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THE MAP OR THE REALITY? HOW LEVERAGE EFFECTS OF TIME LEAKAGES DISTORT KEY RATIOS IN INFORMATION ECONOMY

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Abstract

This paper addresses specifically leverage effects based on the irreversible nature of time and the Cognitive Time Distortion in economy. In service - and information society, time has received an ever increasing importance, not from the perspective of faster production, but due to the fact that the major part of the economic value of Total Revenues and Total Costs is based on time. In this paper, we demonstrate new mathematical mechanisms in economy due to the irreversible nature of time and Cognitive Time Distortion, and we explore their lever effects. It is presented that the lever effect on return on capital employed may rise to many hundred percent of budgeted outcome. It is concluded that even moderate cognitive time distortions cause substantial deviation in budgeted profit as well as it proves to be a mechanism to large delays. The lever effect due to the time perception is an ever present distortion of a true economic outcome.

Key words: leverage effect, time perception, information economy

1. INTRODUCTION

It may be a self-evident statement that economic information of today mostly is about unexpected deviations of the outcome from an unspoken point of reference. There are few who are astonished to read about large profit increases, dramatic economic losses, projects that are delayed or boost of productivity. One example is the report on the Olkiluoto Nuclear Power Plant construction delays as follows:

"The main contractor, Areva, is building the unit for a fixed price of €3 billion, so in principle, any construction costs above that price fall on Areva. In July 2012, those overruns were estimated at more than ***€2 billion*** *and in December 2012, Areva estimated that the full cost of building the reactor would be about* ***€8.5 billion****, well over the previous estimate of €6.4 billion. Because of the delays, TVO and Areva are both seeking compensation from each other through the International Court of Arbitration. In October 2013, TVO's demand for compensation from Areva had risen to €1.8 billion, and Areva's from TVO to €2.6 billion. In December 2013, Areva increased its demand to €2.7 billion." (Wikipedia, 2015-05-07).*

The Olkiluoto Nuclear Power Plant construction delays are not an exception, though the astounding management problems of the project may be attributed to political reasons. We argue for that there is a larger pattern in the society, and that similar problems may even be found in other branches of trade. In Sweden, for instance, the costs for failed IT-projects amount to circa 1 billion Euro on yearly basis, and it is assumed that the figure may be higher (Johnson & Magnusson, 2005). There is also other statistics presenting the poor precision of delivery of completed IT-projects, which exhibit a pattern in which the majority of the projects were delayed in 2008, see table 1 below.

Table 1

Precision of delivery of completed IT-projects under 2000 and 2008.

Precision of delivery of IT-projects	Proportion of projects 2000 (%).	Proportion of projects 2008 (%).
Interrupted	23	31
Delayed	49	53
Completed on time	28	16
Total	100	100

Source: Chaos Report, Standish Group International.

During the year 2000, the costs of the IT-projects in Table 1 were increased by 45 % of the budgeted sum.

Notwithstanding modern computer support for economic management and in spite of sophisticated planning tools for profit, workload and productivity, it is difficult to understand how miscalculations amounting to billions of Euro can emerge. Can it be that *economic mathematics* – not market factors or political factors - falls short of supporting management of services? Can it be that the map – carefully developed by business management tools - simply does not correspond to the reality?

In this paper we investigate the leverage effect based on the irreversible nature of time and the Cognitive Time Distortion in economy. While the leverage effect in economy generally has been applied to real estate, stocks, bonds, commodities, currencies and other investments, we argue here for that the leverage of human perception of time and its implication to economy has so far been little investigated in research literature. We define here leverage effect as the outcome when a relatively small change of one parameter A conveys a relatively large change in another parameter B. The focus of our interest is the mediating mechanism that brings about this leverage effect.

Thus, in other words, we define the leverage effect as a relatively small change in the time perception that conveys relatively large changes in profit, project delay and other key ratios. The mediating mechanisms are the economic formulas presented in von Schéele (2001), von Schéele & Haftor (2014). We do not intend to replicate their deduction and derivation here again, but will apply them to present the leverage effect.

