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# Does Collaboration Always Enhance Work Efficiency? Investigating Collective IS Use from a Process Perspective

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# Does Collaboration Always Enhance Work Efficiency? Investigating Collective IS Use from a Process Perspective

*Completed Research Paper*

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## Abstract

*Previous studies have focused mainly on individual IS use, while empirical evidence on collective IS use remains limited. Collective IS use involves interdependent instances of individual IS use within a common work process to fulfill collaborative work. This paper investigates the impact of collective IS use on collaboration performance, what form of collective IS use is efficient, and how to improve work efficiency. Drawing on coordination theory and taking a process perspective, we conceptualize two forms of collective IS use: asynchronous use and synchronous use. Objective data from a high-tech company reveals that asynchronous use improves work efficiency in terms of the time to complete a workflow, while synchronous use prolongs the time resulting in lower work efficiency. We further investigate the moderating role of worker repetitiveness, manager involvement, and task routineness. This study contributes to understanding collective IS use and offers guidance for optimizing collaboration process design.*

**Keywords:** collective IS use, collaboration technology, asynchronous use, synchronous use, collaboration performance, coordination theory, work process

## Introduction

Collaboration technology has been widely adopted for collaborative work. According to a Gartner survey, nearly 80% of workers are using collaboration tools for work in 2021 (Gartner, 2021). Collaboration technology enables multiple employees to collaborate and complete tasks jointly following a predetermined workflow embedded in the information systems (Brown et al., 2010; Volkoff et al., 2007). Such interdependent instances of individual IS use within the context of a common work process at a collective level is known as "collective IS use" (Negoita et al., 2018, p.1289). A typical example of collective IS use is the implementation of a contract approval process, where an employee drafts a contract, followed by the legal and financial department's review and, eventually the general manager's approval. Once the workflow is set into the system, if an employee enters contract information, the system automatically transmits the information to the next legal department employee, and the subsequent process is conducted likewise until the workflow is complete. It is noteworthy that in such a workflow, the employee's use is mutually dependent. While collective IS use is expected to enhance collaboration performance by reducing coordination costs (Malone & Crowston, 1994), the loss of flexibility in how collaboration is performed may decrease collaboration performance (Strong & Volkoff, 2010; Volkoff et al., 2007). Hence, it remains unclear whether collective IS use can improve collaboration performance. Moreover, different forms of interdependence among individual use shape different forms of collective use, which may impact the desired performance (Negoita et al., 2018). Therefore, to facilitate organizations to better apply information systems in collaboration, it is imperative to investigate whether collective IS use can improve collaboration performance and how to design collective IS use to achieve better collaboration performance.

Previous research efforts have primarily focused on individual IS use of collaboration technology, however, the collective use has not been well studied. Collaboration technologies are used to facilitate collaborative work, including workflow management, resource sharing, information processing, and joint decision-making (Bala et al., 2017; Brown et al., 2010). The existing studies mainly investigated the use and effects of the use of collaboration technology at the individual level (e.g., Bala et al., 2017; Barlow & Dennis, 2016; Dennis et al., 2010; Majchrzak et al., 2005). For example, Bala et al. (2017) found that collaboration technology use leads to employees' higher-level collaboration satisfaction. However, Barlow & Dennis (2016) found that a collective intelligence factor did not emerge among groups that employed computer-mediated collaboration, and Sarker et al. (2018) revealed that IT workers using collaboration technology platforms would experience higher work-life conflict, which leads to lower performance. While valuable, these studies neglected the interdependence among individuals IS use in a collaboration process, i.e., they lack the perspective of collective use. Collaboration technology is designed to be used by two or more individuals to achieve a common goal, and there are interdependencies among their use, e.g., one person's use can affect others' use (Brown et al., 2010; Negoita et al., 2018), and these interdependencies may affect the performance of the collaborative work (Negoita et al., 2018). While advancing processes in sequence according to interdependencies among different individual use can facilitate the smooth execution of the process (Malone & Crowston, 1994), the control of interdependencies in collaboration processes by collaboration systems may reduce the flexibility of employees' work approaches (Strong & Volkoff, 2010; Volkoff et al., 2007). We worried that investigating the use of collaboration technology without considering the interdependences-in-use will ultimately lead to an unnatural, incomplete, and disjointed view of how collaboration technology functions in collaborative work (Burton-Jones & Gallivan, 2007; Negoita et al., 2018). Therefore, to bridge the growing gap between the rich ways of IS use and its measurement and representation (Grover & Lyytinen, 2015) and better understand how individual IS use is organized to realize collective-level goals, it is urgently needed to shift the research perspective from individual use to collective use (Burton-Jones & Gallivan, 2007; Kozlowski & Klein, 2000; Verstegen et al., 2019).

