Journal of Business Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Business Research

journal homepage: www.elsevier.com/locate/jbusres

Temporal workload in economic organizations: A hidden non-linear condition of economic efficiency

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ARTICLE INFO

Keywords:
Performance management
Timetabling
Cognitive processes
Human resource planning
Temporal experience

ABSTRACT

A *temporal workload model* is introduced to identify the relationship between the work time and economic performance of the activities conducted by a human agent in the context of an economic organization. The model's novelty derives from the account of time perception and its consequent *cognitive time distortion*, the latter being understood as a discrepancy between physical and cognitive time. Current praxis, both theoretical and empirical, assumes only *physical time*. This assumption is challenged here through the inclusion of time perception and cognitive time distortion in estimating the temporal workload of an economic agent. This inclusion enables a novel comprehension of frequent operational challenges, such as work delays, human stress, output quality issues, and economic inefficiencies. The main contribution to the literature is a specification of a new condition that governs the performance of any economic organization where human agents conduct time assessments.

1. Introduction

White-collar workers, also known as information-and-knowledge workers, manifest a significant *degree of discretion* with regard to assessing the quality of a work task outcome (Hopp, Iravani, & Liu, 2009). This stems from work tasks constituting the various knowledge professions tending to be less rigidly specified compared to work tasks in industrial contexts, such as a car maker's assembly line (Hopp, Iravani, & Yuen, 2007). The execution of knowledge workers' tasks implies non-trivial information processing, decision making, and judgement, being often driven by human agents rather than machines. In this context, task completion criteria are typically not well-specified, and it is the worker's judgement that determines *when* a certain activity is completed (Hopp et al., 2009). For example, an engineer or a physician may determine how much time to spend on a given activity, such as writing a report or diagnosing a patient, to complete it. While knowledge workers' discretion regarding the *quality* of a work task has received certain attention (Breithaupt, Land, & Nyhuis, 2002; Fransoo & Wiers, 2006; Hopp et al., 2009; Stevenson & Hendry, 2006) the *temporal duration* of a given work task, work-process or project has been ignored until conduct of the work recently (von Schéele & Haftor, 2014). Specifically, this research gap refers to human agents' assessment of either an anticipated temporal workload required to perform a given work task or a consumed temporal workload after a work task execution. To that end, von Schéele and Haftor (2014) introduce the notion of *cognitive time distortion* and its consequences for the conventional profit equation (Hadar, 1971), where cognitive time distortion is the relationship between physical and perceived time, both referring to a given event (e.g., action, activity, task, event, project, process). Their introduction to the cognitively endowed profit equation accounts for two types of temporal experience, cognitive (i.e., perceived or subjective time) and physical time (i.e., clock or objective time), and incorporates that relationship between the two types of time into the profit equation (ibid.).

Despite warnings (Collopy, 1996) not to ignore the discrepancy between cognitive and physical time, virtually all current literature on worker staffing and workloads is based on the assumption of *one type of human temporal experience*, namely, that human agents experience and behave according to *physical time* only (e.g., Comm & Mathaisel, 2003; Crévits, Debernard, & Denecker, 2002; Fredendall, Ojha, & Patterson, 2010; Hopp et al., 2009; Keskinocak, Ravi, & Tayur, 2001; Stevenson, Huang, Hendry, & Soepenberg, 2011; Tan & Netessine, 2014). This means that the extant workload literature omits workers' discretion and judgement of work task *duration*, including its inherent divergence between an agents' assessments of work tasks' duration compared to the tasks' actual duration in physical time. This gap is addressed in this study and is well illustrated with cases such as an engineer's assessment that writing a report required seven hours while it actually consumed

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https://doi.org/10.1016/j.jbusres.2018.01.042
Received 19 June 2017; Received in revised form 15 January 2018; Accepted 17 January 2018
0148-2963/

seven hours and twenty-five minutes, and a physician's perception that a conducted patient diagnosis required twenty minutes when it actually consumed seventeen minutes. Such a temporal distortion may seem irrelevant in relative measures, but we show it deteriorates both profit and temporal workload significantly by means of a hidden *leverage effect*, which challenges the virtuousness of the orthodox business economic theory and practices.

Practically, the use and management of time in business contexts is of constant concern to the business community (Deal, 2015; Huson & Dhanajay, 1995; Rondeau, Vonderembse, & Ragu-Nathan, 2000; Stalk Jr., 1988). This is not surprising, as human labor costs can account for 60%–70% of many service organizations' total costs (Tan & Netessine, 2014). Frequent surveys suggest that over 30% of all complex software projects are delayed, and the trend is increasing and causing major economic losses (Chaos, 2000, 2008).

To address this concern of business practitioners and the gap in the literature, the objective of this paper is to articulate a formal mechanism that accounts for the temporal workload of a human agent, given a level of cognitive time distortion and in the context of an economic organization. The conceptual formulation of the model is based on four literature strands. One is the orthodox managerial economics theory with its profit function (Drury, 2012; Hadar, 1971; Samuelson & Marks, 2006); the second is represented by empirical studies in cognitive psychology that address the time perceptions of human agents (Block, 2014; Block & Eisler, 1999; Levin & Zackay, 1989); the third is the theory of contracts, with its two principal contracts, current account and fixed-price (Bolton & Dewatripont, 2005); and the fourth is the contemporary workload theorizing in operations management (Hopp et al., 2009; Stevenson et al., 2011; Tan & Netessine, 2014). By introducing empirical findings from cognitive psychology into the conventional theories of managerial economics and operations management, this paper contributes to the growing momentum of behavioral economics and business studies (Earl, 2017).