In this paper we assume an economic organization that only trades services. These organizations are characterized by an economy where the main delivered values are based on billed time, and the main production costs emanates from salaries – that is, compensations for worked time. The assumptions brings the economic calculus closer to the reality of labor-intensive economic organizations, with many employees performing administrative tasks, consultancy work or, for instance, work on project basis. These organizations are characterized by an economy where the main delivered values are based on billed time, and the main production costs emanates from salaries. In the information- and service society, these economic organizations make up for the majority, and we intend to investigate the leverage effect of time perception on their economy.

The paper is structured accordingly. First, we define the concepts of Time Perception and the Cognitive Time Distortion, where we also refer to previous research within the area of Time Cognition. Second, we present the mechanism between time perception and economic contract, which is the main cause to leverage between time perception and economy as counted per time unit. Third, we give a brief presentation of the mathematic formulas for Profit distortion and Workload distortion. Fourth, we give some short examples of the lever effect by demonstrating the equations with concrete examples. The paper is ended with a short discussion and conclusions.

2. TIME PERCEPTION

We now wish to introduce a crucial empirical phenomenon, which commonly passes unnoticed: this is the relation between *physical time* and *cognitive time* that inherently gives rise to the phenomenon called here *time perception and its cognitive time distortion*. The divergence between the two kinds of time is well-known in the medical and psychological disciplines (e.g. Guyau, 1890; Bergson, 1910; Block & Eisler, 1999, Levin & Zackay, 1989), yet to our knowledge it has not yet been noticed nor elaborated on by the various management sciences and the economic sciences (e.g. see Orlikowski & Yates (2002) for a recent treatment of time in organizational contexts). More specifically, perception of physical time (hereafter "time perception") is understood here as a mathematical relation between the *cognitive time* of an individual and the *physical time* as measured mechanically by a clock, in relation to some specific event. Therefore, cognitive time is here understood as the human percept that is an estimation of the physical time (see: Bindra & Waskberg, 1956; Cohen 1967; Hancock & Weaver, 2005). While cognitive time of an individual tends to move in jerks and jumps, the physical time passes smoothly and at an even pace (e.g. Levin & Zackay, 1989). Therefore, when individuals estimate time durations they typically, unintentionally and unknowingly, commit errors resulting in significant differences between the self-assessed cognitive time duration and the corresponding physical time duration, as measured by a clock. A review of current research into time perception suggests that the gap, or error, in correct assessment of one hour may vary between 1,02 – 2,14 hours, see Table 2 for an overview.

Table 2

The mean value of one psychic hour, obtained by an individual's self-assessment versus a physical hour.

Source	Mean value of one psychic hour t_c as expressed in physical time t_p (hrs).
Mackleod & Roff (1936)	1,22
Vernon & McGill (1963)	1,08
Siffre (1964)	2,14
Webb & Ross (1975)	1,02 – 1,05
Lavie & Webb (1975)	1,12
Aschoff (1985)	1,47
Campbell (1990)	1,12

Source: Block, 1990:5

In our previous work (c.f. von Schéele & Haftor, 2014), we suggested a mathematical definition of the cognitive time distortion as a ratio between cognitive and physical time. The definition had the disadvantage that the term

“Time perception” was not mathematically accounted for, and discussions were raised on how to include this term in the concept of cognitive time distortion.

Therefore, we here wish to clarify our mathematical definitions about cognitive time distortion by including a suggested formalization for “Time perception” as well. Subsequently, consider the following definition of Time perception τ, with reference to the physical time during the event “i”:

$$\tau_i = \frac{t_{ci}}{t_{pi}} = \left(\frac{t_c}{t_p}\right)_i \tag{1}$$

In Equation 1, we state that Time perception is the ratio between cognitive time (t_c) and physical, or clock, time (t_p). In appraising time perception, it is necessary that cognitive and physical time have the same *frame of reference*, and that they address the *same event*. Thus, ‘frame of reference’ and ‘event’ may signify, for instance, an activity, a process, a project, or a service contract. Therefore, more specifically, time perception, denoted here with “τ_i”, is defined as the ratio between cognitive time, t_c, and physical time, t_p, of a certain event “*i*”. A value of $\tau_i \equiv 1$ means that the cognitive and the physical time for a certain event “i” correspond exactly – which is a most unlikely event. In reality there is almost always a difference between the cognitive and physical time, thus making time perception larger or smaller than unity – therefore we say that it is distorted. The deviations of time perception from unity, we henceforth define as cognitive time distortion, and suggest the formal mathematical definition:

$$\Delta\tau_i = \tau_i - 1 \tag{2}$$

To illustrate Equation 1 and 2, consider a test person reporting that “one minute has passed *now*” (60 seconds) while the clock measuring that time period records one minute and 12 seconds on a timer (72 seconds). The test person will have a cognitive time corresponding to t_c = 72 seconds, while the point of reference, the physical time t_p = 60 seconds. In this example, the cognitive time is the length of a subjective duration, *as measured by a physical clock*, and the time perception in our example comes out as:

$$\tau = \left(\frac{72}{60}\right) = 1{,}20$$

The cognitive time distortion is subsequently:

$$\Delta\tau = 1{,}2 - 1 = 0{,}2$$

This means that the individual has a cognitive time distortion corresponding to 20 %, which is an *overassessment* of the passage of time. A negative value of cognitive time distortion stands for an underassessment of the passage of time.

When we apply the concept of time perception in economic formulas, we distinguish between the time perception of revenues, τ , and time perception of costs, δ (von Schéele & Haftor, 2014). However, here we apply a general notation of time perception as τ unless it is necessary to stress that it is related to costs.

From the definition in Equation 1 it follows that time perception, $\tau_{i,}$ is limited by [0…L], where 'L' is a large number and that a value of $\tau_{i,}$ corresponding to unity signifies the total conformity between cognitive time and physical time.

The time perception τ have some mathematical qualities that are important to mention:

i. P(τ) is not symmetrically distributed around $\tau = 1$, which implies that the arithmetical mean value $\mu_\tau \neq 1$.

ii. P(τ) is not Gaussian-distributed, but exhibits instead an asymmetric distribution with a long "tail" for values of $\tau > 1$ (von Schéele & Haftor, 2013).

3. THE CONTRACT EFFECT; THE MAIN CAUSE TO LEVER EFFECT BETWEEN TIME PERCEPTION AND SERVICE ECONOMY

The main reason to the lever effect is that time is *irreversible*. This perspective accentuate that the economic calculus is about *TR* - and *TC per time unit*. Any deviation from budgeted and contracted time frame, changes accordingly the amount of money to be distributed on the remaining time frame in the *TR* - and *TC per time unit*. In general there are the two contract types to distinguishes between:

First, consider the *fixed-price contract for TR per time unit*. If employees overestimate the time-volume delivered, resulting in the cognitive time, t_c, exceeding contracted or physical time, t_p, the time perception , τ will be larger than unity, thus decreasing *TR* per time unit (A in Figure 1). It corresponds to the situation when the contracted *TR* per time unit must be distributed on more time units than contracted. On the other hand, an underestimation of the time delivered affords a time perception, τ, less than unity, and *TR* per time unit will increase. Thus, from this we are able to draw the conclusion that the relation between time perception, τ, and *TR*, is *inversely proportional* for all fixed-price contracts. From this we conclude that $TR = pt_{tot}$ must be corrected with the time perception $\frac{1}{\tau}$ for all the time t_{tot} that is delivered on fixed price contract.

In Figure 1 below, we see how the time perception generates dissimilar effects on *TR* and *TC* per time unit. The effect is determined by contractual category, and Figure 1 illustrates the *lever-effect* between time perception and the *curve-linear* economic outcome per time unit with reference to the fixed price contract. The lever-effect is also relevant to the workload, see Equation 6 below.

