of spaces of functions which we require to draw up and exploit knowledge functions. Now we can tackle the concrete compilation of knowledge functions.

2. 1 The economic compilation of knowledge functions

For the compilation of concrete knowledge functions we shall opt here for the microeconomic perspective. The macroeconomic view mentioned above leads to the same results.

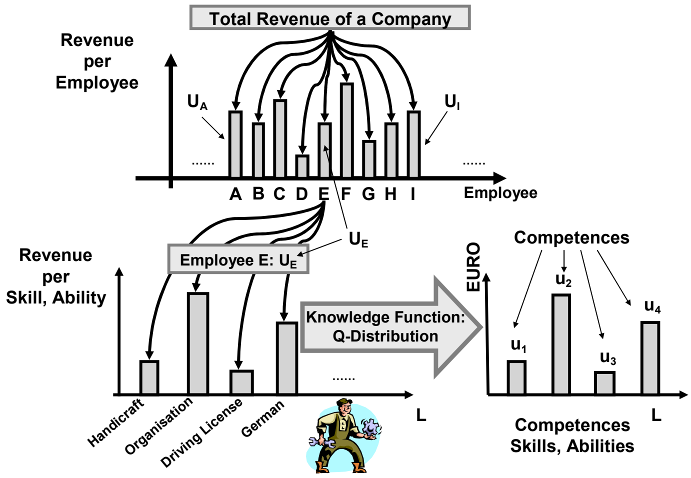


Figure 2: The second distribution of revenue

Humatics assumes that only those companies can survive on the market which deploy the knowledge of their employees to their best advantage in the long term. Thus knowledge within a company stands in a functional relationship to competitive success which, of course, companies measure in terms of their profit. Knowledge manifests itself in people in the way that skills and abilities are used. Therefore, we are looking for mathematical objects in which skills and abilities are attributed to profit. In an initial step we divide the total revenue of a company over the individual employees. This can be shown in diagrams such as in the upper section of Figure 2. Each of the letters A to I in the X-axis symbolises an employee, from whom the company hopes to earn a specific proportion (U_A to U_I) of its revenue. But this per capita revenue does not give us the reason behind the different revenue contributions of different employees. This is only clear from a second distribution (bottom of Figure 2), as introduced by humatics. There the individual employee revenue (for example U_E) is apportioned to the skills and abilities with which each employee contributes to the company revenue. The letter E symbolises in Figure 2 a janitor for whom in this second distribution the highest evaluation is given to his organisational talent and the lowest to his driving licence, while his learned, handicraft skill is evaluated only slightly higher than his driving licence. This could be because the janitor is responsible for the organisation and coordination of other workers so his organisational ability is actually more in demand than his handicraft skill.

The result of this second distribution of revenue is called the knowledge function. The two-dimensional representation of this (as shown in figure 2 at the bottom right) is referred to as a Q-distribution. The skills and abilities lined up beside each other in a Q-distribution are called constituents. We refer to evaluated constituents as competences (according to our analyses above it would be more accurate to speak of competence functions). Each of these competences has some functional relationship to the per capita revenue generated by the janitor which in turn has a functional relationship to the total revenue. The details of the functional relationship do not concern us here. We evaluate each of them with a specific contribution to revenue (in this case: u_1 to u_4). In total, the evaluated competences add up to the revenue per employee.

Companies operating on the market must have already mastered the correct evaluation of skills and abilities, otherwise they would never have been able to assert themselves against the competition on a free market. This means that humatics represents in mathematical structures what is already everyday practice.

2. 2 Operators, knowledge functions and knowledge characteristics

As shown above, operators can be applied to knowledge functions. Depending on the operator, there are varying results which can be interpreted as knowledge characteristics. In the meantime we are aware of more than 24 quantifiable knowledge characteristics, some of which are shown in Figure 3.

The column "Operable Knowledge" shows the defined operable knowledge characteristics. The other columns contain the Symbols, Definitions (dimensions) and the main mathematical operations. The column "Usual Name" shows that the usual use of language is not clearly defined and that in some cases there is a lack of suitable words. There are no adequate words for example for stability and effectivity of knowledge. This is because squares occur in the definition (see column Definitions) and it is difficult to describe such values in language. So, each operable knowledge characteristic is backed by a defined quantity which characterises a certain aspect of knowledge. Figure 3 shows: the complexity of knowledge is manifested in the wide range of operable knowledge characteristics. Thus humatics as the theory of operable knowledge creates its own "clean room" through its mathematical methods. This is of inestimable benefit. In the case of doubt, the mathematical methods behind an operable knowledge characteristic provide clarity. We can assume that in the meantime the diverse operable knowledge characteristics describe knowledge in its complexity more adequately than the language used up to now.

