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ON AN INCREASINGLY YIELD CURVE OF KNOWLEDGE

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Abstract:

The paper examines the behaviour of the yield curve of the knowledge considered as production factor. The concepts of complementarity and substitutability among classical production factors are revisited in order to put the bases to analyse the special production factor (a species of the neo-production factors) namely knowledge. In this context, some distinctions are made between information and knowledge putting in view the added value of knowledge related to information. Some graphical construction and algebraic formalisms are convoked in order to better ground the final conclusions regarding the increasing nature of the knowledge yield curve in the knowledge-based society. The approach is preponderantly logic and conceptualized, trying to get general results which could then be tested, by other researchers, in order either to corroborate or to reject them.

Key words: *knowledge, increasing return, yield curve, knowledge-based society*

1. Introduction

In the standard economic theory the output is generally modelled by intermediation of a production function. A production function is a formal operator (usually in a symbolic, i.e., mathematical expression) which combine the factors of production to deliver the output. The factors of production are called inputs, and it is not necessary to describe or even know the particular technological model of combining the given factors of production (the so-called black-box). Such particular technological device is captured, if it is of interest, through econometric estimation of the production function parameters. What is important in all of these is the behaviour of inputs related to the outputs. In the very standard economic theory, where there are two factors of production, labour and capital (more precise, capital goods), both such factors are consumed in the production process. In other words, certain quantities of labour force and, respectively, certain amount of the value of capital goods are imputed into the cost of production as „responsible" for the output value (not for the output price, which is other issue). So, through selling of the output (either to the supply price

or, generally, to the market price) the imputed monetary value of the factors of production is recovered and, usually, are used to buy new inputs for the next production cycle. So, the factors of production are effectively consumed („destroyed") in the sphere of production and, then, in the sphere of circulation (or exchange) their monetary value is recaptured from the final consumers of the output and reintroduced, in their natural/material form again in the production sphere. As it is well-known, the monetary value of the labour force „destroyed" is called wage (or salary, after case), and the monetary value of the capital goods „destroyed" is called amortization. So, to synthetize, the classical factors of production are always consumed in the production process and are recovered by the realization on the market of the output resulted. It is for long time observed that there are certain factors of production, different from the classical ones, called neo-factors of production which do not follow the standard ways of functioning: consumption within the production process, then recovering within the exchange process. One of such a neo-factors is the information (I'll ignore here the conceptual distinction between the information and the knowledge; in fact, I'll consider the information as equivalent with the knowledge). In the rest of the study I'll examine the behaviour of this neo-factor of production, trying to get the differences it exhibits related to the classical factors of production.

2. What the information/knowledge is it?

Knowledge is not a simple accumulation of information, because information also is accumulated by non-cultural subjects about which, at least at this moment, we cannot say that they come to knowledge. Although the knowledge can be treated as a process, it is also necessary to treat it as a result. So what is knowledge as a result of the process of knowledge? In order to elucidate this problem we will examine the logical (and psychological) chain of acquiring knowledge: signal, sign, date, information, cognizance, knowledge, that is, what we'd call the knowledge pentagon (figure 1).

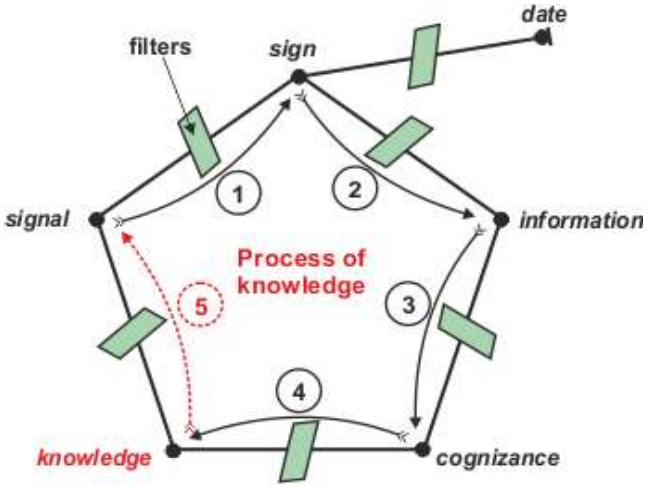

Figure 1. The logical chain signal – knowledge
(Source: author)

a. Signal

Any physical phenomenon that impresses one or more of the subject's natural senses is called a *signal*. Note that both non-cultural and cultural subjects are impressed by signals. In principle, it must be accepted that objects are also impressed by the signals, with the exception that they do not process the signals that impress them. A fundamental difference between the behaviour of the object and the behaviour of the subject when impressed by the signals is the following: objects do not register the signal but only react (programmatically, thus fully predictable) to its action (for example, the metals expand to the heating action, and this expansion is fully predictable), while subjects record it. The signal must be considered the bearer (the vehicle) of the sign. Of course, not every signal bears a sign, but any sign is carried by a signal.

