The Hidden Lever of Cognitive Time: Extending Activity-Based Costing in the Digital Economy

Aram Mohammed-Amin Qadir, MSc[1], Rashed Baker Zakaria Alwardat MSc[2]

[1,2]Department of International Trade, Law and Administration College, University Of Halabja, Halabja, 46018, IRAQ

Abstract: In today's fast-paced digital world, we're finally realizing that "brain time" isn't just a quirky concept but a crucial economic asset. Sure, the clock on the wall is ticking, but what about the mental clock inside our heads? We're all spending a lot of "cognitive time" to complete tasks, solve problems, and come up with innovative ideas, but no one has really figured out how to manage this resource effectively. That's a big problem, especially when you consider that how long you think about a task isn't necessarily the same as how long that task actually takes in "wall clock time."

Enter our new tech solution: Cognitive Time-Driven Activity-Based Costing, or CTABC for short. It's like a software upgrade for the well-known time-driven activity-based costing method, which many businesses already use to figure out how much their activities cost. What sets CTABC apart is that it factors in human cognition—the mental effort it takes to get stuff done. It's like having a mental stopwatch that actually keeps track of how much brainpower goes into every project, task, or activity. And guess what? It's a game-changer. Why? Because CTABC reveals a hidden glitch, or what we like to call the "hidden lever effect," that has been messing with economic efficiency. You see, most traditional costing methods overlook the cognitive load, or mental effort, it takes to complete tasks. As a result, businesses can seriously underestimate costs, leading to all kinds of inefficiencies and budget headaches.

We're not just throwing theories here; we've run tests that show how CTABC can shine a light on these hidden costs and inefficiencies. For example, it reveals how old-school costing models often underestimate the real costs by ignoring cognitive time. Just think about it—how many times have you or your coworkers misjudged how long a task will take, not because you can't tell time, but because you didn't account for the mental effort involved? Exactly. So, what's the big takeaway? Our CTABC tech doesn't just give a more accurate picture of costs; it provides a roadmap for businesses looking to streamline operations, allocate resources more wisely, and get the most bang for their buck in a digital economy that prizes mental agility. And from an academic standpoint, our research adds a fresh perspective to ongoing debates about cost accounting tech and the evolving digital landscape. It's especially useful for tackling the age-old problem of why we're often so bad at estimating how long tasks will take. In a nutshell, CTABC is like having a new set of eyeglasses that lets businesses see the world, and their own operations, more clearly. It's high time we started paying attention to cognitive time, not just clock time, and CTABC is the tool to help us do just that.

Keywords: Cognitive Time; Activity-Based Costing; Digital Economy; Economic Efficiency; Cost Assessment; Human Capital; Time Management; Organizational Performance.

1. Introduction

In the high-stakes world of modern business, it's more crucial than ever for managerial decisions to be rooted in accurate cost accounting (Ganorkar et al., 2020; Hardan & Shatnawi, 2013; Zamrud & Abu, 2020). Without reliable cost data, management can't effectively allocate resources, undermining the financial stability of organizations, firms, and even entire economies (Berisha, 2017; Ganorkar et al., 2020; Hardan & Shatnawi, 2013). The drive to remain competitive has led both for-profit and not-for-profit entities to scrutinize their cost structures rigorously (Hofmann & McSwain, 2013; Stouthuysen et al., 2014; Varila et al., 2007). And yet, achieving a nuanced understanding of costs is far from straightforward. Numerous studies have demonstrated the complexities and pitfalls that accountants and managers face in grasping cost dynamics (Berisha, 2017; Hardan & Shatnawi, 2013; Uyar & Kuzey, 2016). Over the years, various accounting methodologies like traditional costing, activity-based costing (ABC), and time-driven activity-based costing (TDABC) have been developed to provide more accurate data (Barros & da Costa Ferreira, 2017). ABC evolved to fill the gaps left by traditional costing systems, and TDABC was further refined to address ABC's own limitations, including its complexity and high operational costs (Siguenza-Guzman et al., 2013). However, the efficacy of TDABC remains contentious. While some studies advocate for its utility in decision-making (Keel et al., 2017), others question its foundational assumptions and calculations (Mortaji et al., 2013; Barros & da Costa Ferreira, 2017).

One significant oversight across all these models is their inability to adequately consider the element of time, especially in our current digital economy where the human experience of time has become central to assessing costs (Devece et al., 2017; Laudien & Pesch, 2019). Various disciplines in the social sciences have recently delved into the exploration of time, particularly human perceptions of it (Ogle, 2015). Philosophical works like Hagglund's discuss the importance of time as a cornerstone for human life (Hagglund, 2012, 2019). Rosa's sociological theories focus on the concept of time as the lynchpin of societal behavior, introducing ideas like "high-speed society" and "social accelerations" (Rosa, 2010, 2013). This broader discussion on time isn't just academic; it has practical implications. Objective time—what we see ticking away on the clock—is frequently at odds with cognitive or subjective time, the time our brains perceive (Orlikowski & Yates, 2002; Shipp & Jansen, 2021). These disparities create tension within organizational dynamics and pose a false dichotomy: should we prioritize clock time or cognitive time? Our paper aims to revolutionize this paradigm by introducing a novel technology for cost accounting that synthesizes these two seemingly disparate forms of time. By linking cognitive time with objective clock time, we can transcend the limitations of current accounting models, offering a more holistic and nuanced understanding of cost structures. This innovation bridges a critical gap in existing literature and provides a robust foundation for managerial decision-making in the fast-paced digital age.

The digital economy has ushered in a unique era where the focus has shifted from tangible goods to services facilitated by digital technology (Barefoot et al., 2018; Brynjolfsson & Kahin, 2002; Carlsson, 2004). This landscape significantly impacts how organizations consider costs. For example, in a digital environment, the first copy of a product (be it software, music, or written content) is often the only version that incurs a tangible cost; subsequent copies are nearly cost-free (Frew et al., 2016; Rifkin, 2014; Yang et al., 2019). Another defining characteristic of this economy is human time's central role, particularly since most digital services are delivered by human operators (Mont, 2002). Given the paramount importance of human time as a resource in this new economic context, understanding how humans utilize their time—and the subsequent cost implications—is vital. This is the central theme of the present paper. Although Time-Driven Activity-Based Costing (TDABC) has made strides in addressing the flaws in traditional cost accounting, it too has its drawbacks (Barros & da Costa Ferreira, 2017; Cardinaels & Labro, 2008; Gervais et al., 2010; Mortaji et al., 2013; Siguenza-Guzman et al., 2013). TDABC operates on the idea that activities, as organizational cost-generating mechanisms, use resources for a certain amount of time. The system's effectiveness hinges on the accuracy of these time assessments.

However, the subjectivity inherent in human-based time reporting poses significant challenges. For instance, some studies found that up to 30% of errors in time estimation could be attributed to inaccurate human assessments (Hoozée & Bruggeman, 2007). Another study indicated that there was an overestimation bias of 35% when participants were asked to provide time estimates (Cardinaels & Labro, 2008). Further research has shown that the range of time-estimation errors could swing from -22% to +38% (Barrero et al., 2009). These inaccuracies have profound implications for the reliability of the TDABC system, particularly in service sectors where human labor is the dominant cost component and activities are conducted by humans who are also responsible for reporting their time spent on activities (Hardan & Shatnawi, 2013; Haroun, 2015; Tan & Netessine, 2014; Szychta, 2010). Adding to the complexity, the "attention economy" underscores that human cognitive time has limitations, especially when it comes to the accurate assessment of time durations and processing of information (Davenport & Beck, 2000; Falkinger, 2007; Franck, 1999, 2002; Goldhaber, 1997; Simon, 1971). This brings into sharp focus the need to reconcile subjective human time with objective, clock-measured time, particularly in the digital age where the human perception of time has emerged as a crucial, if not the last, asset of the economy. Given the pivotal role of human time in the digital economy, our paper aims to navigate the intricate relationship between time and costs, with the ultimate objective of refining the TDABC model to make it more adaptable and accurate in the current economic landscape. The idea is to account for the subjectivity and limitations in human cognitive time in a way that can improve the overall reliability and effectiveness of cost accounting methods. This goal is especially pertinent in service-based organizations, where human time influences the cost and often constitutes the majority of it.