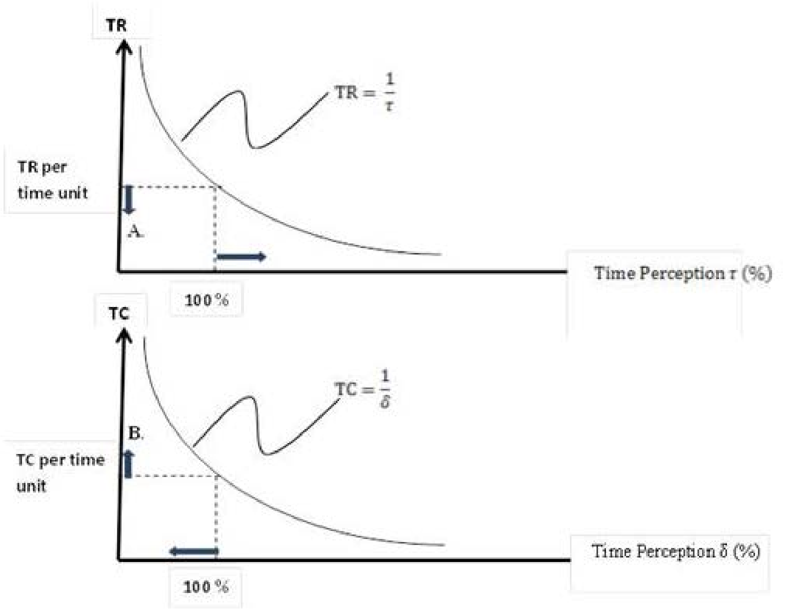

Figure 1. Dissimilar effects on TR and TC per time unit, and its *lever-effect* between time perception and the *curve-linear* economic outcome per time unit.

Sorce: von Schéele, 2001, pp 93.

Consider now for a moment the *fixed price contract for TC per time unit*. As employees overestimate time-volume delivered to customer, their time perception coincides with that their predefined efficiency per time unit decreases. This causes an underestimation of the employee capacity, which in turn, result in increased *TC* per time unit (B in Figure 1).

Finally, consider the *current account* contract. Here, the customers are charged for the contractor's cognitive time assessment, t_c, regardless of whether it equals the actual clock, i.e. physical, time delivered, t_p, or not. Underestimation of the passage of time – leading to undercharging – causes a decrease in *TR* and the time, t_c, reported to the customer will be less than the actual time delivered, t_p. The opposite will occur if time is overestimated. Therefore, we conclude that the relation between time perception, τ, and *TR*, is *linear* for all contracts on current account. (von Schéele, 2001).

Thus, any Cognitive Time Distortion on the *TR per time unit* coincides with *dissimilar* Cognitive Time Distortion on the *TC per time unit*. The time perception on *TR*- and *TC* per time unit stirs the economic calculus and creates fluctuations and unexpected deviations of the outcome from the budgeted point of reference.

Before moving on to elaborate the consequences of these dissimilar effects of time perception due to contractual form, we wish to make a brief observation. The key role of the mode of a commercial contract in relation to production time and for economic results of an organization, as we understand it, appears so far to have passed unnoticed in economic studies. Subsequently, the relation between time perception and the economic outcome has traditionally been assumed to be *linear*. It is, however, the mathematical properties of the curves in Figure 1 that render linear economic equations their *non-linear properties.*

4. PROFIT EQUATION, WORKLOAD EQUATION INCLUDING THE TIME PERCEPTION

Consider now the Profit equation below. It is based on the formula for profit that accounts for any service organization, and is defined as (Hadar, 1971):

$$\pi = TR - TC \qquad \text{[MU]} \qquad \textbf{(3)}$$

π denotes here profit per time unit, *TR* signifies the total revenues per time unit, while *TC* denotes the total costs per time unit. The parameters are expressed in Monetary Units (MU), preferably defined for the time unit of one year. This equation is further developed with consideration to time perception in organization and contract effect (von Schéele & Haftor, 2014).