b. Sign

I call *sign* that signal that has significance for the signal receiver. In other words, if a signal seems to stand related to the signal receiver for something other than itself, then the signal in question becomes a sign for that receiver. It is arisen here the important issue of significance. In the most common sense, significance addresses the referent (the entity, the thing, the phenomenon, the relationship, the state, the property, etc.) for which the sign stands, i.e., the referent which is replaced by the sign in its relation with the signal receiver. Of course, recognizing the signal as a sign is a complicated matter (which I'll not develop here) that calls certain symbolization codes to recognize that the signal stays for something other than itself, namely for a specific denoted. Codes can be both individual (generated by individual experience or reflection) and social (generated by social experience or reflection), and they are, in essence, matrices of correspondence between signals and referentials associated with those codes. Regarding the competence and performance in signal recognition I'll not discuss during this paragraph at all, although these are interesting issues, both from a purely semiotic perspective and, above all, from a cognitive and action perspective. For example, the view of smoke means, for the smoker, the existence of fire (here the smoke is the signal and the referential is the fire: the identification of the referential turns the signal into the sign).

c. Date

I call date the sign that, by referring to the referent, does not influence any uncertainty or incompleteness of the person who receives the sign. The date has a simple role of confirming or strengthening the referential (denoted) whom the subject already associates with the sign in question. So the date brings nothing new, unknown to the subject that interprets the sign. If, for example, I am in North Railway Station in Bucharest, I am waiting for the arrival of a specific train at a specific hour, if it is announced the arrival of that train at that hour, although the signal is a sign for me (I assume the announcement is made in a language I understand), it does not influence (modify, eliminate, reduce) any incompleteness or uncertainty, but only confirms/consolidates what I already knew.

d. Information

By information I'll understand the sign that, by referring to the referent (denoted) modifies, eliminates or reduces either an uncertainty or an incompleteness. In other words, the sign may have two disjunctive alternative "destiny" for the subject: either it remain in the quality of the date, as mentioned above, or it acquires the quality of information. If, to resume the empirical example used in the previous paragraph, the train announcement at North Train Station in Bucharest says that the train will arrive with a delay of 10 minutes, then this sign becomes information because it changes what I knew before.

e. Cognizance

By cognizance we understand that information, which once received as such, finds in the pre-existing cognitive "deposit" of the receiver subject an informational base (and knowledge) that allows its structural integration. If, for example, I get the information that the black holes evaporate, this information becomes cognizance if I already have some cognitive baggage on the physical concept of a black hole. If, however, I am, let's say, a poet and I have no prior knowledge of the concept of a black hole, although I receive the information in question, it will not become cognizance. A question arises here: how can I access a new domain at a cognitive level (i.e., how can I know) if no information received about that domain becomes cognizance? Indeed, it seems that we have a vicious circle here: the first information about a new field can ever become cognizance with the mechanism described above. We assume that there is a solution and it is provided by the psychological characteristics, namely the memory of the subjects: information, although not transformed into cognizance, remains a certain period (short term) in memory. We can call this period with the term of free retention. The free retention interval plays the role of a cognitive "deposit" but without a permanent character (or at least without long-term survival, as happens with the cognitive "storehouse" itself). So, if new information is received within the free retention period of at least one prior information, then the new information becomes cognizance. Moreover, the previous information, which is in the range of free retention, is also "converted" on this occasion, knowingly constituting itself the cognitive "deposit" itself, with long-term existence (tied remanence).

A question is also arising now: does the pre-existing cognitive "deposit" of the subject of the information receiver have a certain size in order to have the ability to integrate new information that would so become cognizance? In other words, is there a threshold below which the new information cannot be integrated into the pre-existing cognitive "deposit"? An answer to this question can no longer be of a logical nature, it must be empirically decided. Obviously, we do not have an answer here. A graphic example of the above proposals can be represented as in Figure 2.