Time-Driven Activity-Based Costing (TDABC) fundamentally relies on clock time or physical time as its objective measure. However, cognitive science literature suggests that there's a significant discrepancy between a worker's perception of time (cognitive time) and actual clock time (Block & Eisler, 1999; Levin & Zakay, 1989). This divergence results in what is known as Cognitive Time Distortion (CTD), a phenomenon that describes the relationship between human-perceived time and clock-measured time. CTD has significantly influenced crucial economic metrics, including profitability, productivity, workload, and risk (von Schéele, 2001; von Schéele & Haftor, 2014, 2018; von Schéele et al., 2019, 2020). Given that TDABC is highly susceptible to subjectivity, especially in self-assessments of time, the central goal of the study presented in this paper is to refine TDABC by incorporating the theory of CTD. The hypothesis is that a technology enhanced by the CTD framework could ameliorate the long-standing issues of time assessment in traditional TDABC, thus supporting more accurate and reliable managerial decision-making. Preliminary findings suggest that this modified technology can substantially improve the accuracy of a company's overall profitability when both revenue and cost equations are adjusted to include inherent CTD factors. In the emerging digital economy, where human time serves as a pivotal resource, this has substantial implications. Moreover, the study also uncovers that failing to account for CTD in time assessments can result in skewed revenue and cost evaluations, thereby adversely affecting profits. Such discrepancies could produce a 'lever effect' that misguides managers in their decision-making processes based on potentially erroneous profitability figures.

The structure of the remainder of the paper is methodically designed to offer comprehensive insights into this groundbreaking approach. Initially, the paper provides an overview of various costing systems and delineates their respective merits. Subsequently, it delves into key theoretical concepts, including the profit equation and the role of CTD. The innovative technology incorporating CTD is then elaborated upon, complemented by a case study that exemplifies its impact on profitability. The paper culminates in a discussion section and concludes by summarizing the pivotal findings The study endeavors to bridge the gap between the traditional TDABC approach and the nuanced understanding of time as elucidated by cognitive science. By doing so, it addresses the subjectivity that has historically hampered the efficacy of TDABC, paving the way for a more accurate and reliable system. This enhanced system has the potential to be instrumental in the digital economy, where the proper valuation of human time could very well be the defining factor in an organization's success or failure.

2. Essential Financial Tracking Methods

In the modern business landscape, characterized by rapidly evolving technologies and shrinking product life cycles, conventional cost accounting systems are increasingly becoming obsolete (Tse & Gong, 2009; Rifkin, 2014). The traditional costing systems, which were effective in stable environments with limited activities and costs, have been found to be less accurate for contemporary business needs. They often result in flawed total product cost estimates, thereby affecting pricing strategies and overall competitiveness (Gupta & Baxendale, 2008; Myers, 2010). Activity-Based Costing (ABC) emerged in the 1980s to address these limitations, offering a more nuanced approach to overhead cost allocation (Cooper & Kaplan, 1998; Kaplan & Atkinson, 1989). Unlike traditional methods that used arbitrary overhead rates, ABC employs cost drivers to allocate costs more accurately to various activities within an organization (Allain & Laurin, 2018; Mortaji et al., 2013). The fundamental premise of ABC is that products vary in their production complexities, and different products consume activities in different proportions (Siguenza-Guzman et al., 2013). The ABC system gathers requisite data on time expenditure for various activities through interviews, observations, and surveys (Kaplan & Anderson, 2004). Academic studies on ABC can generally be categorized into four main groups: design-focused studies, case studies on implementation, surveys on adoption factors, and its applications in the service sector (Hoozée & Bruggeman, 2007; Szychta, 2010).

Despite its advantages and widespread scholarly attention, the ABC system has not been without challenges. Many organizations have retreated from its implementation due to high operational costs, employee dissatisfaction, and complexities in application (Carli et al., 2014; Herath et al., 2010; Javid et al., 2016). Additionally, with the advent of digital industries where marginal costs often approach zero, overhead costs and their accurate allocation have gained unprecedented importance, making the limitations of traditional systems even more glaring (Barros & da Costa Ferreira, 2017). As we navigate through the intricate terrains of modern businesses that are being significantly influenced by digital technologies, the need for more refined, dynamic, and responsive costing systems becomes paramount. Though a marked improvement over traditional systems, existing systems like ABC require further refinement and possible integration with emerging technologies to accurately capture cost dynamics. Companies must remain vigilant and adaptable in selecting and customizing the costing systems that best suit their evolving needs. The challenges and limitations of the existing systems not only call for innovation in cost accounting but also imply that organizations must foster a culture of continuous improvement and learning to remain competitive. The fast-paced changes in technology and consumer expectations necessitate an equally rapid evolution in cost accounting methodologies. Failing to adapt could result in financial losses and impair strategic decision-making, as inaccurate costing information can mislead managers and stakeholders. Therefore, investing in developing or adapting more accurate and efficient cost accounting systems is no longer just an option but a business imperative for contemporary organizations.

Activity-Based Costing (ABC), which emerged to rectify traditional costing systems' inaccuracies, presented multiple challenges. These included the complications in collecting, storing, and processing data, high costs of both implementation and maintenance, difficulties in linking cost drivers to individual products, and issues with subjective time estimates from employees (Carli et al., 2014; Gosselin, 2006; Herath et al., 2010; Kaplan & Anderson, 2004, 2007; Siguenza-Guzman et al., 2013). Moreover, both traditional and ABC systems have been criticized for not delivering accurate information regarding the consumption of resources and activities (Gunasekaran et al., 2005). To address some of ABC's limitations, Time-Driven Activity-Based Costing (TDABC) was introduced (Kaplan & Anderson, 2004). Unlike ABC, TDABC places a different emphasis on time in its cost allocation process (Cidav et al., 2020; Hoozée & Bruggeman, 2010). In TDABC, cost allocation is a two-step process: First, the cost per unit time of supplying resource capacity to an activity is determined. Then, the time units required for each activity are estimated. This is usually done through interviews or direct observations (Kaplan & Anderson, 2004, 2007; Yilmaz, 2008). TDABC has found applications across various sectors, including agriculture, healthcare, and service industries (Bank & McIlrath, 2009; Dalci et al., 2010; Everaert et al., 2008; Gervais et al., 2010; Pernot et al., 2007; Somapa et al., 2010, 2011; Varila et al., 2007; Yilmaz, 2008).

However, case studies indicate that TDABC is not without its own issues. In particular, the theoretical assumptions and calculations behind the system have come under scrutiny (Gervais et al., 2010; Mortaji et al., 2013; Siguenza-Guzman et al., 2013). A significant issue lies in the subjectivity of time estimation by employees, also known as Cognitive Time Distortion (CTD). This subjective time assessment introduces substantial measurement error into the TDABC system (Cardinaels & Labro, 2008; Gervais et al., 2010; Mortaji et al., 2013; Ratnatunga & Waldmann, 2010; Siguenza-Guzman et al., 2013). CTD is characterized by a divergence between clock time and a worker's perception of time spent on an activity. Given this backdrop, the integration of CTD into TDABC calculations becomes a promising avenue for refinement. By incorporating a more nuanced understanding of time perception, TDABC can potentially rectify one of its significant flaws. This can have far-reaching consequences, as more accurate cost allocation directly impacts profitability calculations, risk assessment, and overall managerial decision-making. while ABC and TDABC have advanced our understanding of cost accounting and provided more robust frameworks than traditional methods, both systems have notable limitations. In the case of TDABC, the challenge of incorrect time assessment due to CTD introduces significant error into the system, thereby affecting its reliability. By integrating CTD into TDABC calculations, it may be possible to offer a more accurate, reliable, and comprehensive cost accounting methodology that stands up to the complexities of contemporary business environments.

3. Advancing Towards a Novel Cost Accounting Methodology

In the subsequent portion of this text, an in-depth exploration into the theoretical constructs and mathematical modeling underpinning both profit equations and Time-Driven Activity-Based Costing (TDABC) is conducted. Initially, a comprehensive definition of profit in the context of any generated service is provided. The concept of Cognitive Time Distortion (CTD) is introduced after this. This idea bridges objective, clock-measured time and the subjective, cognitive perception of time for a specific event or activity. Finally, we scrutinize the ripple effects of CTD on profit margins, revealing its substantial impact on financial outcomes. This multifaceted examination aims to shed light on the intricacies of modern costing systems, particularly in how variations can influence them in time perception. The discussion ultimately seeks to contribute to more accurate and reliable decision-making processes in cost accounting.