No	Operable Knowledge	Usual Name	Symbol	Definition (Dimension)	Used Operation
1	Harmonisation	Establishing a Team	Q(L)	Knowledge Function	Addition
2	Human Potential	Amount of Knowledge	H	hbit human bit	Extended Shannon Formula
3	Economic Temperatur	Effect of Knowledge	T	$\frac{\text{money flow}}{\text{hbit}}$	Division
4	Specifity	Specialisation	μ (mu)	Quotient $0 < \mu < 1$	Logarithm Division
5	Shift of Perspective	Knowledge Perspective	Q(L)	Knowledge Function	Rotation
6	Stability	No	S	$\frac{\text{hbit}^2}{\text{money flow}}$	Potency Division
7	Effectivity	No	E	$\frac{\text{money flow}}{\text{hbit}^2}$	Division Potency
8	Constituent	Competence	L	Number	Counting
9	Competence Grade	Competence	Φ (Phi)	hb (human beings)	Matrix-operation
10	Redundancy	Potential of Rationlisation	R	Quotient $0 < R$	Division
11	Innovation Impulse	Innovation	∇ (Nabla)	hbit $0 < \nabla < 1$	Extended Shannon

Figure 3: Overview of Operable Knowledge Characteristics

In Figure 3 the so-called external characteristics of knowledge functions are shown in lines 1 to 10. These arise from the interaction of knowledge between people, i.e. they can be explained by the mathematical combination of Q-distributions. In contrast to the external knowledge characteristics, Line 11 shows an internal characteristic in the form of the innovation impulse. This does not require any link with other Q-distributions, because innovation – as a natural peculiarity of knowledge - can only be determined from the inner structure of knowledge functions. We will only concern ourselves here with the external characteristics of knowledge functions and concentrate on the positions 1, 2, 3 and 5 of Figure 3.

Examples of Quantifiable Characteristics of Knowledge Functions

It was shown above that certain quantities can be gained from knowledge functions by the application of operators. The Shannon formula can be regarded as such an operator (see formula line 2 in the upper part of Figure 4). The Shannon formula has been used up to now in communication science for the determination of quantities of information and is the basis for the expression of such quantities in bit or byte units.

2. 3 Human potential H and economic temperature T

$$1: \quad H = \mathbf{H}\,Q$$

$$2: \quad Shannon \; : \; \mathrm{H} = -\sum_{k=1}^{L} p_k \; ld \; p_k = -\sum_{k=1}^{L} \frac{u_k}{U} \; ld \; \frac{u_k}{U} \; ; \qquad U = \sum_k u_k$$

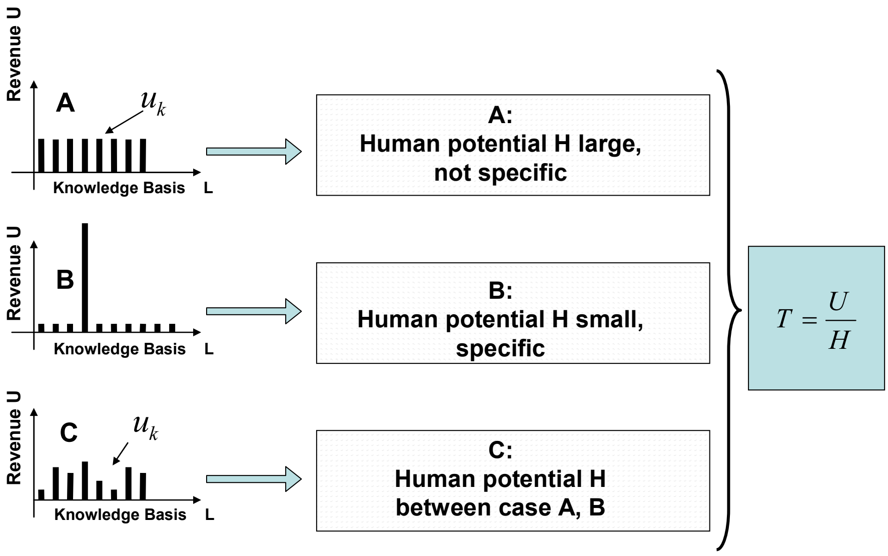


Figure 4: Human potential and Q-distributions

Here we apply the Shannon formula to Q-distributions. In operator notation in formula 1, Figure 4, this is represented as follows: H = **H**Q. The bold-printed **H** indicates an operator, Q represents a Q-distribution as a knowledge function upon which the operator acts. The result H is a numerical value and is referred to as the human potential of a knowledge function. It represents a quantity value for knowledge functions and is expressed in the unit human bit (hbit). Ultimately the formulation H = **H**Q is a symbolic, abbreviated formulation of line 2 of the formula in box 3, Figure 1, page 3.