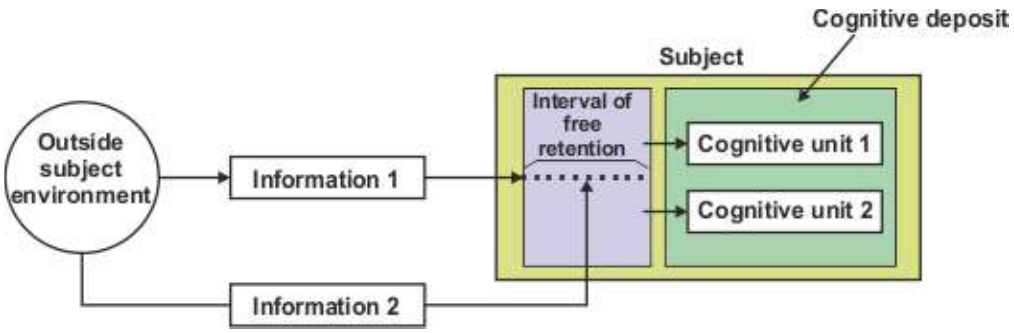

Figure 2. Logic of forming the cognitive deposit at the subject which receives the information (Source: author)

f. Knowledge

By *knowledge* we understand the ensemble of cognitive domains that have cognitive deposits formed in a subject consciousness. When I say the ensemble, I understand both the logical sum between the cognitive deposits taken individually and the synergy generated by the inter-action between these cognitive deposits. As I said above, I'll not develop here the concepts of cognitive competence, namely, cognitive performance, our aim being to clarify the concept of knowledge, both as a process and as a result.

3. Information/knowledge and the production function

a. The concept

The information could enter the production function in an indirect way, namely: a) by the incorporated „intelligence", or the so-called technical progress, of the capital goods – the more improved technology in the fixed capital, the more information participant at production process is; b) by the incorporated knowledge of the labour force: qualification, education, social cooperation determination etc. – the more qualified the labour force is, the more information participant at the production process is; c) by the management provided by the entrepreneur – the more performant the management is, the more information participant at production process is. So, the information enters the production process in a bound form, namely bound to its bearers, capital goods, labour force, and management. Making a conceptual connection with the entropy principle from the thermodynamics, we could say the information is low entropy bound to its bearers (or vehicles). Of course, the capital goods and the labour force, by themselves constitute also inputs of low entropy in the production process, but the information contained by them increases such low entropy. Let's make a brief examination in the matter (figure 3 shows a synoptic view of the way in which information enters the production process).

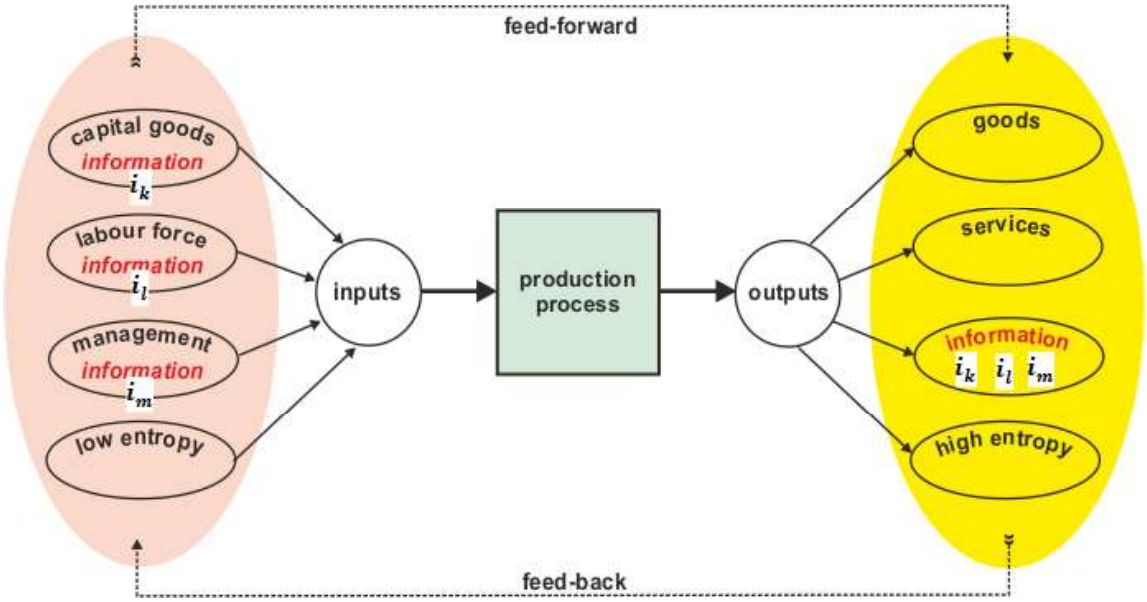

Figure 3. Ways (bearers) through which the information enters the production process (Source: author)