3.1 Organizations that Operate on a Time-Sensitive Basis and the Role of TDABC.

Companies aim to earn a profit for their long-term viability (Hadar, 1971). Profit, represented as π, is determined by subtracting total costs (TC) from total revenues (TR). Mathematically, this relationship is expressed by the equation (1).

$$\boldsymbol{\tau = TR - TC.} \qquad (1)$$

Profit can be derived from two primary factors: the time allocated for tasks and the materials used in those tasks (Varian, 2014). This concept is mathematically captured in Equation Eq. (2)Eq. (2).

$$\textbf{Profit}(\boldsymbol{\tau})\textbf{=Total Revenue (TR)}-\textbf{(Time Cost of Resources+Material Costs)} \qquad (2)$$

This equation is denoted as Eq. (2). It captures the idea that profit is the difference between total revenues and the sum of the costs of time resources used and materials consumed in activities.

In service-based firms, profitability hinges on accurate time assessment as it relates to costs and revenues (Everaert et al., 2008). This focus on time is particularly relevant because labor often represents the largest cost component in many service organizations. Therefore, understanding time-related total revenues (TR) and total costs (TC) is crucial. TR is tied to sales orders, while TC is linked to purchase orders. Importantly, these orders are considered to be fixed (Everaert et al., 2008). Time-Driven Activity-Based Costing (TDABC) operates on two levels in this context. The first level pertains to the employee contract and calculates the cost of the time each employee spends on various activities (Everaert et al., 2008). The second level, often overlooked, relates to the customer contract or sales contract. This level must also consider gross margins, which make the time sold to the customer more expensive. For a firm to maintain a stable profit margin, the TDABC system needs to take into account the time specified in the sales contract, along with the associated gross margin. Furthermore, achieving overall firm profitability is not solely a matter of covering product or service costs through sales revenue. It also involves ensuring that the gross margin is sufficient to cover the 'cost to serve' the customer (Shapiro et al., 1987). This 'cost to serve' encapsulates a variety of expenses, including those related to processing orders, specialized logistics, administrative functions, and sales activities (Everaert et al., 2008). Thus, an effective TDABC system should be comprehensive, incorporating both the employee and customer contracts. Doing so captures a more accurate picture of the firm's true costs and revenues, thereby allowing for more reliable decision-making regarding profitability. In sum, TDABC offers a multi-dimensional approach to understanding the nuanced cost structures inherent in service organizations, which is key to sustaining profitability in today's complex business landscape.

3.2 Perception of Time Alteration

In exploring the intersection of time, profitability, and Time-Driven Activity-Based Costing (TDABC), this paper delves into the transformative concept of Cognitive Time Distortion (CTD). The traditional frameworks for profitability and TDABC have been built on the assumption that physical clock time serves as the ultimate arbiter for all time-related calculations (Kaplan & Anderson, 2004, 2007). However, a growing body of cognitive science literature suggests that this assumption oversimplifies humans' complex relationship with time (Block & Eisler, 1999; Levin & Zakay, 1989; Nembhard & Uzumeri, 2000). CTD refers to the divergence between how time is objectively measured ("clock time") and how it is subjectively experienced ("cognitive time") (von Schéele & Haftor, 2014, 2018). In other words, while clock time remains constant, cognitive time can vary significantly based on a range of psychological and contextual factors. The concept of CTD adds a layer of complexity to TDABC, which traditionally only considers physical time. Ignoring CTD can introduce significant errors into the TDABC model, thereby affecting crucial economic indicators like profit, productivity, workload, and risk. Including CTD into TDABC allows for a more nuanced understanding of resource allocation in terms of both time and cost. It introduces a recalibration of time as understood traditionally in cost accounting systems, replacing the singular focus on clock time with a more complex interplay between objective and subjective experiences of time. To formalize CTD, it's useful to introduce an equation that captures the relationship between cognitive time (tc) and physical clock time (tp). In mathematical terms, CTD (τi) can be defined as the ratio of cognitive time to physical time, which can be expressed as:

$$\boldsymbol{\tau i} = (\boldsymbol{tc} \div \boldsymbol{tp})\boldsymbol{i} \qquad (3)$$

The integration of this new variable into TDABC potentially corrects the inaccuracies in traditional costing models by aligning the estimated time with the employees' perceived time spent on activities. Such an alignment improves the reliability and accuracy of cost and revenue assessments and lends a robust empirical basis to managerial decision-making. The effect is especially relevant in today's digital economy, where human time has become an increasingly scarce yet crucial resource. Therefore, incorporating CTD into TDABC models offers a revolutionary way to navigate the complexities of modern-day service organizations, potentially leading to more accurate, reliable, and thus more profitable business operations.

In the realm of cost assessment and economic modeling, the influence of Cognitive Time Distortion (CTD) remains largely unexplored, despite its profound impact on crucial economic indicators like profitability, productivity, workload, and risk (von Schéele, 2001; von Schéele & Haftor, 2014, 2018; von Schéele et al., 2019). CTD serves as a variable that could apply to various operational elements—be it a process, a project, an event, an activity, or even a service contract. Specifically, research indicates that the subjective experience of one cognitive hour can diverge widely, ranging between 1.08 to 2.14 physical clock hours (von Schéele et al., 2019). This time perception variance can potentially introduce significant discrepancies into traditional time-dependent economic models. Despite its considerable implications, current literature largely neglects the transformative influence of CTD, an oversight that this paper aims to address. Thus, incorporating CTD into time-dependent economic models enriches our understanding of cost assessment and can significantly enhance the accuracy of predictions concerning profitability and other key performance indicators.

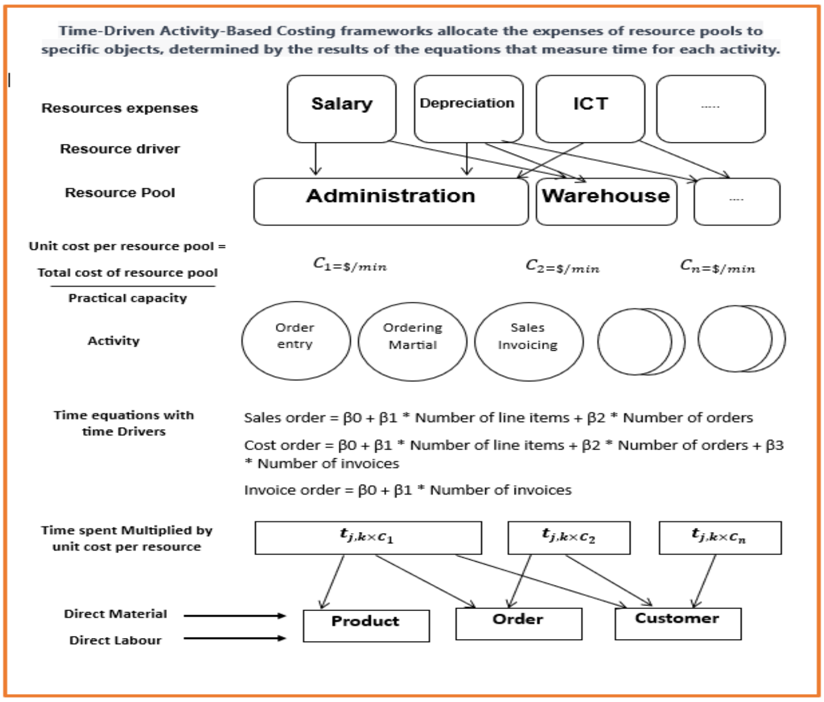

Figure 1: Time-Driven Activity-Based Costing Model

(Adapted from Everaert et al., 2008).