The human potential H depends on the form of the Q-distribution. This is represented in the three distributions A, B, C of Figure 4. In A the competences are equivalent; the knowledge of this person is not specific. It does, however, contain the greatest potential for development. In this case the operator **H** supplies the maximum H value. This is: H_{max} = ld L, i.e. it is the binary logarithm of the number of constituents. For 8 constituents there are 8 hbits. With this simple correlation, the maximum human potential value H_{max} can immediately be stated for every Q-distribution. In Q-distribution B one competence is evaluated much more highly than the others. The Q-distribution is very "sharp". It is specifically focussed on one outstanding competence. In this case the operator **H** provides a small H-value, i.e. the quantitative value of this Q-distribution is low. In case C, the H-values lie between those of A and B.

If we now divide the constant revenue U by the respective value H we receive a new economic value, the economic temperature T, which is measured as revenue per knowledge unit (i.e. money flux per hbit). We can regard the economic temperature as the effect of knowledge in relation to the revenue generated. This is practically identical to the competitiveness of knowledge.

The relationship between the values U, T and H is expressed by the simple formula U = T H. This thus represents a result of the application of an operator to knowledge functions. This example makes the power of the operator concept in the economic space of functions clear: specific, operator-dependent knowledge aspects can be expressed in the form of mathematical formulae. This is in complete contrast to the heuristic substantiation of economic formulae which have arisen in recent times, particularly in the field of knowledge management. Due to its special significance, the correlation U = T H is referred to as the First Humatic Fundamental Formula.

In the case of a constant U, all of the value pairs T, H of random Q-distributions are on hyperboles determined by the formula U = T H. This is shown in Figure 5. If we move, for example, from the H-value H_1 to the lower value H_2, the temperature increases from T_1 to T_2. This increased temperature indicates that this knowledge function must contain some more highly evaluated competences; the knowledge function has become "sharper". If the value of knowledge is increased (i.e. the money flow U caused by knowledge has increased) from U_1, for example, to U_2, this leads to a higher branch on the hyperbole. Now we receive for the same human potential value H_1 an increased temperature value T_2. As H_1 does not change, the "broad" form of the knowledge function remains. The value of all the competences has increased, however, leading to the increased temperature.

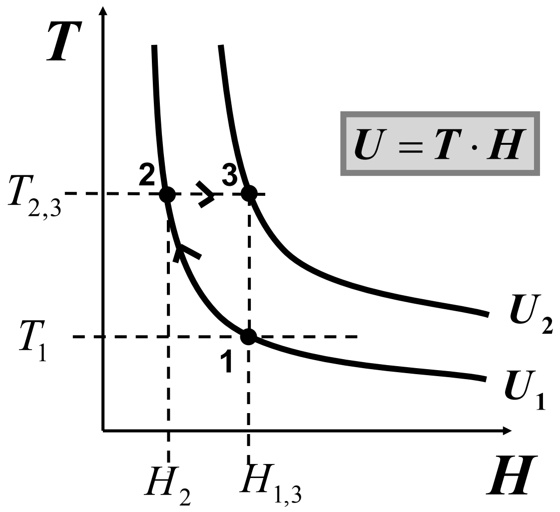
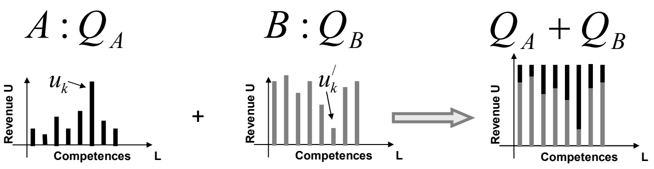


Figure 5: T-H-Diagram of human potential H and economic temperature T

The hyperbole example can be used to show that knowledge quantities of structural characteristics depend on knowledge. This is in contrast to the addable quantities we are accustomed to in everyday life. For example, the weight of a basket of apples can be added up regardless of the arrangement of the apples in the basket, this does not apply to knowledge. When two people and their knowledge come together, not only the quantity of knowledge is important, but also the distribution structure of their knowledge.