So, principled, the production function could be expressed as:

$$[y] = f[x]$$

where:

$$[x] = \begin{bmatrix} k \\ l \\ i_m \\ i_k \\ i_l \end{bmatrix}$$

with:

- k: capital goods
- l: labour force
- i_m: information included into the management
- i_k: information included into the capital goods
- i_l: information included into the labour force

and:

$$[y] = \begin{bmatrix} g \\ s \\ \bar{i}_m \\ \bar{i}_k \\ \bar{i}_l \end{bmatrix}$$

with:

- g: goods
- s: services
- $\bar{i}_m$: information regarding the management
- $\bar{i}_k$: information regarding the technology
- $\bar{i}_l$: information regarding the labour force

f is an operator of transformation, which transfers inputs into outputs according to a matrix called black-box, so:

$$\begin{bmatrix} g \\ s \\ \bar{i}_m \\ \bar{i}_k \\ \bar{i}_l \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{11} & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 & 0 & 0 \\ 0 & 0 & \alpha_{33} & \alpha_{34} & \alpha_{35} \\ 0 & 0 & \alpha_{43} & \alpha_{44} & \alpha_{45} \\ 0 & 0 & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \cdot \begin{bmatrix} k \\ l \\ i_m \\ i_k \\ i_l \end{bmatrix}$$

so, what is important for us, are the following three equations:

$$\begin{cases} \bar{i}_m = \alpha_{33} \cdot i_m + \alpha_{34} \cdot i_k + \alpha_{35} \cdot i_l \\ \bar{i}_k = \alpha_{43} \cdot i_m + \alpha_{44} \cdot i_k + \alpha_{45} \cdot i_l \\ \bar{i}_l = \alpha_{53} \cdot i_m + \alpha_{54} \cdot i_k + \alpha_{55} \cdot i_l \end{cases}$$

b. What is different with the information?

First of all, it is to be observed that the information is found both in inputs and in outputs. More than that, both in inputs and in outputs, we find the same three kinds of information: a) information contained in the management; b) information contained in the capital goods; c) information contained in the labour force. Such a case is not met in the classical factors of production, that is, in inputs we find capital goods and labour force, while in outputs we do not find capital goods and labour force, but consumption goods and consumption services. Also, consumption goods and consumption services are not part of inputs.

Secondly, there is a crucial difference between the classical factors of production and information, regarding their behaviour inside the production process. As we said before, a part of the labour force is definitive consumed (it is recovered, after the realization of the output on the market, by trade, under the form of wage/salary), and a part of the capital goods is definitive consumed (it is recovered, after the realization of the output on the market, by trade, under the form of amortization). Instead, the information entering the production process participates to obtaining the output anticipated (by feed-forward) but it is not consumed at all during this process. In fact, the information behaves analogously with a catalyser: it intermediates the production process but, at the end, it shows up itself entire and fresh, as it was at initial time.

Thirdly, the information is even more than a catalyser. While a catalyser recovers itself entirely from the process conditioned, the information gains something new, over maintaining its quantitative integrity as a result of participating to the production process: this result could be called as *information gain*. I'll detail a little bit the concept of information gain.

(1) It is in contrast to the concept of capital gain. While the capital gain is generated by preserving the capital in case (either by storing it as banking deposits, or by investing it – directly, or indirectly), the information gain, by the contrary, arises just by using that information. In fact, the information which is

non-used is liable to loose, partially or totally, its value of using. Do remember, for example, that the obsolescence of the fixed capital (a species of capital goods) is explainable just by loosing of the information value contained in the „body" of that fixed capital;