To clearly understand the variations in time expenditure within sales and cost contracts, a refined definition of Cognitive Time Distortion (CTD) is essential. Mathematically, this is captured in two distinct equations: one for sales contracts and the other for cost contracts. In the (Equation 4), ts represents the subjectively assessed time spent on activities as laid out in the sales contract. This serves as an objective benchmark for Total Revenues (TR), helping to quantify the magnitude of time distortion relative to the time stipulated in the sales contract. Similarly, in the (Equation 5), ts is used to represent the subjective time perception of an employee's work, which acts as a reference point for the Total Costs (TC) within the cost contract.

$$CTD\ sales = \frac{SubjectiveTime\ sales \times TaskComplexity\ sales \times EmployeeEfficiency\ sales}{ContractTime\ sales}$$

$$CTD\ sales = \tau = \frac{t_s}{t_{0\ Sale}} \tag{4}$$

$$CTD\ cost = \frac{SubjectiveTime\ cost \times TaskComplexity\ cost \times EmployeeEfficiency\ cost}{ContractTime\ cost}$$

$$CTD\ cost = \delta = \frac{t_s}{t_{0\ Cost}} \tag{5}$$

In these equations, Task Complexity is a variable that accounts for the degree of difficulty or intricacy involved in completing the tasks associated with the contract. Employee Efficiency could be a measure that quantifies how efficiently an employee is able to perform the tasks, possibly based on previous performance metrics. By introducing these additional variables, the equations become more nuanced, allowing for a more comprehensive understanding of the factors affecting CTD and, by extension, the total revenues and total costs in sales and cost contracts, respectively. These equations offer a robust framework for evaluating CTD in diverse contract types. Equation 4 primarily generates Total Revenues (TR), while Equation 5 focuses on accumulating Total Costs

(TC). By applying these equations, businesses can more accurately assess the variances between perceived and contractual time, thereby gaining a more nuanced understanding of their overall profitability and operational efficiency.

In the realm of contract accounting and profitability, Cognitive Time Distortion (CTD) plays a significant role, as defined by Equations 4 and 5. Equation 4 focuses on the total revenues (TR) generated from sales contracts. Here, ts symbolizes the subjective assessment of time, used as a basis for calculating revenues. Conversely, Equation 5 zeroes in on the total costs (TC) accrued through employee contracts. In both equations, contract time serves as an objective anchor for gauging the magnitude of time distortion affecting either revenues or costs (von Schéele et al., 2019; von Schéele & Haftor, 2018). Figure 2 explicates that misjudgments in time assessment can create disparate modes of CTD, which have a substantial lever effect on both TR and TC. Such a lever effect escalates the total costs per unit time, while concurrently diminishing the total revenues per unit time, as these distortions in time perception take effect simultaneously in both sales and employee contracts. For example, an employee who underestimates the time devoted to a task may inadvertently offer more time to the customer than was originally budgeted, leading to an overshooting of the planned costs while simultaneously underperforming in generating revenue.

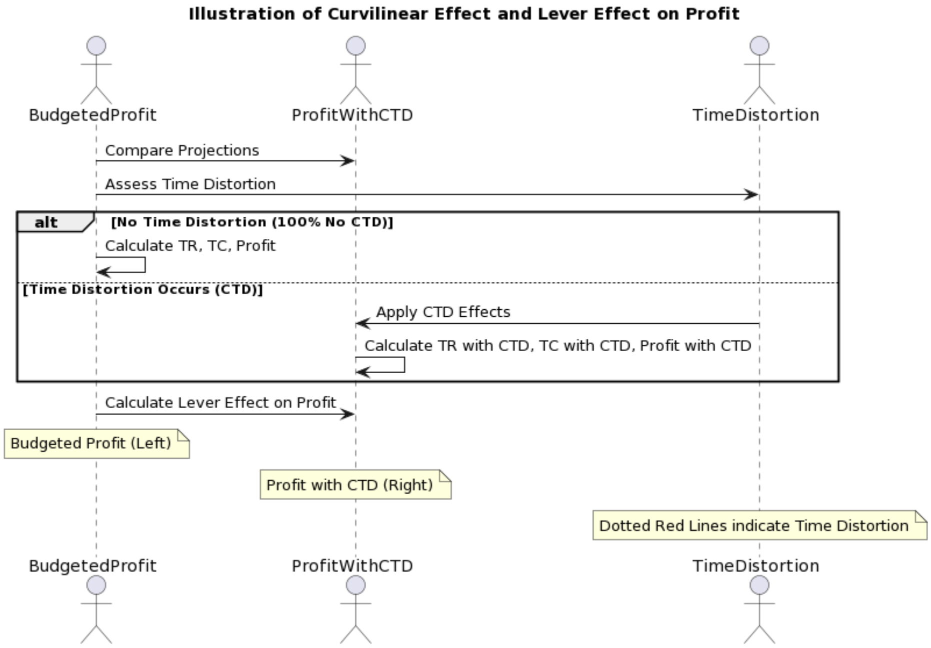

Figure 2: Illustration of Curvilinear Effect and laver Effect on Profit

This confluence of time distortions induces a ripple effect on profitability. Moreover, the relationship between CTD and Time-Driven Activity-Based Costing (TDABC) is not linear but curvilinear, further complicating the relationship between cost, revenue, and time (see Fig. 2). Consequently, the projected profits, when considered in the absence of CTD, are substantially different from the actual profits that include the impact of CTD. Further complicating this scenario is the finding by Drury (2012) that all fixed contracts exhibit a nonlinear relationship between volume and value. Thus, when calculating profit per unit time, it becomes imperative to correct for the CTD factors affecting both the sales order and the cost order. Specifically, the time distortions, represented by τ and δ, should be applied to adjust the subjective time assessments in sales and cost contracts, respectively. The necessity for such corrections is not limited to long-duration activities but also applies to short-term tasks. Therefore, even though the time allocation for varied activities (β) may appear constant across Equations 6, 7, and 8, one cannot ignore the corrections required for subjective time errors to accurately determine profit per unit time. Ignoring these factors would lead to a skewed and inaccurate representation of an organization's financial health.

4. Cognitive time-driven activity-based costing

Imagine you're trying to figure out how much a project will cost you, but you also want to consider how our brains perceive time — let's call it "mental time" for simplicity. This new approach is what we're dubbing "Cognitive Time-Driven Activity-Based Costing," or CTABC for short. It's like the traditional Time-Driven Activity-Based Costing (TDABC), but with a twist. We consider how our mind warps time — like how 5 minutes can feel like an hour during a boring meeting! So, how do you do it? First, you've got to nail down the basics of TDABC. You know, understanding the core steps involved in figuring out how much activities will cost in terms of time and resources. Then, we take those standard time equations from TDABC and give them a little makeover to factor in our brain's funky time perception, or CTD (Cognitive Time Distortion). Once you've got that down, you can start crunching the numbers. What's super cool about this is you can actually compare how profitable your project will be if you consider this cognitive time element versus if you don't. Basically, it's taking TDABC to the next level by adding a layer of human psychology. Neat, right?

4.1 TDABC modified to account for CTD

The Time-Driven Activity-Based Costing (TDABC) system has been critiqued for its limitations, particularly when applied to fixed-price contracts. According to Everaert et al. (2008), this model shows less than optimal outcomes for profitability. One of the key issues with TDABC is its inability to account for variations in time volume, which directly affects both sales and purchase contracts. Drury (2012) has noted that this influence isn't linear but rather curvilinear, adding complexity to the model. Another considerable drawback of TDABC is its failure to incorporate Cognitive Time Distortion (CTD), a factor that can drastically alter the effectiveness of the model. To remedy these shortcomings, a revised approach known as Cognitive Time-Driven Activity-Based Costing (CTABC) has been developed. This enhanced model closely follows the foundational steps of TDABC but introduces modifications to account for CTD. In the first stage, the model identifies different resource groups and makes an objective total cost estimation for each. These figures are assumed to represent budgeted costs accurately. The practical capacity—essentially the total time output—of each resource group is then calculated. The per-unit cost of these resource groups is also objectively determined and is used as a reference point for subsequent calculations.

The real game-changer in CTABC comes into play in the fifth step, where the time estimations for each activity or event are adjusted using CTD. By doing so, CTABC corrects the time errors that are commonly present in the traditional TDABC model. Finally, unlike TDABC, the CTABC model ensures that the last step of the costing process—multiplying the unit cost of each resource group by the time estimation for each event—is also fine-tuned to incorporate the effects of CTD. This makes for a more accurate, reliable, and comprehensive costing model that provides a better representation of profitability. The introduction of CTD adjustments into the costing model adds an additional layer of accuracy, making CTABC a more reliable tool for calculating profitability, especially in scenarios with fixed-price contracts. This revised approach, therefore, represents a significant advance over the traditional TDABC model.