2. 4 Team harmonisation

Team harmonisation provides an example of the application of the formula described above.



$1: \quad Q_A \quad + \quad Q_B \quad = \quad Q_A + Q'_A$

$2: \quad H(Q_A) \quad + \quad H(Q_B) \quad = \quad H(Q_A + Q_B)$

$3: \quad$ **Grade of Harmonisation:** $\kappa = \dfrac{H(Q_A + Q_B)}{ld L}$

Figure 6: Team harmonisation

The point of a team is that the individual team members compensate for each other's strengths and weaknesses. This applies as much to a company or an orchestra as it does to sport. The upper section of Figure 6 shows how this harmonisation of knowledge might appear in the case of two employees A and B with their respective Q-distributions Q_A and Q_B. As we can see from the example of the indicated competence u_k, this has a high valuation for employee A, and a low valuation for employee B. If the competence in question was, for example, an ability to speak English, employee A might have a high competence value in this area and employee B would possess a low competence value u_k'. If the two employees work in a room together and if their job is to advise customers in different languages on the telephone, B might have just enough English to tell a caller that his English-speaking colleague A would be back in a minute. The degree of harmonisation can be shown graphically by addition of the Q-distributions ($Q_A + Q_B$) (see line 1 in the box). If, in the real case, a random number of Q-distributions are added, and if the external appearance of the added distributions is more even than that of the individual distributions, this indicates a harmonisation of knowledge. In the ideal case (shown here for illustrative purposes), there is a uniform level of the competence values in the grouped distribution ($Q_A + Q_B$). We saw above that a completely uniform evaluation of competences in a knowledge function is characterised by the maximum value of the human potential H_{max} =

ld L. The lower part of Figure 6 shows how this value can be used to quantify the degree of harmonisation of knowledge functions. A value κ (kappa) can be derived which assumes its highest value (κ = 1) when the merged knowledge functions are complementing each other in the optimum fashion. Thus it is clear that computers can examine Q-distributions for harmonisation and make suggestions as to which employees fit together, at least in terms of their operable knowledge characteristics. To what extent this is actually possible in reality for two differently motivated people, cannot, of course, be predicted on the basis of the operable knowledge characteristics. This still requires the experience and intuition of the management or just trial and error.

3. A change of perspective and the profit and loss account
What it exactly means if we can apply a knowledge quantity to real situations can be explained using the practical example of an employee moving from Development to Sales (see Figure 7). The illustration shows employees with their individual knowledge functions in the three corporate areas of Development, Production and Sales. The arrow indicates the switch of an employee from Development to Sales. The background to this might be that a product has come from Development into Sales where there are now more technical questions from customers about the product, and Sales wants to react to this by improving its technical competence. A developer has volunteered for this new challenge in Sales. What the company expects is that the knowledge of the developer will have in the ex post situation (after the moving of the developer) the positive effect of increasing the sales of the new product. How can this expectation be represented in the form of knowledge functions? After all, the switch is being carried out in the ex ante situation on the basis of an assumption which already exists in the heads of the parties involved, i.e. in their knowledge before they have had the actual experience. If knowledge functions reflect real knowledge then they should also reflect this special "foresight" of knowledge. This is to be demonstrated here.

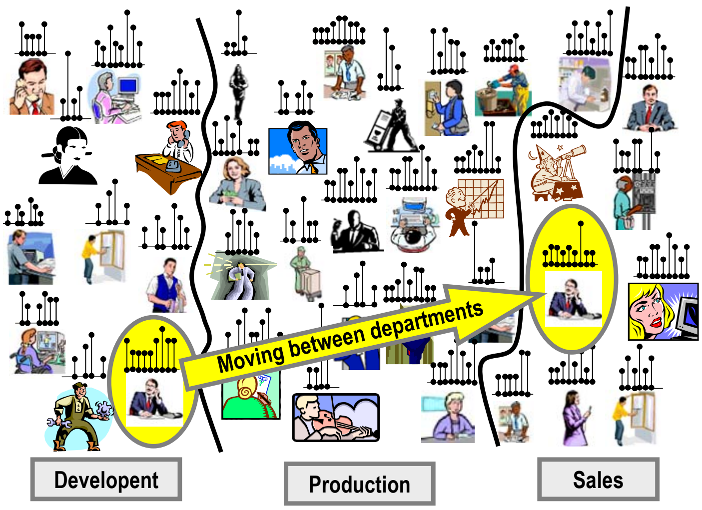


Figure 7: Employee moving from Development to Sales

Figure 8 shows in four tables (1) to (4) the so-called knowledge matrices. Knowledge matrices contain on the left-hand side data which is familiar from conventional controlling. This is shown in column 1 to 3. Column 1 shows the revenue U from the profit and loss account, column 2 the amount of employees B, and column 3 the revenue per employee. In columns 4 and