Research on collective IS use emphasizes the importance of interdependence between individual use, but there is still a lack of empirical exploration on identifying the basic forms of collective IS use based on the interdependence between individual use instances and their impact on collaboration performance. The existing literature conceptualizes collective IS use as a multilevel construct rooted in instances of individual-level use and their interdependence, and emphasizes that the defining characteristic of collective IS use is the interdependence between individual use instances, which distinguishes it from individual IS use (Burton-Jones & Gallivan, 2007; Negoita et al., 2018). Researchers have noted the heterogeneity of collective IS use, but existing classifications of collective IS use have not adequately reflected the interdependence between individual IS use instances. As pioneers in collective use research, Burton-Jones and Gallivan (2007) suggest two possible patterns of collective IS use, depending on similarity or dissimilarity in instances of individual IS use, while the role of interdependence has been somewhat neglected. Negoita et al. (2018) conceptually described four ideal forms of collective IS use, shaped by specific levels of task interdependence, user interdependence, and system interdependence. However, further detailed investigations are needed to identify the basic forms of collective IS use formed by interdependence between individual use instances. Moreover, although researchers have warned that different forms of collective IS use may lead to different outcomes (Burton-Jones & Gallivan, 2007; Negoita et al., 2018), empirical evidence on how collective IS use affects collaboration performance is lacking, which results in a theoretical gap in understanding the influence of collective use and makes it difficult to provide guidance for organizational practice in applying IS.

Motivated by the above research gaps, this paper endeavors to investigate how collective IS use affects collaboration efficiency from a process perspective. Since collective IS use is rooted within the context of a work process and the different processes of interaction lead to different forms of collective IS use (Kozlowski & Klein, 2000), observing the process of collective use of collaboration technology in the context of workflow enables us to identify the interdependence between instances of individual use and therefore identify different forms of collective IS use. Drawing on coordination theory, we identify two forms of collective use based on interdependence in collaborative workflows: asynchronous use and synchronous use. Thus, this paper aims to address two research questions: 1) Will collective IS use improve collaboration performance? 2) What forms of collective IS use generate better collaboration performance? We conducted an empirical study to answer the questions. Based on coordination theory, we developed a research model to depict how different forms of collective IS use affect collaboration performance. We tested the variance model using real objective data of collaboration processes recorded in the collaboration system of a leading high-tech company.

The work is expected to make several contributions. Theoretically, first, this study provides an in-depth empirical investigation of collective IS use, while existing empirical evidence on the emerging IS use is scarce. Second, we identify two forms of collective use and examine their respective impacts on collaboration efficiency, thus offering a more nuanced understanding of the pros and cons of collective IS use. Third, this paper delves into the influencing mechanism from the perspectives of human participation and task characteristic, thereby enhancing our understanding of how collective IS use generates value for organizations. Finally, the real data of IS use and collaboration performance from a major high-tech company provides convincing evidence for our findings. For practice, this work provides managers with actionable advice for applying collaboration technology while being mindful of potential drawbacks such as rigidity. We also provide suggestions for optimizing the design of collaborative workflows to leverage the potential of IS in facilitating collaboration performance.