4.2 Equations for calculating time in TDABC

In the process of incorporating Cognitive Time Distortion (CTD) into time calculations, our starting point is the time equations as outlined in Time-Driven Activity-Based Costing (TDABC) by Everaert et al. (2008). These equations are then systematically adjusted based on Figure 1, which also takes into account both sales and cost contracts to accurately model a service organization's profitability. We make a clear distinction between CTD as it affects the sales contract, which involves customer interactions, and CTD in the context of the cost contract, typically between employers and employees. These are separately specified in Equations (4) and (5). By doing this, we address the 'lever effect'—a phenomenon where small changes in time estimations can have disproportionate effects on profitability. Therefore, our adapted model aims to offer a more nuanced view of time allocation and its subsequent impact on organizational economics (Everaert et al., 2008).

Table 1: Fundamental Stages in CTABC (Adapted from Everaert et al., 2008).

STEP	RESOURCE GROUPS INVOLVED	EXPLANATION
1	Identify the activities that consume resources	List the tasks that are performed by each resource group (department) and assign them to cost pools
2	Estimate the total cost of each resource group	Calculate the sum of all the costs (direct and indirect) incurred by each resource group
3	Determine the cost drivers for each resource group	Identify the factors that cause the resource consumption to vary across different activities or products
4	Estimate the cost driver rates for each resource group	Divide the total cost of each resource group by the total amount of the corresponding cost driver
5	Assign the costs of each resource group to the activities	Multiply the cost driver rate of each resource group by the amount of the cost driver consumed by each activity
6	Calculate the activity costs for each product	Sum up the costs of all the activities that are required to produce each product
7	Compute the CTD per unit of each product	Divide the total activity cost of each product by the number of units produced

The equations (6), (7), and (8) are specific cases of the linear function, where y represents different outcomes (sales order, cost order, or invoice order) and x represents different predictors (number of line items, number of orders, or number of invoices). The coefficients β0, β1, β2, …, βp are the estimates of the intercept and slope parameters for each outcome and predictor.

The equations are:

$$\text{Sales order} = \beta 0 + \beta 1 * \text{Number of line items} + \beta 2 * \text{Number of orders} \tag{6}$$

$$\text{Cost order} = \beta 0 + \beta 1 * \text{Number of line items} + \beta 2 * \text{Number of orders} + \beta 3 * \text{Number of invoices} \tag{7}$$

$$\text{Invoice order} = \beta 0 + \beta 1 * \text{Number of invoices} \tag{8}$$

Step 1: Collect data on the outcome and predictor variables for a sample of observations.

Step 2: Plot the data on a scatter plot to see if there is a linear relationship between the variables.

Step 3: Use a statistical method (such as least squares) to estimate the coefficients of the linear function that best fits the data.

Step 4: Interpret the coefficients and test their significance using hypothesis tests or confidence intervals.

Step 5: Use the fitted linear function to make predictions or inferences about the outcome variable for new values of the predictor variable.

In Everaert et al. (2008), Equations (6), (7), and (8) appear to be analogous. Nevertheless, it's crucial to discern the nuances among these equations because inaccuracies in time estimation will impact the sales and cost contracts differently, thus altering the analysis outcome. Specifically, the total profitability for a given customer contract needs to be articulated in a distinct manner, as indicated in Equation (2) (Everaert et al., 2008). The careful consideration of these differentials is vital for a nuanced understanding of contract-based profitability.

$$\text{Profit}_{\text{TDABC}} = \text{Revenue}_{\text{Time}} - \text{Cost}_{\text{Time}}$$

$$\text{Profit}_{\text{TDABC}} = X_j \times (\, t_{j,k} \times \, C_{\text{sale}\,j} - \, t_{j,k} \, \times \, C_{\text{cost}\,j}) \qquad (9)$$

1. $\mathbf{Profit_{TDABC}}$: This is the profit calculated using the Time-Driven Activity-Based Costing method. We aim to find this value.
2. **Revenue Time and Cost Time:** These terms represent the time-adjusted total revenue (TR) and total cost (TC), respectively. They are calculated based on the activities and resources involved.
3. $\boldsymbol{X_j}$: Represents the time drivers for each activity j, such as the number of order lines for the sales order entry activity.
4. $\boldsymbol{t_{j,k}}$: This is the time spent on activity j by resource k.
5. $\boldsymbol{C_{\text{sale}j}}$: This is the total revenue generated from the customer contract that involves j specific activities.
6. $\boldsymbol{C_{\text{cost}j}}$: This is the total cost incurred for resource pool n, which relates to j specific activities in a customer contract.
7. $\boldsymbol{X_j \times (\, t_{j,k} \times \, C_{\text{sale}j} - \, t_{j,k} \times \, C_{\text{cost}j})}$ Here, we multiply the time spent on activity j by its unit cost for both the sales and cost contracts, factoring in the respective time drivers.

In the improved equation, we break down the Revenue and Cost components separately before subtracting them to arrive at Profit. This should help in understanding how each part contributes to the overall Profit, especially when corrected for Cognitive Time Distortion (CTD).

4.3 Time equations in TDABC adapted to include Cognitive Time Distortion (CTD)

In integrating Equations (4) and (5) with Equations (6), (7), and (8), we arrive at a revised understanding of time allocation per sales and purchase orders, which now accounts for Cognitive Time Distortion (CTD). Specifically, in Equations (10) and (11), two distinct forms of CTD are addressed: τ pertains to the time discrepancy relative to the customer contract, while δ concerns the error in time assessment vis-a-vis the employee contract. This dual approach allows for a more comprehensive and accurate assessment of time-related costs, thereby refining the original TDABC model.

$$tsales = \beta\tau 0 + \textstyle\sum_i^p = 1 \, \beta\tau \times x_i \qquad (10)$$

$$tcost = \beta\delta 0 \textstyle\sum_i^p = 1 \, \beta\delta \, \times X_i \qquad (11)$$

$t_{j,k}(\tau,\delta) \times C_1$= CTD-adjusted time spent × unit cost per resource

sale=Total revenue from j specified activities in customer order $\boldsymbol{C_{\text{sale}j}}$
=Total revenue from j specified activities in customer order

cost=Total cost for j specified activities in resource pool n $\boldsymbol{C_{\text{cost}j}}$
=Total cost for j specified activities in resource pool n

1. **Time in Sales Order (Customer Contract):** $\boldsymbol{t_{\text{sales}}}$ is the time spent on a sales order that accounts for Cognitive Time Distortion (CTD), represented by τ. Here, $\beta\tau$ is the time parameter for each activity adjusted for τ, and X represents the time drivers for each activity j. This equation takes the initial time parameter $0\beta\tau 0$ and adds it to the sum of each $\beta\tau$ multiplied by its corresponding X from 1 to p.

2. **Time in Cost Order (Employee Contract)**: $\boldsymbol{t_{\text{cost}}}$ functions similarly to $\boldsymbol{t_{\text{sales}}}$ but pertains to the employee contract. The CTD in this context is represented by δ.
3. **CTD-Adjusted Time Spent:** $\boldsymbol{t_{j,k}}(\tau,\delta)\times \boldsymbol{C_1}$ represents the time adjusted for CTD (τ and δ) for each activity j in the time equation, multiplied by the unit cost of the resource $\boldsymbol{C_1}$.
4. **Total Revenue in Customer Order:** $\boldsymbol{C_{\text{sale}j}}$indicates the total revenue generated from j specified activities in a given customer order.
5. **Total Cost in Resource Pool**: $\boldsymbol{C_{\text{cost}j}}$ shows the total cost associated with j specified activities in resource pool n, which might include labor, materials, and overhead.

This revised formulation offers a more nuanced understanding of how CTD impacts both the revenue and cost sides of transactions.

In this framework, the term **:** $\boldsymbol{t_{j,k}}(\tau,\delta)\times \boldsymbol{C_1}$ denotes the adjusted time spent per unit cost and per unit of time, incorporating cognitive time distortions. Using this term, we can precisely articulate the total profit for each customer order based on a specific equation. This refined representation allows for a more accurate calculation of profitability, as it accounts for nuanced time-related factors.

$$\text{Profit}_{\text{CTABC}} = \text{TR} - \text{TC} = X_j \times t_{j,k}(\tau,\delta) \times C_{sale,j} - x_j \times t_{j,k}(\tau,\delta) \times C_{\text{purchase},j} \tag{12}$$

1. $\textbf{Profit}_{\textbf{CTABC}}$: This is the profit calculated using CTABC, which accounts for cognitive time distortion (CTD).
2. **TR and TC**: These are the total revenue and total cost, respectively. The goal is to find their difference to determine profit.
3. $\boldsymbol{X_j}$: This represents the time drivers for each activity j. For example, this could be the number of order lines for a sales order entry activity.
4. $\boldsymbol{t_{j,k}}(\tau,\delta)$: This term is the time spent per activity j, adjusted for cognitive time distortions (τ for customer contracts and δ for employee contracts).
5. $\boldsymbol{C_{\text{sale}j}}$: This is the total revenue generated from the customer order that includes j specified activities.
6. $C_{\text{purchase},j}$: This is the total cost associated with the resource pool that is related to j specified activities in a customer contract.