5 we find some of the new data from humatics: the knowledge quantity H in human bits (hbit) and the economic temperature T (in revenue per knowledge quantity: U / H). These parts of an extended profit and loss account in which the operable knowledge data of humatics are included, is referred to as the Humatics core. Ultimately, depending on the analysis situation, all of the data of the table in Figure 3, page 8 can appear here.

(1) Knowledge Matrix First Period

	Controlling Data (Profit and Loss)			Humatics-Core	
	1 U Revenue Mio. €	2 B Amount of Employees	3 Revenue per Employee Mio. € / B	4 H Knowledge Quantity hbit	5 T = U / H Revenue per Unit of Knowledge € / mhbit
D: Development	2,0	10	0,200	70,000	28,571
P: Production	4,0	20	0,200	140,000	28,571
S: Sales	4,0	20	0,200	140,000	28,571
Company Total	10,0	50	0,200	350,000	28,571

(2) Knowledge Matrix Second Period without Shift of Perspective

	Controlling Data (Profit and Loss)			Humatics-Core	
	1 U Revenue Mio. €	2 B Amount of Employees	3 Revenue per Employee Mio. € / B	4 H Knowledge Quantity hbit	5 T = U / H Revenue per Unit of Knowledge € / mhbit
D: Development	1,8	9	0,200	63,000	28,571
P: Production	4,0	20	0,200	140,000	7 28,571
S: Sales	4,2	21	0,200	147,000	28,571
Company Total	10,0	50	0,200	350,000	28,571

(3) Knowledge Matrix Second Period with Shift of Perspective

	Controlling Data (Profit and Loss)			Humatics-Core	
	1 U Revenue Mio. €	2 B Amount of Employees	3 Revenue per Employee Mio. € / B	4 H Knowledge Quantity hbit	5 T = U / H Revenue per Unit of Knowledge € / mhbit
D: Development	1,8	9	0,200	63,000	28,571
P: Production	4,0	20	0,200	140,000	6 28,571
S: Sales	4,2	21	0,200	146,000	28,767
Company Total	10,0	50	0,200	349,000	28,653

(4) Knowledge Matrix Third Period with Shift of Perspective and Increase of Sales

	Controlling Data (Profit and Loss)			Humatics-Core	
	1 U Revenue Mio. €	2 B Amount of Employees	3 Revenue per Employee Mio. € / B	4 H Knowledge Quantity hbit	5 T = U / H Revenue per Unit of Knowledge € / mhbit
D: Development	2,0	9	0,220	63,000	31,429
P: Production	4,4	20	0,220	140,000	31,429
S: Sales	4,6	21	0,220	146,000	31,644
Company Total	11,0	50	0,220	349,000	31,519

Figure 8: Profit and loss accounts extended by the knowledge matrix.

The Knowledge Matrix (1) shows the starting situation before the employee switches from Development to Sales. In table (2) the change has been made. The only changes in table (2) are the reduction of the employee number and knowledge quantity (see columns 2 and 4) in Development and the resulting, proportional increase of these quantities in Sales. Since all the table data are linear, we have the same results in the quotients in column 3 and 6. This data does not tell us the reason for the employee change, the knowledge of the employee provides the same contribution to revenue in Development as in Sales. The situation is different for knowledge functions. These have a different form depending on whether they are evaluated from the perspective of Development or from that of Sales. This is already symbolically indicated in Figure 7. There the knowledge function appearing in Sales has a "sharper" appearance. How this perspective change can be shown mathematically as a rotation of the coordinate system is shown in Figure 9.