(2) The information gain consists at least in the following two effects generated by using the information:
   a. verifying of the information regarding its truth value: all three kinds of information contained in the three kinds of inputs (capital goods – especially fixed capital, labour force, and management) are verified, even in the strong ways proposed by Popper, in the production process. In the information is correct, then the actual outputs will be very closed to the predicted (expected) one, but, if it is incorrect, then such coincidence at the output level doesn't occur. In other words, one of the added value of the information used in the production process is its validation from the truth value perspective. I would wish call such a phenomenon as *validation effect*;
   b. increasing of the information stock by a sui generis positive feed-back generated around the existent information. Here could be useful to remember the well-known hub-effect: an auto-catalytic process initiated by a small (and, often accidental) agglomeration (of money, of connections, of information, of power etc.). Such an increasing of the information stock could happen through two main ways:

(b.1.) the existent information attracts new information, either complementary or substitutable (NB: here we are, however, something similar to the complementarity/substitutability occurred in the case of the classical factors of production). I would wish to call such an effect as *hedgehog effect* – simply, an information hangs other information in a necessary way (for example, after reading a number of books in a field, any extra books read will bring more information than in the past and, probably, such a phenomenon could exhibit an exponential trend;

(b.2.) the existent information reorganises itself so increasing its value both of knowing and of using. I would wish call such an effect as *auto-poietic effect*. Through this auto-poietic effect, the existent information, partially from internal pushes, partially from external ones (for example, the hedgehog effect could initiate the auto-poietic one, by the well-known „law" of the qualitative jump under the quantitative accumulation).

The mechanism through which the information gain occurs could be synthesized as in figure 4.

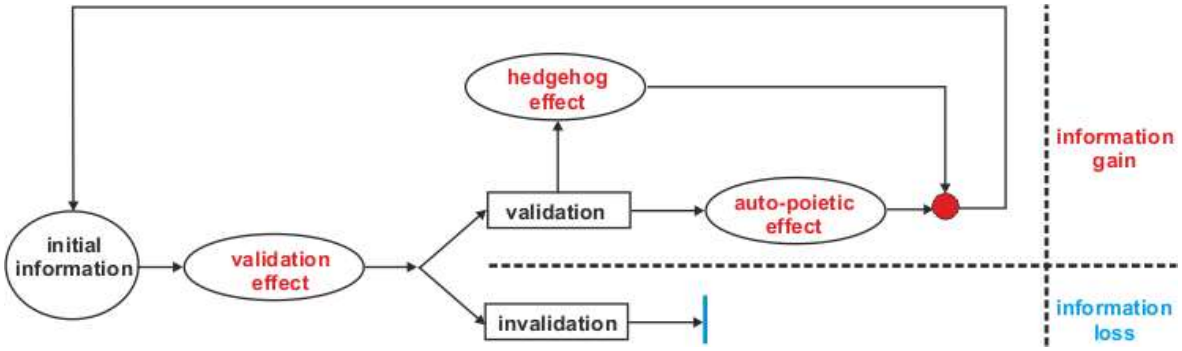

Figure 4. Information gain mechanism
(Source: author)

1. A possible increasing function of the knowledge yield curve

Let's analyse closely the production process in which the information is introduced, carried by the three vehicles mentioned above: the fixed capital, the labour force, and the management. Generally, if two factors of production are done, x, and y, and an operator of transformation (or matrix of transformation) of factors of production into the output, z, is noted with f, then we can write: $z = f(x,y)$. Let's consider, for the moment, x and y are classical factors, for example, x is the fixed capital, and y is the labour force. Presuming the factor x is multiplied with a coefficient α (where $\alpha > 1$), i.e., $x_\alpha = \alpha \cdot x$, then we expect, generally have $z_\alpha = f(x_\alpha, y) = f(\alpha \cdot x, y) = \alpha \cdot f(x,y)$. Identically, presuming the factor y is multiplied with a coefficient β (where $\beta > 1$), i.e., $y_\beta = \beta \cdot y$, then we expect, generally have $z_\beta = f(x, y_\beta) = f(x, \beta \cdot y) = \beta \cdot f(x,y)$, and even, if is presumed the both factors of production are multiplied with the same factor γ (where $\gamma > 1$), so $x_\gamma = \gamma \cdot x$, and $y_\gamma = \gamma \cdot y$, the we expect generally have $z_\gamma = f(x_\gamma, y_\gamma) = f(\gamma \cdot x, \gamma \cdot y) = \gamma \cdot f(x,y)$. Well, such a result doesn't occur because two necessary well-known constraints: 1) the spatial constraint; 2) the return constraint. Below I'll done, briefly, an examination of the two constraints.