The equation essentially calculates the profit by taking the total revenue and subtracting the total cost. Both revenue and cost are adjusted for time distortions (τ and δ) and scaled by the time drivers $\boldsymbol{X_j}$.

When comparing Equation (9) with Equation (12), the key difference lies in the measurement of time spent on each activity. Specifically, $\boldsymbol{t_{j,k}}$ in Equation (9) signifies time without any cognitive distortions, while $\boldsymbol{t_{j,k}}(\tau,\delta)$ in Equation (12) accounts for time distortions in both costs and revenues. This adjustment aligns with the factors specified in Equations (4) and (5), emphasizing the impact of cognitive time distortions on both the cost and revenue sides of the equation.

5. Examining Order Profitability Through a Customer-Level Case Study

To assess the impact of Cognitive Time-Driven Activity-Based Costing (CTABC) on profitability in service operations, we can contrast it with traditional Time-Driven Activity-Based Costing (TDABC). Let's assume we have three time drivers for a specific customer: X2,X3, and X4, and the duration for each respective activity is $\beta2$,$\beta3$, and $\beta4$ time units (TUs). Given the following parameters:

$\boldsymbol{C_{\text{sale}j}}$= 6 monetary units (MUs)

$C_{\text{purchase},j}$= 4 MUs

$\beta2$= 3 Tus, $\beta3$= 4 Tus, $\beta4$= 5 TUs, X2= 1,X3= 1,X4= 1

τ=1.2 (Average time distortion compared to customer contract)

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 3 (2023)

δ=0.8 (Average time distortion compared to employee contract)

We can first calculate Profit in TDABC with Equation 9:

$\text{Profit}_{\text{TDABC}}$ =6×(3+4+5)−4×(3+4+5)=6×12−4×12=72−48=24 MUs

Next, we can compute Profit in CTABC using Equation 12, which accounts for time distortion:

$$\text{Profit}_{\text{CTABC}} = 6 \times \left(\frac{3}{1.2} + \frac{4}{1.2} + \frac{5}{1.2}\right) - 4 \times \left(\frac{3}{0.8} + \frac{4}{0.8} + \frac{5}{0.8}\right)$$

≈6×10−4×15=60−60= 0 MUs

In this revised example, TDABC shows a profit of 24 MUs, whereas CTABC, which accounts for time distortions, shows zero profit. This stark contrast underscores the importance of accounting for Cognitive Time Distortions when assessing profitability.

To find the relative change in profitability between CTABC and TDABC, we can use the following formula:

$$\text{Relative Change in Profitability} = \frac{\text{Profit}_{\text{TDABC}}}{\text{Profit}_{\text{CTABC}}}$$

From the previous calculations, we found:

$\text{Profit}_{\text{TDABC}}$=0 MUs

$\text{Profit}_{\text{CTABC}}$=24 MUs

Plugging these into the formula, we get:

$$\text{Relative Change in Profitability} = \frac{0}{24} = 0$$

In this example, the relative change in profitability drops to zero when accounting for Cognitive Time Distortions via CTABC. This indicates that the distortions in time estimates have a significant impact on profitability.

The impact of Cognitive Time Distortion (CTD) on profitability calculations within the realm of service operations is striking and cannot be ignored. In the previously discussed example, the profit figure adjusted to account for CTD was 44% less than the profit derived from the traditional Time-Driven Activity-Based Costing (TDABC) model, which does not take CTD into account. This stark difference reveals the "lever effect," where small errors in time calculations can drastically impact the profitability of a contract (see Figure 2 for details). The issue becomes even more glaring when the ratio of $\text{Profit}_{\text{CTABC}}$ to $\text{Profit}_{\text{TDABC}}$ is observed across various levels of CTD, as shown in Table 2. This ratio serves as an indicator of the real economic loss that occurs when CTD is present at a given level. The ratio's decline, even at low levels of CTD, reveals a nonlinear relationship between CTD and economic loss. In other words, even a slight misjudgment in time can have an exponentially negative effect on profitability.

Thus, traditional TDABC, although a more accurate measure of profitability than many older methods, remains deficient in one key aspect: it does not account for the cognitive biases that impact time perceptions among employees and customers alike. The neglect of CTD in the TDABC model therefore has substantial repercussions. For example, even if the TDABC model could otherwise offer more precise information about the profitability of specific contracts, ignoring CTD introduces errors that can greatly inflate the lever effect. Given that time is a critical component in calculating profit, as specified in Equation 2, it is crucial to consider CTD to prevent substantial miscalculations. Ignoring this vital component could lead to severe misjudgments in operational decision-making. Therefore, accounting for CTD provides a more nuanced and accurate portrayal of costs and revenues, allowing managers to make more informed decisions. This is particularly significant when managerial judgments are being made based on temporal evaluations, underscoring the necessity for a more comprehensive model like Cognitive Time-Driven Activity-Based Costing (CTABC).

CTD level	ProfitTDABC	ProfitCTABC	Ratio: ProfitCTABC/ProfitTDABC
1.00	18	18	1.00
1.05	18	14	0.77
1.10	18	10	0.56
1.15	18	7	0.38
1.20	18	3	0.16
1.25	18	0	0
1.30	18	− 4	− 0.22
1.35	18	− 8	− 0.44
1.40	18	− 13	− 0.72

Table 2: Comparison of Estimated Profits Using TDABC and CTABC Methods

In this table, the first column represents different levels of Cognitive Time Distortion (CTD). The second and third columns show the calculated profits for TDABC and CTABC, respectively, at those CTD levels. The last column gives the ratio of Profit in CTABC to TDABC, serving as an indicator of the relative impact of CTD on profitability. As the CTD level increases, the profitability under the CTABC model declines more rapidly compared to the TDABC model, sometimes even becoming negative.

6. Discussion and conclusions

In the contemporary competitive landscape, the precision of cost and revenue calculations has become increasingly critical for organizational sustainability and long-term profitability (Berisha, 2017; Ganorkar et al., 2020). While determining the accurate cost of goods and services is inherently complex, the Time-Driven Activity-Based Costing (TDABC) model emerged to address the limitations of conventional costing frameworks, including the Activity-Based Costing (ABC) model. TDABC's uniqueness resides in its emphasis on time as the primary variable for cost evaluation. However, this approach has limitations, primarily due to the susceptibility of employees' time estimations to inaccuracies, leading to potential decision-making errors (Barros & da Costa Ferreira, 2017; Cardinaels & Labro, 2008; Gervais et al., 2010). TDABC primarily focuses on objective, physical time, overlooking the complexities of perceived or cognitive time as detailed in cognitive science research (Block & Eisler, 1999; Levin & Zakay, 1989). To address these limitations, this paper introduces an enhanced TDABC version called Cognitive Time-Adjusted Activity-Based Costing (CTABC). This updated model incorporates the element of cognitive time distortion (CTD), acknowledging that perceived time and objective time frequently differ. By doing so, CTABC compensates for the shortcomings of the traditional TDABC model in assessing time-related costs.