3. 1 Perspective change in knowledge functions

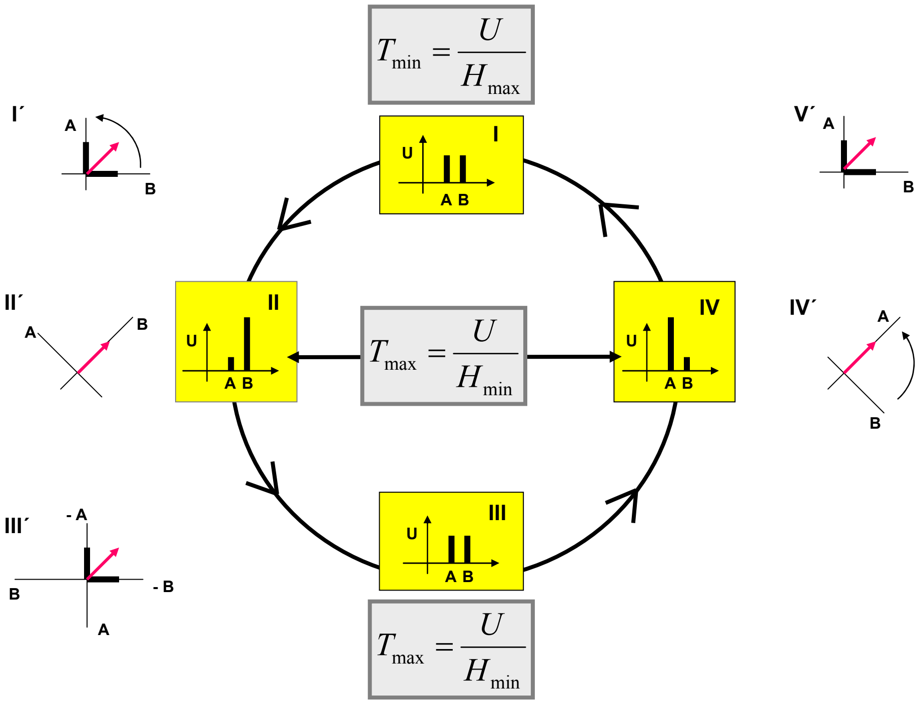


Figure 9: Perspective change in knowledge functions by rotation

In Figure 9 we will deal with a very simple knowledge function which consists of only two competences A, B) and which is presented in the four positions I to IV. The sum U of the constituents is constant in all positions. Thus we find ourselves on a branch of the hyperbole function as shown in Figure 5, page 11. If, therefore, one constituent is changed, this is at the expense of the others. A could be, for example, the technical competence for the new product to be sold. This is the knowledge that the Sales department wants. B, for example, can be the ability to speak a foreign language. Position I shows a Q-distribution with equal evaluation of its two constituents. As we move around the circle, preference is given first to constituent B (position II) and then, as we pass position III, preference is given to A (position IV). From the above analyses we know that in the two positions I and III the amount of the human potential H is at its highest value H_{max} and therefore the economic temperature T (revenue per hbit) is at its lowest T_{min}. The opposite is the case if the knowledge function is very "sharp", i.e. if some knowledge characteristics are evaluated more highly than others, as is the case in the two positions II and IV. We receive reduced values for H and increased values for T.

Now we want to show that such a reduction of the human potential H is the result of the differing perspectives from which the knowledge of an employee in Development or Sales is observed. This change of perspective is continually applied in corporate practice. This occurs as follows: As the specific, technical product knowledge A is also present in other developers in the Development department, it is a value which is multiply present and can thus not be evaluated very highly. This, however, does not apply to Sales, as the knowledge A is unique there. In contrast to this, competence B could be frequent in Sales, which means it would receive a correspondingly lower evaluation. It is of particular significance now that from the perspective of the individual employee, his individual knowledge remains constant regardless of how it looks from the perspective of the respective department.

We will now show that the practical effects of a perspective change result automatically (algorithmically) from knowledge functions by use of coordinate rotation. This should be explained in detail and is represented by the four graphics I' to V' in Figure 9. First we can see that the thick arrow (vector) does not change its direction or length in the graphics I' to V'. This indicates that from the perspective of the employee nothing changes (he sees his skills, abilities, so to speak, from the point of view of inside the arrow). A different view (perspective) results when we rotate the coordinates (i.e. we alter the outer view) in an anticlockwise direction (we could, of course, also rotate in a clockwise direction). Position I' shows the situation before the rotation starts, the two thicker coordinate parts A, B are equal. This corresponds to the representation of a knowledge function with two equal constituents (see position I). In position II' the rotation (i.e. the change in perspective) has progressed to the extent that there is only a representation of the arrow on B, i.e. B is the most highly evaluated constituent. That corresponds to the Q-distribution in position II. The rotation continues through 180° to position III', where we again have equal coordinate parts A and B (now they are both negative, which is of no consequence for the mathematical evaluation). That corresponds to Q-distribution in position III. In position IV' the rotation has progressed so far that only A is evaluated, and in position V' - having travelled through 360° - we are back to the starting position with the equal constituents (which corresponds to Q-distribution in position I). Obviously we can derive different appearances of Q-distribution and, therefore, the alteration of the human potential and the economic temperature from rotations alone. It should also be mentioned in passing that, mathematically, rotations are group characteristics whose generators can be represented as tensors (e.g. in the form of differential derivations of vectors), which opens up a completely new field for the interpretation of knowledge functions.