Q(τ,δ), The **Distortion Equation** due to cognitive time-assessment

$$\pi(\tau,\delta) = p\, t_{\mathrm{vol}}\left(\left(\alpha \sum_{i=1}^{n}\left(\frac{\varepsilon}{\tau}\right)_i + (1-\alpha)\sum_{i=1}^{n}(\varepsilon\,\tau)_i\right) - \sum_{j=1}^{m}\left(\frac{v_p\,\varphi}{\delta}\right)_j\right) \qquad \text{[MU]}$$

(4)

The distortion of *TR* on **fixed-price customer contract**.

The distortion of *TR* on **current-account customer contract**.

The distortion of *TC* on **fixed-price employee contract.**

The Equation 4 consist of several parameters (see Table 3 below for further clarification) that we now intend to insert in the equation to demonstrate the lever effect. In our examples below we have assumed a time perception τ on *TR* corresponding to 110 %, while the time perception δ on *TC* is 90 %.

Table 3

Explanation of parameters in Equation 4 and their values in the calculus examples in paragraph 5 below.

Parameter	Parameter value
Budgeted profit, π	250 Monetary Units
Price, p	100 Monetary Units / hour
Budgeted workload (customer contract time), t_{vol}.	10 hours
Number of customer contracts, ε	1
Number of employee contracts, ϕ	1
Price policy margin, v_p	0,75
Time perception on customer contract, τ	1,1
Time perception on employee contract, δ	0,9
Proportion of fixed price contract variable, α	1
Total Budgeted Revenues, TR	1000 Monetary Units
Total Budgeted Costs, TC	750 Monetary Units

Consider for a moment the expression between the large parentheses on the right hand side of Equation 4. Let us call this parenthesis Q(τ,δ); it expresses the Distortion Equation which accounts for various distortions of *TR* and *TC* due to time perceptions based on disparate contract modes. Thus, we modify Equation 4 accordingly.

$$\pi(\tau,\delta) = p\, t_{\mathrm{vol}}\, Q(\tau,\delta) \qquad \text{[MU]} \qquad (5)$$

Equation 5, the profit equation, informs about *how much profit* π *is distorted due to poor time perception*, given that price per hour p and budgeted workload (customer contract time), t_{vol}, remains constant (a common management assumption).

In order to calculate how budgeted workload (customer contract time), t_{vol}, fluctuate with the time perception, we rearrange Equation 5 accordingly.

$$t_{\mathrm{vol}}(\tau,\delta) = \frac{\pi}{p}\frac{1}{Q(\tau,\delta)} \qquad \text{[hours]} \qquad (6)$$

Equation 6, the workload equation, informs about *how much the workload is distorted due to poor time perception*, given that the targeted profit π and the price per hour p remains constant (a common management assumption).

5. LEVERAGE ON PROFIT DUE TO TIME PERCEPTION

Let us now proceed with an example of the leverage mechanism on profit in Equation 4. As indicated in Table 3, we assume that the time perception is 110 % on *TR* and 90 % on *TC*. Should we disregard from the contract mode effect and calculate the effect of the time perception on *TR* and *TC* separately, the result is trivial: it gives us the outcome that *TR* and *TC* differs 10 % from target value respectively.

If we on the other hand apply Equation 4, that considers the dissimilar effects of time perception and contract mode simultaneously in the same equation, we get:

$$\pi(\tau,\delta) = 100 * 10\ (1 * \frac{1}{1,1} - \frac{0,75 * 1}{0,9})$$

[MU]

$$\pi(\tau,\delta) = 1000\ (0,076) = 76$$

[MU]

Instead of a profit of 250 U (as budgeted in Table 3 above), the profit *decreased with almost 70 % : (250 -76)/250 = 0,69.* Here we have a leverage effect in which a cognitive time distortion of 10 % is leveraged to a profit decrease of almost 70 %. The mediating mechanism is the profit equation as suggested in Equation 4 and 5. This lever effect refers mainly to the dissimilar time perception on *TR* and *TC* that is further amplified by *subtraction* in Equation 4.

6. LEVERAGE ON WORKLOAD DUE TO TIME PERCEPTION

Now, continue with another example now focusing on the mechanism of the leverage effect on the workload as described in Equation 6. Again we assume a time perception of 110 % on *TR* and 90 % on *TC*. A common misconception is that cognitive time distortion corresponds to “loss of time” by working the corresponding amount of time extra. This misconception does not account for the *division effect*, neither does it take into account that *profit and price per hour shall remain constant*.