This work contributes significantly to cost accounting scholarship by shedding light on the subjectivity inherent in employee time assessments and how this affects cost calculation. We argue for the incorporation of cognitive time as a new variable in the CTABC model to ameliorate the inaccuracies of time assessment present in the conventional TDABC model. Specifically, our findings reveal that when CTD is factored into both revenue and cost equations, CTABC provides a more accurate measure of overall profitability. Traditional TDABC, while useful for providing a generally optimistic outlook on the profitability of specific contracts, falls short by neglecting the errors introduced by CTD. Such errors can escalate rapidly due to a "lever effect," significantly skewing the final profitability calculations. The study underlines the necessity for managerial attention to the differentiation between objective, physical time and employees' perceived time. As demonstrated, failure to account for this differentiation through CTD can result in distorted profitability assessments. By integrating CTD into the costing equations, CTABC offers a more nuanced and accurate tool for profitability management, thereby aiding more effective decision-making in the evolving competitive milieu. The advancement of Cognitive Time-Adjusted Activity-Based Costing (CTABC), as introduced in this study, addresses the critical issue of time management in economic transactions, affecting both revenues and costs (Brynjolfsson & Kahin, 2002). The interaction between time inefficiencies on both these fronts results in a "lever effect," leading to substantial nonlinear implications for operational profitability. Even a slight distortion in cognitive time (CTD) can generate considerable economic inefficiencies, which the CTABC model aims to articulate and mitigate. As the digital economy evolves, optimizing the use of human time—a vital resource in economic activities—becomes increasingly important.

Consider, for instance, U.S. tech behemoth Microsoft, which employs hundreds of thousands of professionals. These employees essentially monetize their time in delivering services to clients. A mere 1% reduction in time inefficiencies could lead to dramatic economic benefits on an annual scale. The theoretical contribution of this work fundamentally alters existing perspectives in cost accounting literature, especially those pertaining to Activity-Based Costing (ABC) and Time-Driven Activity-Based Costing (TDABC). Traditional frameworks focus on the assessment of human agents' physical time; however, our proposed CTABC approach integrates both physical and cognitive time. The existence of CTD, stemming from the discrepancy between these two forms of time, significantly influences activity profitability. This research serves as a clarion call for further scholarly work on governing, measuring, and controlling employees' cognitive time. It implies that managerial practices should include training and awareness programs to help employees align their perception of time with its actual physical measure. Additional investigations are required to offer more targeted recommendations on controlling CTD and the kind of feedback mechanisms that can help improve time-use assessment. Subsequent research could also explore the practical application of the CTABC system, scrutinizing its effects on organizational profitability through cost calculations that account for CTD.

For practitioners, this study paves the way for a novel approach to managing profitability by integrating the complexities of time distortion within the TDABC framework. Given that the digital economy is increasingly dependent on optimized human time management, the insights provided by this study offer invaluable directions for enhancing operational efficiency and profitability. By adopting a more comprehensive understanding of time through the CTABC model, companies can not only improve their bottom line but also gain a competitive edge in the rapidly evolving digital landscape.

7. Reference

[1] Allain, E., Laurin, C., 2018. Explaining implementation difficulties associated with activity-based costing through system uses. J. Appl. Acc. Res. 19 (a), 181–198.

[2] Bank, D.E., McIlrath, T., 2009. Utilizing time-driven activity-based costing in the emergency department. Ann. Emerg. Med. 3 (54), S5.

[3] Barefoot, K., Curtis, D., Jolliff, W., Nicholson, J.R., Omohundro, R., 2018. Defining and Measuring the Digital Economy. In: US Department of Commerce Bureau of Economic Analysis, Washington, DC, p. 15.

[4] Barrero, L.H., Katz, J.N., Perry, M.J., Krishnan, R., Ware, J.H., Dennerlein, J.T., 2009. Work pattern causes bias in self-reported activity duration: a randomised study of mechanisms and implications for exposure assessment and epidemiology. Occup. Environ. Med. 66 (1), 38–44.

[5] Barros, R.S., da Costa Ferreira, A.M.D.S., 2017. Time-driven activity-based costing: designing a model in a Portuguese production environment. Qual. Res. Account. Manag. 14 (1), 2–20.

[6] Berisha, V., 2017. Strategic management of costs: a new tool to gain competitive advantage. In: Advances in Applied Economic Research. Springer, Cham, pp. 239–254.
[7] Block, R.A., Eisler, H., 1999. The complete bibliography on the psychology of time, 1839–1999. In: Machine-readable Data File. Montana State University, Department of Psychology [Producer and Distributor], Bozeman.
[8] Brynjolfsson, E., Kahin, B., 2002. Understanding the digital economy: Data, tools, and research. MIT press.
[9] Buera, F.J., Kaboski, J.P., 2012. The rise of the service economy. Am. Econ. Rev. 102 (6), 2540–2569.
[10] Cardinaels, E., Labro, E., 2008. On the determinants of measurement error in time-driven costing. Account. Rev. 83 (3), 735–756.
[11] Carli, G., Canavari, M., Grandi, A., 2014. Introducing activity-based costing in farm management: the design of the FarmBO system. Int. J. Agric. Environ. Inf. Syst. 5 (4), 69–84.
[12] Carlsson, B., 2004. The digital economy: what is new and what is not? Struct. Chang. Econ. Dyn. 15 (3), 245–264.
[13] Cidav, Z., Mandell, D., Pyne, J., Beidas, R., Curran, G., Marcus, S., 2020. A pragmatic method for costing implementation strategies using time-driven activity-based costing. Implement. Sci. 15, 1–15.
[14] Cooper, R., Kaplan, R.S., 1998. Cost and Effect: Using Integrated Cost Systems to Drive Profitability and Performance. In: Harvard Business School Press, Boston, MA, pp. 12–13.
[15] Dalci, I., Tanis, V., Kosan, L., 2010. Customer profitability analysis with time-driven activity-based costing: a case study in a hotel. Int. J. Contemp. Hosp. Manag. 22 (5), 609–637.
[16] Davenport, T.H., Beck, J.C., 2000. Getting the attention you need. Harv. Bus. Rev. 78 (5), 118–126.
[17] Devece, C., Palacios-Marqu´es, D., Galindo-Martín, M.A., ´ Llopis-Albert, C., 2017. Information systems strategy and its relationship with innovation differentiation and organizational performance. Inf. Syst. Manag. 34 (3), 250–264.
[18] Drury, C., 2012. Management and Cost Accounting. In: Eighth edition. Cengage Learning EMEA, United Kingdom., p. 30
[19] Everaert, P., Bruggeman, W., Sarens, G., Anderson, S.R., Levant, Y., 2008. Cost modeling in logistics using time-driven ABC: experiences from a wholesaler. Int. J. Phys. Distrib. Logist. Manag. 38 (3), 172–191.
[20] Falkinger, J., 2007. Attention economies. J. Econ. Theory 133 (1), 266–294.
[21] Franck, G., 1999. Scientific communication – a vanity fair? Science 286 (5437), 53–55.
[22] Franck, G., 2002. The scientific economy of attention: a novel approach to the collective rationality of science. Scientometrics 55 (1), 3–26.
[23] Frew, B.A., Milligan, M., Brinkman, G., Bloom, A., Clark, K., Denholm, P., 2016. Revenue sufficiency and reliability in a zero marginal cost future (No. NREL/CP-6A20- 66935). National Renewable Energy Lab. (NREL), Golden, CO (United States).
[24] Ganorkar, A.B., Lakhe, R.R., Agrawal, K.N., 2018. Time driven activity-based costing (TDABC) model for cost estimation of assembly for a SSI. Int. J. Product. Manag. Assess. Technol. 6 (2), 56–69.
[25] Ganorkar, A.B., Lakhe, R.R., Agrawal, K.N., 2020. Productivity and profitability of process industry using TDABC: a case study. Int. J. Process Manag. Benchmarking 10 (2), 240–260.
[26] Gervais, M., Levant, Y., Ducrocq, C., 2010. Time-driven activity-based costing (TDABC): an initial appraisal through a longitudinal case study. J. Appl. Manag. Account. Res. 8 (2), 1.
[27] Goldhaber, M.H., 1997. The attention economy and the net. First Monday 2 (4).
[28] Gosselin, M., 2006. A review of activity-based costing: technique, implementation, and consequences. In: Handbooks of Management Accounting Research, 2, pp. 641–671.
[29] Gunasekaran, A., Williams, H.J., McGaughey, R.E., 2005. Performance measurement and costing system in new enterprise. Technovation 25 (5), 523–533.
[30] Gupta, M., Baxendale, S.J., 2008. The enabling role of ABC systems in operations management. J. Cost Manag. 22 (5), 5–17.
[31] Hadar, J., 1971. Mathematical Theory of Economic Behavior. Addison-Wesley Publishing Company.