(1) The spatial constraint is a physical one. The most known example is the agricultural land, where no any number of people or machines can work. Of course, mutated mutandis, in any economic activity (the virtual economy should be, however, separately examined, but not in this paper) such a constraint plays (in the tertiary economic sector, for example, at a work place cannot work more than one worker). This constraint leads us to a very general economic „law", namely the „law" of decreasing return. This „law" says that an increase of the quantity of a factor of production will increase the output, but in a decreasing curve (something analogous with the decreasing marginal utility, with the difference we have to do here with a decreasing of the total output, not of a marginal one). The explanation is that, because the spatial (physical) constraint, the productivity of the given factor of production decreases when the quantity of the factor increases. Figure 5 visualize this result;

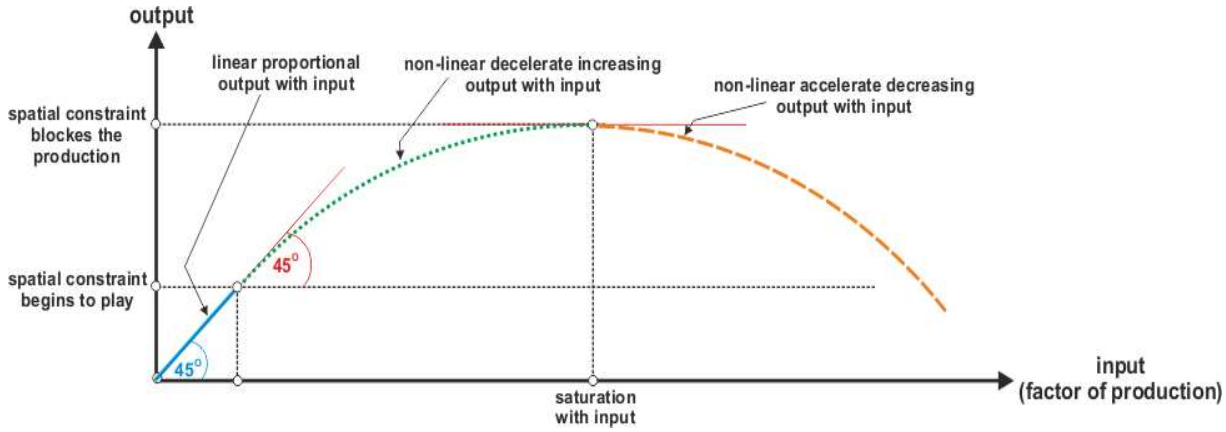

Figure 5. Functional relationship between classical factors of production and output (Source: author)

(2) To examine this second constraint, it is useful to remember the concept of complementarity among the factors of production. By the complementarity between let's say, two factors of production, x and y, is understood a range of the rates of intensity between them, under the condition the production process be still possible. So, such a rate of intensity as rate o complementarity can be expressed as follows: $k_c^{x/y} = \frac{q_x}{q_y}$, meaning that q_x units of factor x is compatible with q_y units of factor y so the output be possible. The same can be expressed for the inversely situation: $k_c^{y/x} = \frac{q_y}{q_x}$, with an analogous signification. In this case, the production function can be express as: $z_{x,y} = f_{x,y}(q_x, q_y) = f_x(q_x, k_c^{y/x} \cdot q_x) = f_y(k_c^{x/y} \cdot q_y, q_y)$. So, there are only a finite number of „pairs" (q_x, q_y) so they are viable from the point of view of the production function. Let's note such a set as $\mathcal{C}_{x,y} = \{(q_x, q_y) | q_x \in [q_x^{min}, q_x^{max}], q_y \in [q_y^{min}, q_y^{max}]\}$. So, the „pairs" of (q_x, q_y) must be contained only in those interval which ensure the functional compatibility between them, so leading to the output (figure 6 illustrates this idea).