3.2 Tracing the perspective shift in the extended profit and loss account

Let us return now to the operable knowledge characteristics in the Knowledge-Matrices in Figure 8. We know that from the perspective of Sales, the product knowledge of the developer is more highly evaluated than in Development. This means that the knowledge function has become "sharper", the Shannon formula gives a lower value for H. We show this case here for demonstration purposes by reducing the knowledge quantity H of the developer in Sales symbolically by 1 hbit so that the total knowledge quantity in Sales drops from 147 to 146 (see the marked circles in table 2, table 3). This reduction would, of course, be automatically registered by rotation of coordinates as soon as the knowledge function of the developer appears in Sales. So the change in perspective is advanced by the program. If we divide the constant revenue (column 1) by this reduced knowledge quantity in the Sales perspective (column 4), the temperature T increases in Sales accordingly (between table 2 and 3). This is the desired result. If the change from Development to Sales is to make any sense, the revenue contribution of the knowledge in Sales must have an increased value. This indicates to the controller a significant, corporate change which he can observe directly by comparing table (1) with table (3). In this case we are dealing with an ex ante situation (i.e. a view before an event happens, that is usually a scenario). This is fully analogous to scientific methods in physics in which changes of complex systems can be determined on the basis of starting conditions. In conventional controlling such changes are not apparent to the management. For example, in contrast to the revenue per knowledge unit (economic temperature), the per capita revenue remains constant (see tables 1, 3). So, the operable knowledge characteristic T reflects an internal change in a company without any outer effect. Table (4) shows the simulated ex post situation (i.e. the view after an event, these are real values) with an increased revenue which leads to a further increase of the economic temperature. The view of the Sales department has been confirmed, the market has rewarded the change in perspective, the new perspective was the right one.

Perspective changes for knowledge have long been an intuitive tool of any good manager. This is how companies can benefit from correctly applied knowledge management as presented here: intuition is complemented by reproducible, verifiable quantities. Humatic analysis could be used to determine how high the growth in revenue would be if an internal change in perspective takes place. For further details please refer to [3]. The representation of operable perspective changes makes it clear that management in the future will have access to completely new methods of company orientation and performance control.