The significance of the proposed temporal workload model comes from it being a hidden, counter-intuitive and not explored economic mechanism that manifests a non-linear relationship between a worker's task and its time distortion, on one hand, and the economic profit of the agent's operations on the other hand. In this sense, the present contribution to the literature specifies a novel condition for the economic performance of an economic actor.

2. Time distortion

Studies in cognitive psychology show that human agents have various types of temporal experiences (Bergson, 1910; Block & Eisler, 1999; Guyau, 1890; Levin & Zackay, 1989), such as biological time (Kreitzman & Foster, 2004) and cognitive time (Block, 2014)—for example, the former is experienced in the form of the so-called "jet-lag." While the various economic and management disciplines occasionally address the notion of two types of time in broad and general terms (e.g., Orlikowski & Yates, 2002), the specific distinction between cognitive and physical time and its relation to business economics is ignored except by von Schéele and Haftor (2014).

Physical time is the socially accepted notion of what a clock measures. This, in turn, is defined in relation to a particular physical event, where a *second* corresponds to the duration of a specific number of periods of the radiation of the *cesium* atom in its ground state at the temperature of 0 K (ISU, 1998). The universality of this agreement penetrates into all areas of current civilization, such as contracts specifying employment and delivery of products, levels of taxation, corporate and governmental budgets, medical treatments, teaching in schools, and governmental regimes. Cognitive time, on the other hand, refers to humans' mental experience of the duration of a given physical event (Bindra & Waksberg, 1956; Cohen, 1967; Hancock & Weaver, 2005). While cognitive time tends to move in jerks and jumps, physical time passes smoothly and evenly (Levin & Zackay, 1989).

Studies show that individuals' estimation of the time duration of a given event conducted without access to a clock to determine the physical time, typically generates unintentionally and unknowingly a gap between the self-assessed time duration, expressed as physical time, and the corresponding actual physical time duration of the given event. Nearly a century of independent studies show that the mean value of 1.00 cognitive hour can correspond to the range of 1.02–2.14 physical hours (Aschoff, 1985; Campbell, 1990; Lavie & Webb, 1975; Mackleod & Roff, 1936; Siffre, 1964; Vernon & McGill, 1963; Webb & Ross, 1972), which suggests that individuals tend to underestimate the physical time passed.

The relationship between physical and cognitive time is here regarded as *time perception*, which accounts for the ratio of cognitive (t_c) to physical time (t_p), referring to the same event, such as a work task, an activity, an assignment, a project, or a work-process. Time perception is denoted here as τ_i, and represents the relationship between cognitive time, t_c, and physical time, t_p, for a given event *i*, as shown in Eq. (1):

$$\text{Time perception:} \tau_i = \frac{t_{ci}}{t_{pi}} = \left(\frac{\mathrm{t_c}}{\mathrm{t_p}}\right)_i \tag{1}$$

A value of $\tau_i \equiv 1$ means that the cognitive and physical time for a given event *i* correspond exactly. Such correspondence is very unlikely, as empirical experience shows convincingly that the *cognitive* and *physical time* for a given event are seldom equal (e.g., Levin & Zackay, 1989). This gives rise to time perception larger or smaller than unity and is, therefore, understood here as *distorted*. Consequently, a deviation of the time perception from unity is a *cognitive time distortion* and motivates the following definition in Eq. (2):

$$\text{Cognitive time distortion:} \Delta\tau_i = \tau_i - 1 \tag{2}$$

Time perception, τ_i, as defined in Eq. (1), is limited by [0…L], where L is a large number, and a value of $\tau_{i,}$ corresponding to unity signifies the total conformity between cognitive and physical time. Therefore, $\tau_i = 1$ signifies perfect compliance between cognitive and physical time, which also implies $\tau_i = 100\%$. In other words, a time perception corresponding to 100% is the only point for which the *cognitive time distortion* is zero.

Several characteristics of cognitive time distortion suggest that it should not be ignored for the following reasons. First, cognitive time distortion is unconditionally prevalent in all human life, and its scope is extensive as it influences all human activities independently of their context (Levin & Zackay, 1989). Second, time perception with its consequent cognitive time distortion is dynamic rather than constant, and is conditioned by an individual's characteristics and context, such as age, gender, health, mental well-being, motivation, physical fatigue, cultural and educational upbringing, perceived stress, and work task at hand (Levin & Zackay, 1989; Wei, Donthu, & Bernhardt, 2012). Third, the probability function of the stochastic time perception variable τ is not symmetrically distributed around $\tau = 1$ (Aschoff, 1985), which means that individuals who assess time either overestimate or underestimate its passage, typically the latter (Aschoff, 1985). Additionally, the probability function of the stochastic time perception variable τ is not Gaussian-distributed, as it manifests an asymmetric distribution with a long tail for $\tau > 1$ (ibid.). This means that errors are committed when assuming a Gaussian distribution of the time perception.

Cognitive time distortion manifests similar patterns both at the human individual level and at that of a group of individuals (von Schéele & Haftor, 2014), such as an economic organization (Levin & Zackay, 1989). Finally, cognitive time distortion emerges in both retrospective and prospective assessments, where the former refers to an individual's assessment of a past event and the latter to an individual's assessment of a planned or anticipated event (von Schéele & Haftor, 2014).