# Theoretical Foundation

## *Coordination Theory*

This study uses coordination theory as the theoretical foundation to identify the basic forms of collective use in a collaboration process. The existence of interdependence among individual use is key to distinguishing collective IS use from traditional individual IS use, and different interdependence among individual use instances shapes different forms of collective IS use (Burton-Jones & Gallivan, 2007; Negoita et al., 2018). Therefore, this paper identifies the forms of collective IS use based on interdependence, and coordination theory provides a perspective for understanding interdependence in collaboration processes.

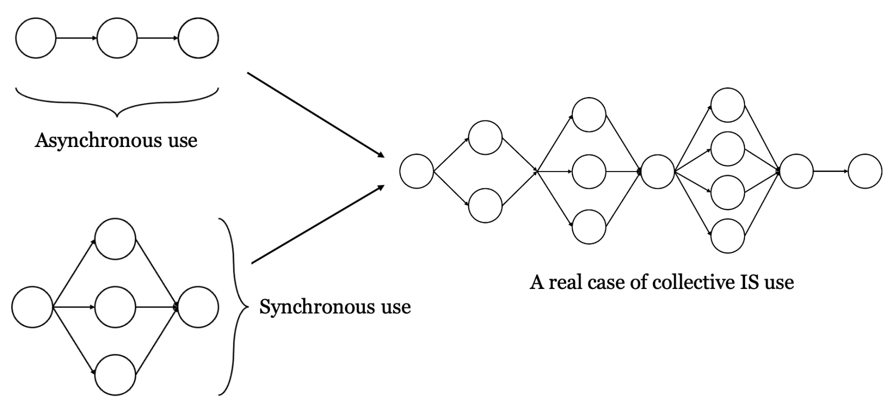


**Figure 1. Two Forms of Collective IS Use: Asynchronous Use and Synchronous Use**

As Morgeson & Hofmann (1999) suggested, studying the phenomenon of collective use requires examining the process by which the collective use emerged. According to coordination theory, the collaboration process consists of a common goal, activities required to achieve the goal, collaborators performing the activities, and interdependence between these activities, among which the interdependence is a central concern of coordination theory and reflects the collectivity in collaboration processes (Malone & Crowston, 1990, 1994). Interdependencies are "patterns of action and interaction where two or more [entities] are mutually dependent on each other", constantly occurring in the collaboration process (Karsten 2003, p. 408). Coordination theory identifies two types of basic interdependencies in a collaboration process: synchronous interdependence and asynchronous interdependence, which serve as the foundation for identifying the forms of collective IS use. Asynchronous interdependence arises whenever one activity produces a resource that is used by the next activity (Malone et al., 1999). For example, the marketing staff completes the activity of drafting a contract, and the contract document is used by the legal department for review activities. Synchronous interdependence occurs when multiple activities use the same resource and collectively produce a single resource (Malone et al., 1999). For example, after the finance department approves a budget, several different engineers start designing the components of a car (such as the engine, the transmission, and the body), and the parts they design together are combined into a single car design that is submitted to the leader for review. Based on the two types of basic interdependencies, this paper conceptualizes two forms of collective IS use: asynchronous use and synchronous use. Asynchronous use reflects asynchronous interdependence among individual IS use, which means that one activity can automatically start after the completion of the previous activities in the collaboration system, where users use the system in sequence. Synchronous use reflects synchronous interdependence among individual IS use, which means that once the previous activities are completed, multiple use activities can start simultaneously and be executed in parallel, with a specific output obtained after all these activities are completed in the system. The two forms of collective IS use are illustrated in Figure 1.