[32] Hagglund, M., 2012. Dying for Time: Proust, Woolf, Nabokov. Harvard University Press.
[33] Hagglund, M., 2019. This life: why mortality makes us free. In: Profile Books.
[34] Hardan, A.S., Shatnawi, T.M., 2013. Impact of applying the ABC on improving the financial performance in telecom companies. Int. J. Bus. Manag. Sci. 8 (12), 48.
[35] Haroun, A.E., 2015. Maintenance cost estimation: application of activity-based costing as a fair estimate method. J. Qual. Maint. Eng. 21 (3), 258–270.
[36] Herath, S.K., Wickramasinghe, D., Indrani, M.W., 2010. A teaching case on implementing an activity-based costing system in a service firm: Lakhiru insurance company. Int. J. Manag. Financ. Account. 2 (2), 177–195.
[37] Hofmann, M.A., McSwain, D., 2013. Financial disclosure management in the nonprofit sector: a framework for past and future research. J. Account. Lit. 32 (1), 61–87.
[38] Hoozee, S., Bruggeman, W., 2007. Towards explaining cost estimation errors in time equation-based costing. In: Working Paper. University of Gent.
[39] Hoozee, S., Bruggeman, W., 2010. Identifying operational improvements during the design process of a time-driven ABC system: the role of collective worker participation and leadership style. Manag. Account. Res. 21 (3), 185–198.
[40] Javid, M., Hadian, M., Ghaderi, H., Ghaffari, S., Salehi, M., 2016. Application of the activity-based costing method for unit-cost calculation in a hospital. Glob. J. Health Sci. 8 (1), 165.
[41] Kaplan, R.S., Anderson, S.R., 2004. Time-driven activity-based costing. Harvard Business Review November, 131–138.
[42] Kaplan, R., Anderson, S., 2007. The innovation of time-driven activity-based costing. J. Cost Manag. 21 (2), 5–15.
[43] Kaplan, R.S., Atkinson, A.A., 1989. Advanced Management Accounting. 3 Prentice-Hall, USA.
[44] Kaplan, R.S., Cooper, R., 1998. Cost and Effect: Using Integrated Cost Systems to Drive Profitability and Performance. Harvard Business School Press, Boston, MA.
[45] Keel, G., Savage, C., Rafiq, M., Mazzocato, P., 2017. Time-driven activity-based costing in health care: a systematic review of the literature. Health Policy 121 (7), 755–763.
[46] Laudien, S.M., Pesch, R., 2019. Understanding the influence of digitalization on service firm business model design: a qualitative-empirical analysis. Rev. Manag. Sci. 13 (3), 575–587.
[47] Levin, I., Zakay, D. (Eds.), 1989. Time and human cognition: A life-span perspective. Elsevier.
[48] Mont, O.K., 2002. Clarifying the concept of product–service system. J. Clean. Prod. 10 (3), 237–245.
[49] Mortaji, S.T.H., Bagherpour, M., Mazdeh, M.M., 2013. Fuzzy time-driven activity-based costing. Eng. Manag. J. 25 (3), 63–73.
[50] Myers, J.K., 2010. Traditional versus activity-based product costing methods: A field study in a defense electronics manufacturing company. Journal of Business Accounting 2 (Fall 2009/March 2010), 160–170.
[51] Nembhard, D.A., Uzumeri, M.V., 2000. Experiential learning and forgetting for manual and cognitive tasks. Int. J. Ind. Ergon. 25 (4), 315–326.
[52] Ogle, V., 2015. The global transformation of time: 1870–1950. Harvard University Press.
[53] Orlikowski, W.J., Yates, J., 2002. It's about time: temporal structuring in organizations. Organ. Sci. 13 (6), 684–700.
[54] Pernot, E., Roodhooft, F., Van den Abbeele, A., 2007. Time-driven activity-based costing for inter-library services: a case study in a university. J. Acad. Librariansh. 33 (5), 551–560.
[55] Ratnatunga, J., Waldmann, E., 2010. Transparent costing: has the emperor got clothes? Account. Forum 34 (3–4), 196–210.
[56] Rifkin, J., 2014. The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism. St. Martin's Press.
[57] Rosa, H., 2010. High-speed society: Social acceleration, power, and modernity. Penn State Press.
[58] Rosa, H., 2013. Social acceleration. In: Social Acceleration. Columbia University Press.
[59] Rubalcaba, L., 2007. The new service economy. In: Books.

[60] Shapiro, B., Rangan, K., Moriarity, R., Ross, E., 1987. Manage customers for profits (not just sales). Harv. Bus. Rev. 65 (5), 101–108.
[61] Shipp, A.J., Jansen, K.J., 2021. The “other” time: a review of the subjective experience of time in organizations. Acad. Manag. Ann. 15 (1), 299–334.
[62] Siguenza-Guzman, L., Van den Abbeele, A., Vandewalle, J., Verhaaren, H., Cattrysse, D., 2013. Recent evolutions in costing systems: a literature review of time-driven activity-based costing. Rev. Bus. Econ. Lit. 58 (1), 34–64.
[63] Simon, H.A., 1971. Designing organizations for an information-rich world. In: Greenberger, Martin (Ed.), Computers, communication, and the public interest. The Johns Hopkins Press, Baltimore, MD, pp. 40–41.
[64] Somapa, S., Cools, M., Dullaert, W., 2010. Time driven activity-based costing in a small road transport and logistics company. In: Proceedings of the 2nd International Conference on Logistics and Transport & the 1st International Conference on Business and Economics.
[65] Somapa, S., Cools, M., Dullaert, W., 2011. The development of time driven activity-based costing models: a case study in a road transport and logistics company. In: Current Issues in Shipping, Ports and Logistics, pp. 431–445.
[66] Stouthuysen, K., Schierhout, K., Roodhooft, F., Reusen, E., 2014. Time-driven activitybased costing for public services. Public Money Manag. 34 (4), 289–296.
[67] Szychta, A., 2010. Time-driven activity-based costing in service industries. Social Sciences 67 (1), 1392–0758.
[68] Tan, T.F., Netessine, S., 2014. When does the devil make work? An empirical study of the impact of workload on worker productivity. Manag. Sci. 60 (6), 1574–1593.
[69] Tse, M., Gong, M., 2009. Recognition of idle resources in time-driven activity-based costing and resource consumption accounting models. J. Appl. Manag. Account. Res. 7 (2), 41–54.
[70] Uyar, A., Kuzey, C., 2016. Does management accounting mediate the relationship between cost system design and performance? Adv. Account. 35, 170–176.
[71] Varian, H.R., 2014. Intermediate Microeconomics, 9th ed. Norton, New York.
[72] Varila, M., Seppanen, ¨ M., Suomala, P., 2007. Detailed cost modelling: a case study in warehouse logistics. Int. J. Phys. Distrib. Logist. Manag. 37 (3), 184–200.
[73] von Sch´eele, F., 2001. Controlling Time and Communication in Service Economy. Royal Institute of Technology, Stockholm.
[74] von Sch´eele, F., Haftor, D.M., 2014. Cognitive time distortion on the performance of economic organizations. Syst. Res. Behav. Sci. 31 (1), 77–93.
[75] von Sch´eele, F., Haftor, D., 2018. Temporal workload in economic organizations: a hidden condition of economic efficiency. J. Bus. Res. 88, 415–420.
[76] von Sch´eele, F., Haftor, D.M., Pashkevich, N., 2019. Cognitive time distortion as a hidden condition of worker productivity. J. Bus. Res. 101, 591–596.
[77] von Sch´eele, F., Haftor, D.M., Pashkevich, N., 2020. Cognitive time as a service price determinant: hidden dynamics and price collapse. J. Bus. Res. 112, 248–253.
[78] Wolfl, ¨ A., 2005. The Service Economy in OECD Countries. In: OECD, Paris, pp. 27–63.
[79] Yang, J., Dong, Z.Y., Wen, F., Chen, G., Qiao, Y., 2019. A decentralized distribution market mechanism considering renewable generation units with zero marginal costs. IEEE Trans. Smart Grid 11 (2), 1724–1736.
[80] Yilmaz, R., 2008. Creating the profit focused organization using time-driven activitybased costing. In: EABR & TLC Conferences Proceedings, 8. Clute Institute for Academic Research, Salzburg, Austria.
[81] Zamrud, N.F., Abu, M.Y., 2020. Comparative study: Activity based costing and time driven activity-based costing in electronic industry. J. Mod. Manuf. Syst.Technol. 4 (1), 68–81.