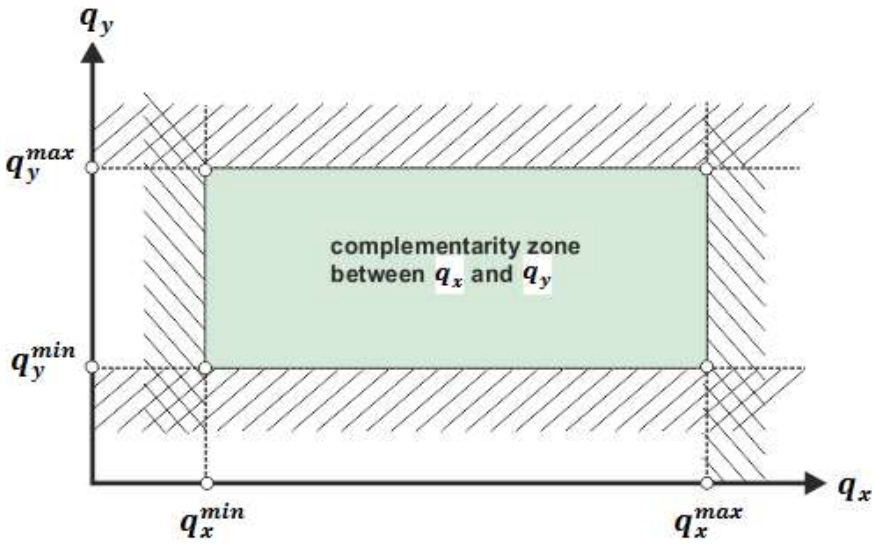

Figure 6. Complementarity constraint of the classical factors of production
(Source: author)

So, the output is technologically possible if, and only if the quantities of the two factors of production are combined inside the complementarity zone in figure 6. Now, given the complementarity zone between q_x and q_y, the question is: could the information (more specifically, the knowledge), and if yes, how could it to influence such a complementarity, while preserving the technological possibility of the output obtaining? The answer is the following:

- firstly, the information contained into the classical factors of production is not under the spatial constraint, simply because the information doesn't occupies space. As consequence, the spatial constraint doesn't exist for the information (or, more specifically, for the knowledge);
- secondly, the information doesn't modify the quantities of the factors of production involved in the production function, but does modify their quality only. By modifying that quality, the information extend, implicitly, the complementarity zone of the viable „pairs" of combination between q_x and q_y (figure 7).

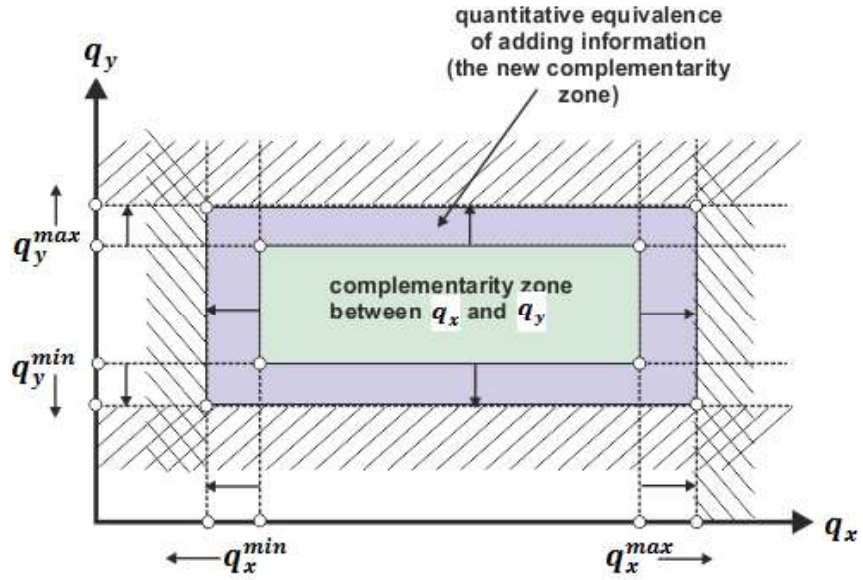

Figure 7. Relaxing of the complementarity constraint through information (knowledge) (Source: author)

So, by now were been identified two main categories of impact imputable to information (knowledge) in the production process: a) an extending (in an implicitly, i.e., equivalent, way of the complementarity zone of the classical factors of production; b) an self-improving (both quantitatively – see the hedgehog effect – and qualitatively – see the auto-poietic effect) of the information during its using between the entering as inputs and exiting as output. In what is left of this work, I'll try to valuate these results from the perspective of the yield curve of the information (knowledge).

(a) the implicitly (equivalently) extending of the complementarity zone has as effect simply an adding to the return curve shown in the figure 5 of the linearly proportionally relationship between inputs and outputs (figure 8).