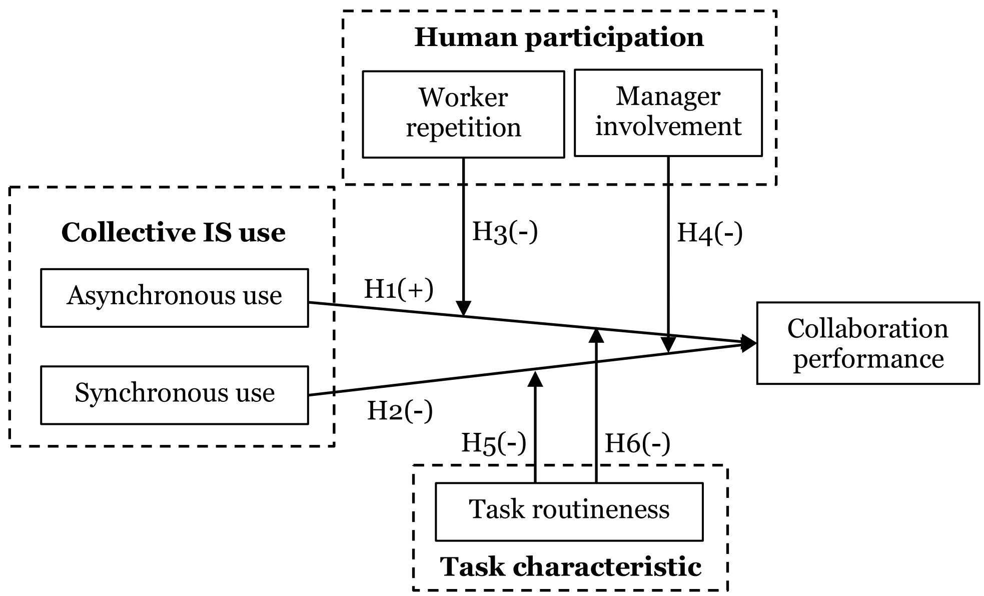


**Figure 2. Research Model**

Coordination theory also helps understand the impacts of collective IS use on collaboration performance, as it posits IS's potential to achieve coordination by managing interdependence. Interdependencies in collaborative work create complex workflows that link activities and determine how collaborative work is carried out at the collective level. However, these interdependencies can also lead to coordination problems, which constrain how activities can be performed (Bala et al., 2017; Crowston, 1997). Research on coordination theory suggests that information systems can support humans in defining collaboration processes and managing interdependence to achieve coordination (Crowston, 2003; Crowston et al., 2004). The widespread use of information systems changes the ways people work together (Crowston, 1997; Malone & Crowston, 1990, 1994). Information systems such as collaboration platforms enable users to embed the interdependencies between activities into the system, facilitate collaboration across geographically dispersed teams, and require all collaborators to adhere strictly to the workflow embedded in the system (Briggs et al., 2014; Volkoff et al., 2007). Information systems can also affect the relationship in collaboration by allowing team members to communicate and share information (Guinan et al., 1998). For example, with the support of information systems, engineering changes can be automatically sent to engineers whose work may be affected by the changes, even when the person making the change does not know who else it will affect (Malone & Crowston, 1990). In the context of collective IS use, asynchronous use and synchronous use are the manifestations of information systems managing interdependence, which may enhance collaboration performance by realizing the coordination mechanism. Specifically, asynchronous use manages the asynchronous interdependence to coordinate the sequencing activities, while synchronous use manages the synchronous interdependence to coordinate simultaneous activities. We next derive the relationships between the two forms of collective IS use and collaboration performance, the research model was shown in Figure 2.

## Hypotheses

### *Collective Use and Collaboration Performance*

Asynchronous use may improve collaboration performance by reducing coordination costs and instilling discipline into collaboration practices. Asynchronous use divides the stage of a collaboration process, by which it decomposes complex business requirements into simple tasks and allows collaborators to achieve the goal by sharing these simple tasks (Vickery et al., 2016). For the individual employees, the fine-grained sequential processes set in the collaboration system can aid in their understanding of tasks and reduce the cost of coordination with other collaborators (Baldwin & Clark, 1997; Gosain et al., 2014; Malone & Crowston, 1994). Since collaborative work is partitioned into smaller, simple, and actionable activities, employees can more easily grasp the demands of their assigned work, and the achieved specialization of labor will result in high levels of performance (Meixell et al., 2006). Additionally, employees in such fine-grained asynchronous use can comprehend how their roles fit into the entire network of activities within the collaboration process, which can help reduce confusion and coordination costs with other collaborators, and allow them to appreciate the impacts of their own actions and thus engage into the tasks (Volkoff et al., 2005). According to coordination theory, lower coordination costs are related to higher collaboration efficiency (Crowston, 1997). For example, Anderson and colleagues' (2018) interviews and surveys suggested that modularizing the activities in the new product development process reduces coordination conflicts that require timely intervention, thus development efforts can take place with less time or cost. In this sense, asynchronous use improves collaboration performance by reducing the costs of coordination among collaborators.