We consider these things by taking applying Equation 6 and insert the parameter values from Table 3 with the following result:

$$t_{\mathrm{vol}}(\tau,\delta) = \left(\frac{250}{100}\right)\frac{1}{\left(1\ \frac{1}{1,1} - 0,75\ \frac{1}{0,9}\right)}$$

[hours]

$$t_{\text{vol}}(\tau, \delta) = 31{,}3$$ [hours]

The *combined* effects of a time perception of 1,1 (on *TR*) and 0,9 (on *TC*) respectively, informs us that the empoyees needs to work 31,3 hours to balance the cognitive time distortion – should all other parameters (budgeted profit, price level and salary level) *remain constant*. Here we have a leverage effect when a time distortion of 10 % increases *the workload by some 300%.* The mediating mechanism is the Equation 6 and we attribute this lever effect mainly to the mathematical operation of *division*.

It is obvious that mathematic operators deteriorate the validity of an economic analysis. We have compared the leverage effect of a time perception of 1,02 in a company with turnover corresponding to 405 Million Monetary Units. In Table 4, we see the relative difference of the keyratios, compared to if there is no cognitive time distortion at all (time perception $\tau = 1$).

Table 4.

An example of mathematical leverage effects on key-ratios in an organization with a turnover of 405 Million Monetary Units.

Key – ratio	Budgeted outcome	Relative difference from budgeted outcome with cognitive time distortion of 2 % on fixed price contracts (Leverage effect)
Turnover	405 Million MU	- 1,96 %
Operating expenses	400 Million MU	1,01 %
Profit percentage	0,86 %	- 347,18 %
Turnover rate of Capital	5,06 times/year	- 1,96 %
Return on Total Capital	4,48 %	- 342,33 %

The column “Budgeted Outcome” displays the target level of each key-ratio. The right column “Relative difference from outcome with cognitive time distortion…” displays the leverage effect when there is a time perception on 1,02 on fixed price contracts. This means that, for instance, the Return on Total Capital decreases with 342,33 % when there is a cognitive time distortion of 2 %. The more sophisticated the keyratios are, the larger the leverage effect.

7. DISCUSSION AND CONCLUSIONS

In this paper we have introduced a new kind of economic lever effect, one that is sourced in the *perception of time* as made by employees in economic organizations. More specifically, human agents unconditionally perceive time, both prospectively and retrospectively, in a manner that is typically not in unity with the rhythm of physical time (i.e. clock time), while the latter kind of time mentioned is universally assumed by economic contracts hence governing all kinds of economic affairs. The unconditional gap between perceived time and the physical time is dynamic and gives rise to time leakage, which has profound economic implications, particularly for economic organizations intensive on human labor, such as various kinds of services. The dynamic nature of cognitive time distortion gives rise to the here lever effect due implying that only minor temporal distortions produces economic loss that with multiple size of the distortion.

We wish to suggest that this ‘temporal lever effect’ may have profound effects on all economic affairs that are implicitly or explicitly based upon the conventional notion of time, i.e. physical time. This implies that any theoretical body founded on physical time – whether macro or micro – requires a revision, in terms of its account for the temporal distortion here featured. Secondly, the practices of managers and policy makers are also in need of development to include conceptual apparatus that enables the detection and assessment of present cognitive time distortion and thereafter its management, for instance through employee learning.

From this paper we draw the following conclusion about the lever effect:

- Even a moderate cognitive time distortions cause substantial deviation in budgeted profit as well as it proves to be a mechanism to large delays. The lever effect mechanism can be modelled and predicted by mean of the here presented mathematic model. The lever effect due to the time perception is an ever present distortion of a true economic outcome.

Thus, future research should focus both on the update of current theoretical bodies that are based in the conventional notion of physical time only, and to develop managerial techniques that enable the detection and positive management of various levels of temporal distortions.

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