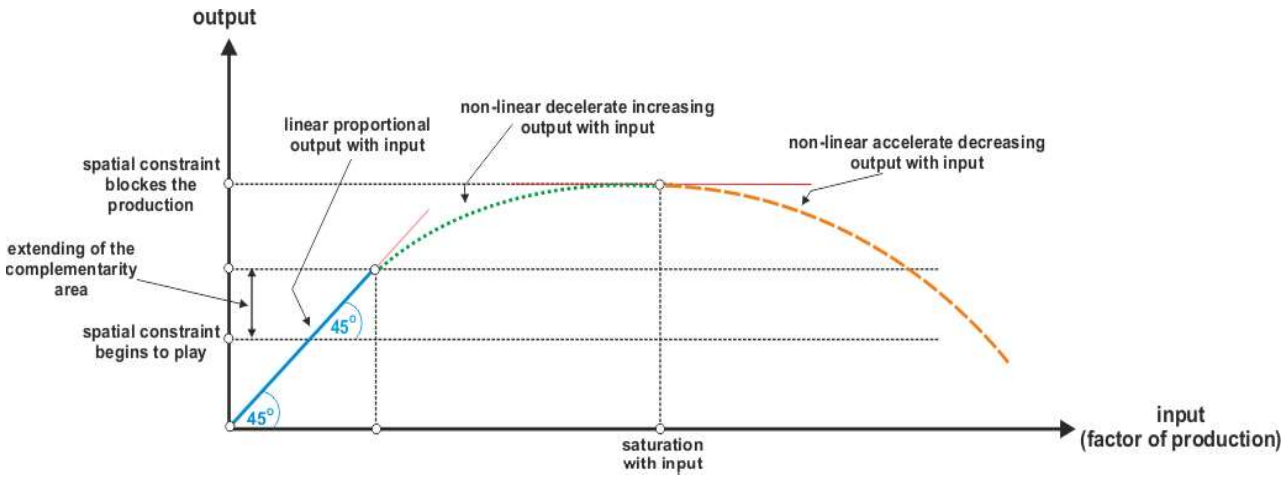

Figure 8. Extending of the linearly proportionally relationship between input and output by the information (Source: author)

(b) because the second impact of the information on the output, the two own effect generated by the information (knowledge) on itself (hedgehog effect, and auto-

poietic effect, respectively), it seems that the information as output is larger than the information as input, so adding new information (either directly, by the management, or indirectly, by the fixed capital and the labour force) the obtained information is increasingly more. Formally, this idea could be interpreted as an increasing marginal informational-output related to the informational-input: if is noted with i_i^{j-1} the quantity of information (or knowledge) as input at the moment $(j-1)$, with i_o^j the quantity of information (or knowledge) as output at the moment j, and with $i_m^{j/(j-1)}$ the marginal information between the moment (j-1) and the moment j, then:

$$i_m^{j/(j-1)} = \frac{\Delta i_o^j}{\Delta i_i^{j-1}} = \frac{i_o^j - i_o^{j-1}}{i_i^{j-1} - i_i^{j-2}} > 1$$

So, comparing with the classical factors of production yield curve (shown in figure 5) and even comparing with the improved of the complementarity zone between classical factor of production (shown in figure 7 and 8), the information (knowledge) yield curve could be drawn as in figure 9.

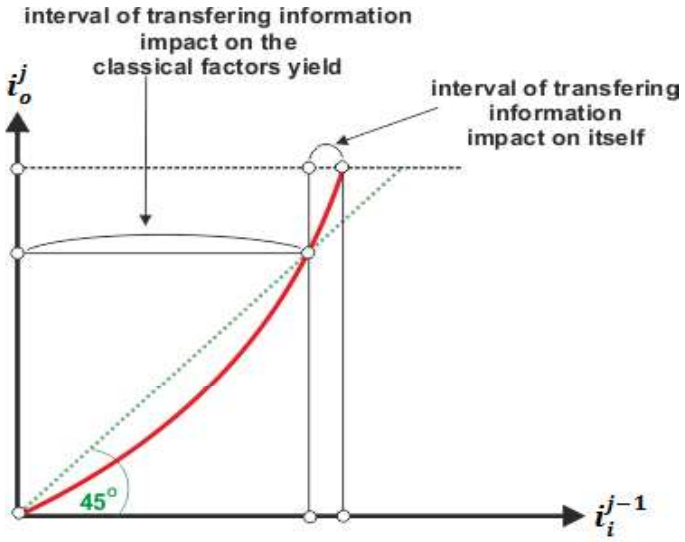

Figure 9. The information (knowledge) yield curve (Source: author)

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