Asynchronous use may also improve collaboration performance by instilling discipline throughout the entire collaboration process (Meixell et al., 2006; Volkoff et al., 2007). Following disciplined processes will lead to increased efficiency and superior performance when collaborators perform tasks that are clearly understood (Adler & Cole, 1993). The finely detailed task execution sequence in collaboration systems effectively regulates and directs the behavior of collaborators, which builds discipline among them. Specifically, collaborators are required not only to complete their tasks in the specified order but also to submit task outcomes in a predetermined format and on time (Volkoff et al., 2005). As researchers (e.g., Arvey & Ivancevich, 1980) have long recognized, discipline can be used as a method to manage ineffective performance in organizations, e.g., social loafing. Discipline fosters accountability, which helps to prevent delays, miscommunications, and other obstacles that might hinder collaboration progress. Thus, the discipline enabled by asynchronous use helps build a seamless and efficient collaboration process, and we proposed the following hypothesis:

H1: Asynchronous use positively influences collaboration performance.

Synchronous use may reduce collaboration performance by causing rigidity in collaboration process. Due to personal and work environment factors, emergencies inevitably occur at work, which may lead to delays in work execution, especially in virtual collaboration (Du et al., 2017). In collective IS use, the workflow is fixed in the system, e.g., the next task can only be started after all tasks in the current stage are completed, hindering employees from flexibly adjusting the sequence or content of tasks to cope with unexpected situations (Volkoff et al., 2007). The more collaborators at the same stage, the more likely the work at the stage is to be delayed since someone in the stage may experience unexpected circumstances, resulting in lower performance of the entire collaborative work. Moreover, with the system taking responsibility for coordinating collaborative work in collective IS use, employees are less responsible for coordinating collaboration (Latané, 1981; Latané et al., 1979), feel less pressure, and are less motivated to coordinate work when meeting circumstances (Chidambaram & Tung, 2005; Stieglitz et al., 2022). Therefore, this paper proposed the following hypothesis:

H2: Synchronous use negatively influences collaboration performance.

## Moderating Roles of Human participation and Task Routineness

To guide the organizations to leverage the benefits of collective use and avoid the negative effects, as well as to answer more completely our second research question, how to design collective IS use to achieve better collaboration performance, we next investigate the influencing mechanisms of collective IS use on collaboration performance. We identify user and task as key perspectives to investigate the influencing mechanism based on the literature on collective IS use and coordination theory. Researchers emphasize that users and tasks should be considered when investigating collective IS use (Negoita et al., 2018). Coordination theory also highlights that interpersonal coordination and task-based coordination are important parts of coordination modes (Malone & Crowston, 1990, 1994; Van Fenema, 2002). Specifically, human participation related to authority relationships and employee engagement may shape employees' attitudes and behaviors (Van Fenema, 2002; Yuan et al., 2009), and task characteristic such as routineness affects coordination demands (Levitt et al., 1999), both may affect the effectiveness of technology-enabled coordination in collective IS use. We next derive the roles of human participation (including manager involvement and worker repetitiveness) and task routineness in the relationships between collective IS use and collaboration performance.