4. Perspective change on the macroeconomic level

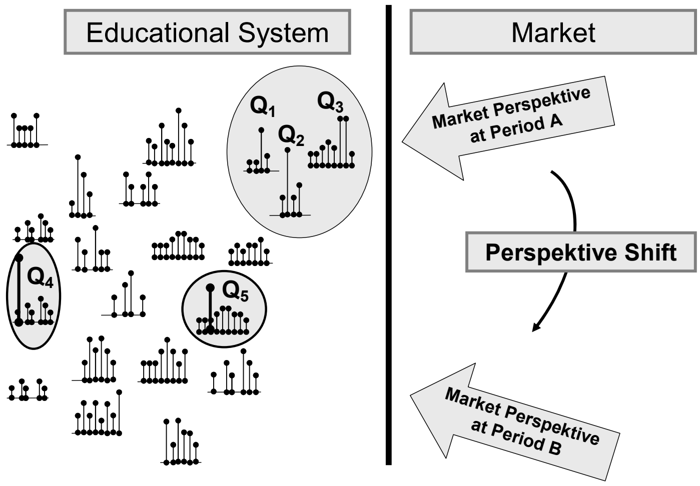


Figure 10: Perspective change on the macroeconomic level

Changes of perspective also make themselves felt on the macroeconomic level. This is illustrated in Figure 10. The education system (left-hand side) is constantly providing the knowledge functions required by companies on the free market (right-hand side). The demand of companies for competences changes with the market requirements. Consequently, in an initial period A, companies have a particular perspective regarding the evaluation of the skills and abilities which the education system has provided. For this perspective the knowledge functions Q_1, Q_2, Q_3 may meet the company and market requirements. At a later date this perspective has changed; the knowledge functions Q_4, Q_5 now appear important. It is immediately apparent that an education system will never be able to predict – any more than the companies themselves - the needs of companies and the market in the future. [5] shows that an education system which allows a continuous movement of people between the economic system and the education system provides more favourable prosperity indicators than the system of education we are accustomed to up to now. This means that the demand for life-long learning can be substantiated on the basis of operable knowledge characteristics. If there was a stock exchange for the evaluation of skills and abilities, the constantly changing value of knowledge functions in societies would be immediately apparent. If such a stock exchange was created in a national economy, citizens willing to go into education would be able to trace the value trends for skills and abilities. With the determination of knowledge functions for the population of a currency area it is also possible to answer the question posed at the outset with regard to the knowledge quantity and structure behind a currency.

5. Concluding comments

The methods introduced for the quantification of knowledge open up completely new possibilities for microeconomic and macroeconomic analysis. Quantities can be given for at least some of the long-sought "intellectual properties" and a lot of new and hitherto unknown knowledge characteristics have been identified. Knowledge structures in companies become visible. Corporate analyses, corporate evaluations, share evaluations, stock exchange listings all receive new instruments in the form of operable knowledge characteristics. Supraregional comparison of knowledge data in companies is now possible. The credit conditions required by Basel II receive a quantifiable basis, which can be used in controlling systems. On the macroeconomic level the interaction between the education system and the economic system can now be placed on a new, transparent footing. New relationships were revealed between innovation and national income.

By using functions as mathematical objects to describe knowledge, it is possible to grasp the complexity of knowledge at least in some areas. Thus, functions describing reality have proved superior than purely numerical representations even in the field of economic science. With the uncompromising further development of humatics, economic science can take advantage of the same successes as gained in natural scientific disciplines as a result of using the concept of functions (e.g. in physics in the form of quantum mechanics). We can assume that there is a whole range of economic insights and interactions still waiting to be discovered.

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Dipl.-Ing., born in 1943 in Hamburg, scientist, engineer and inventor, multiple entrepreneur, owner and participant of different companies.

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ADE -Applied Digital Electronic Inc. / USA, Paoli
CLM CombiCard License Marketing
first patent house GmbH
Vision Patents AG

More than 70 intemationally patented inventions many of which are already being sold as products by well-known companies: Electronic house-door Key Ikotron, Ikon AG, Berlin; POMUX, electr. length measurement System, Max Stegmann Company, Donaueschingen; Chip card patents (Siemens, Gemplus, PAV)

1986. Frankfurt: **Arthur- Fischer- DABEI prize** "Invention and innovation for humankind"

1987. Frankfurt: **Innovation prize of the German Economy** for the non-contact Chip card

Since 1988. Bonn/Berlin: **Member of the Research and Development Committee of the DIHK** (Head of German Commercial Chambers)

1989, Berlin: **Chairman of the association "Free Elections GDR",** first public presentations on the "fair economy" with representatives of the GDR citizens' movement

1996. Helsinki: **ESCAT- European SmartCard prize**

1997. Darmstadt: **GMD SmartCard prize** of the Society for Mathematics and Data Processing for smart card inventions

1999, Hamburg: Completion of the work **"Humatics"** (operability of knowledge, Thermoeconomics)

1999, Berlin: Awarded the **Federal Service Cross** of the Federal Republic of Germany at an award ceremony by German President Johannes Rau

23. 2. 2001, Wittringen: Awarded the **Rudolf Diesel Gold Medal** for extraordinary achievements as an inventor at an award ceremony by First Minister Clement

March 2001, Berlin, Book: **Das Humanpotential**, Wissen und Wohlstandswachstum (Human potential, knowledge and prosperity) ISBN 3-89700-142-X, Berlin, VWF Verlag für Wissenschaft und Forschung GmbH

6. Sept. 2001, Helsinki: **Member of Hall of Fame** of ESCAT for latest achievements in the measurement of human knowledge

24. Oct. 2001, Neuss: Awarded the **Prize of Innovation** for exploring the operability of knowledge by Netz innovativer Bürger and Bürgerinnen (network of innovative citizens)

Nov. 2003, Berlin, Book: **Geld und Wissen,** (Money and Knowledge, Theory of operable knowledge characteristics), ISBN 3-89998-021-2, Weißensee Verlag

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