### Human participation

Although asynchronous use helps improve collaboration performance, inappropriate design of human involvement, e.g., worker repetitiveness, may diminish the positive impact of asynchronous use. Asynchronous use improves collaboration performance by enabling employees to clearly understand tasks, reduces coordination costs, and focus on tasks. However, we may need to be wary of inflated sequential collaboration, for example, worker repetitiveness, i.e., a worker is involved in different stages of a collaboration process (e.g., A and D). After completing the task in stage A, the worker usually has to participate in other tasks; and when stage D starts, he/she has to come back to the process. The worker needs to re-understand and get familiar with the relevant content each time they return to the collaboration process, making it difficult to achieve seamless link-up in the collaboration process (Volkoff et al., 2007). Research has found that when switching from one task to another, employees need to disengage from their previous state and then mobilize new knowledge and mindsets, and such switching incurs costs (Leroy, 2009). When people resume their interrupted work under time pressure, they will find it difficult to switch their attention to the interrupted task (Leroy & Glomb, 2018) and experience memory disconnection (Dodhia & Dismukes, 2009). Thus, worker repetitiveness leads to a decrease in employee understanding and focus on the task and also increases the cost for employees to coordinate different collaboration processes and tasks, thus undermining the positive impacts of asynchronous use on collaboration efficiency.

H3: Worker repetitiveness negatively moderates the positive influence of asynchronous use on collaboration performance, such that the positive influence is weaker when worker repetitiveness is high.

Synchronous use may reduce collaboration performance, but the negative effect may be mitigated by manager involvement. Studies have noted that supervisory factors are related to lower social loafing and higher work motivation (Khan et al., 2020; Stieglitz et al., 2022), and the presence of supervisors plays an important role in collaboration processes (Gittell, 2001). In collective IS use, the task progress of each participant in the process is visible on the system. When managers are involved in the collaboration process, employees perceive that their progress and outcomes are under the supervision. Collaborators' perceived supervision serves as an adjustment mechanism to align their actions with organizational goals, thereby minimizing their opportunism and increasing their effectiveness (Kim & Jung, 2018; Zajonc, 1965). In particular, employees in synchronous use are in competition with each other, i.e., one can easily contrast with others if he/she is too inefficient. Thus, the presence of managers exhibits a social facilitation effect that makes employees work faster (Zajonc, 1965). Thus, manager involvement may moderate the negative effects of synchronous use on collaboration performance.

H4: Manager involvement negatively moderates the negative influence of synchronous use on collaboration performance, such that the negative influence is weaker when manager involvement is high.

**Task routineness**

We further investigate the influencing mechanisms of collective IS use on collaboration performance from the perspective of the task. In particular, we examined collective IS use on tasks that varied in routineness. Since task routineness is widely recognized as a contextual condition that shapes information processing activities (Arrow et al., 2000; Gladstein, 1984), it may influence the coordination demands and moderate the relationship between collective IS use and collaboration performance. Tasks that are high on the dimension of routineness are characterized by greater repetitiveness, simplicity, and certainty (Jehn, 1995). Because routine tasks generally involve activities that are predetermined and predictable, they generally are less knowledge- and information-intensive (Brown & Miller, 2000) and require less coordination (Van de Ven et al., 1976). In contrast, performing less routine tasks may require collaborators to process complex and difficult information (Campion et al., 1996; Chung & Jackson, 2011).

H5: Task routineness negatively moderates the positive influence of asynchronous use on collaboration performance, such that the positive influence is weaker when task routineness is high.

Task routineness may weaken the positive effects of asynchronous use and alleviates the negative effects of synchronous use on collaboration performance. In non-routine tasks, the benefits of asynchronous use would be more pronounced since asynchronous use divides work into small, simple individual activities that help individuals understand the requirements of their jobs (Meixell et al., 2006). Therefore, we hypothesize that asynchronous use has a higher positive impact on collaboration performance in tasks with a lower level of routineness. As for synchronous use, the complexity and uncertainty of non-routine tasks may lead to a greater likelihood of delays. Handling less-routine tasks requires employees to deal with unfamiliar, complex, and difficult situations, which may lead to more unexpected problems resulting in delays. At the same time, when multiple people work simultaneously on less routine tasks, there is less incentive for individuals to contribute to the work, given the greater difficulties and risks and the presence of others to take on the task together (Latané, 1981). On the contrary, synchronous use has a lower negative impact on collaboration performance in more routine tasks. Therefore, we hypothesized that task routineness alleviates the negative effects of synchronous use on collaboration performance.

H6: Task routineness negatively moderates the negative influence of asynchronous use on collaboration performance, such that the negative influence is weaker when task routineness is high.

# Methodology

## *Research Context*

To verify the above research hypotheses, we obtained real objective data of collaboration processes recorded in the collaboration system in a leading high-tech company (hereafter referred to as Z, a pseudonym). Z is a collaboration software provider listed on the Science and Technology Innovation Board in China. Z has been focusing on the research and development of collaboration information systems since its establishment. With more than ten thousand government agencies and enterprises on its client roster, Z has held the top market share of collaboration software in China for over a decade. Overall, the collaboration information system of Z is mature and well-received by the market.

All of the employees of Z perform collaborative work on its collaboration system. With over 1000 employees dispersed across 39 branches located in various provinces of China, daily operations at Z necessitate collaboration between employees from different departments and even different regions. At present, all of Z's staff carry out collaborative work on the collaboration system, which generates hundreds of thousands of records of collaboration processes every year. The system supports various collaborative work within an enterprise, including product research & development, marketing, performance evaluation, reimbursement, contract approval, and so on. Here we did not pay specific attention to the differences between various collaborative tasks, which does not mean that the task type is not important, but that it is at an inappropriate level of analysis; it is too broad.

The collaboration process that includes interdependencies can be embedded in and accomplished by the collaboration system. Every employee can log in and use the system with their unique ID, and they can act as an initiator of collaborative work or a collaborator who performs the activities in collaborative work. The collaboration process begins by first allowing an initiator to construct the workflow process on the collaboration system. Specifically, the initiator applies a pre-designed workflow template or constructs one by himself or herself. The workflow specifies the stages of the collaborative work process, assigns specific tasks to be performed at each stage, designates the employees responsible for carrying out each task, and establishes the criteria for successful completion. The initiator can also indicate the level of importance of the collaboration process and establish deadlines for each stage, etc. After establishing a workflow in the system, the initiator clicks "Submit", and then the collaboration process is then set into motion. Collaborators who are assigned to the first stage of the workflow process are immediately notified in the system and can then review the task requirements, complete the assigned task, and submit their outcomes in the predetermined format. Once all collaborators of the stage have submitted their outcomes, the collaborators responsible for the next stage are notified and are then able to begin their tasks in turn.

The collaboration process supported by the collaboration system demonstrates how two forms of collective IS use to manifest themselves in practice. Specifically, the collaboration process was divided into multiple stages, upon the completion of assigned activities at a given stage, the collaboration system automatically sends the outcomes to the collaborators responsible for the subsequent stage; this reflects the asynchronous use. When multiple collaborators are working in the same stage, they will receive the outcomes of the previous stage simultaneously, can start their work at the same time and share the information in the collaboration process, and their work outcomes will jointly provide input for the activities in the next stage; this reflects the synchronous use.

## *Empirical Model and Operationalization of Variables*

This paper used real objective data of collaboration processes recorded in the collaboration system at Z to test the hypotheses. The raw dataset consists of 366,350 records of collaboration processes in the whole year of 2017, of which 336,682 records remained after excluding invalid records such as incomplete records. We formulate the following model to examine the main effects (H1 and H2):

$$ColPer = \beta_0 + \beta_1 Asyn + \beta_2 Syn + \beta_3 Importance + \beta_4 Department + \beta_5 Region + \beta_6 Urge + \varepsilon \quad (1)$$

and we further formulate the following model to examine the moderating effects of human participation (H3 and H4, see Formula (2)) and task routineness (H5 and H6, see Formula (3)):

$$ColPer = \beta_0 + \beta_1 Asyn + \beta_2 Syn + \beta_3 WorkerRepe + \beta_4 Asyn \times WorkerRepe + \beta_5 ManagerInvol + \beta_6 Syn \times ManagerInvol + \beta_7 Importance + \beta_8 Department + \beta_9 Region + \beta_{10} Urge + \varepsilon \quad (2)$$

$$ColPer = \beta_0 + \beta_1 Asyn + \beta_2 Syn + \beta_3 Routine + \beta_4 Asyn \times Routine + +\beta_5 Syn \times Routine + \beta_6 Importance + \beta_7 Department + \beta_8 Region + \beta_9 Urge + \varepsilon \quad (3)$$

where ColPer = Collaboration performance, Ayn = Asynchronous use, Syn = Synchronous use, WorkerRepe = worker repetitiveness, ManagerInvol = manager involment, Routine = task routineness, Importance = The importance of the collaborative work, Department = Departmental diversity, and Region = Region diversity, Urge = how collaborators are urged in the collaboration process.

Dependent Variables. Collaboration performance (*ColPer*) was measured by the time efficiency of the collaboration process since we investigated collective IS use from a process perspective. Specifically, the collaboration performance was measured by the average time of each stage within a collaboration process, which was calculated by dividing the total working time of the collaboration process by the number of stages present in the collaboration process (see Formula (4)). The total working time of the collaboration process referred to the minutes spent from the moment that the first-stage collaborators received the collaboration process to the moment that the last-stage collaborators submitted their work outcomes.

$$\text{Collaboration performance} = \frac{\text{The total working time of the collaboration process}}{\text{The number of stages in the collaboration process}} \quad (4)$$

Independent Variables. Asynchronous use (*Asyn*) was measured by the number of stages present in a collaboration process. Asynchronous use means that one activity can be automatically started when the previous activity is completed in the collaboration system, the number of stages in a collaboration process reflects the frequency of occurrence of asynchronous interdependence in use. Synchronous use (*Syn*) means that more than one collaborator is working at the same stage in a collaboration process, we measured synchronous use as the degree to which the number of collaborators working at the same stage deviates from 1. Drawing on the idea of calculating the standard deviation, we calculate synchronous use as shown in Formula (5), where the "n" represents the number of stages present in a collaboration process. We add 1 at the end of the formula to avoid that asynchronous use equals 0 and to make it more comparable with the asynchronous use.

$$\text{Synchronous use} = \left(\sqrt{\frac{\sum_{1}^{n}(\text{the number of collaborators working at the same stage} - 1)^2}{n}}\right) + 1 \quad (5)$$

Moderators. Manager Involvement (*ManagerInvol*) was measured by the maximum difference among collaborators' levels of positions, where the levels of positions are divided into seven levels in the company. Worker Repetitiveness (*WorkerRepe*) was measured by the maximum frequency of collaborators' participation in the collaboration process. Task Routineness (*Routine*) was identified by checking whether a collaboration process applies a workflow template or not. Specifically, if the collaboration process applies a workflow template, it means that the process is commonly used, and thus has been built as a workflow template, and therefore the task is of high routine. Conversely, if the collaboration process does not apply a workflow template, it usually indicates that the task is less routine, so there is no corresponding template in the template library.

Control Variables: The importance of the whole collaborative work (*Importance*) was measured by the level of importance recorded in the system, where level 1 represents "ordinary", level 2 represents "important", and level 3 represents "very important". Departmental diversity (*Department*) was measured by the number of departments where the collaborators are located. Region diversity (*Region*) was measured by the number of regions where the collaborators are located. *Urge* measures the number of times the collaborators are urged in the collaboration process. Identified outliers of each variable were winsorized at 99%. Table 1 displays the results of the descriptive statistical analysis.

| Variable | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. *ColPer* | 11767.91 | 29393.99 | 1.00 | | | | | | | | |
| 2. *Asyn* | 2.73 | 2.20 | -0.15$^{***}$ | 1.00 | | | | | | | |
| 3. *Syn* | 3.41 | 4.72 | 0.25$^{***}$ | -0.19$^{***}$ | 1.00 | | | | | | |
| 4. *WorkerRepe* | 1.41 | 0.57 | -0.10$^{***}$ | 0.43$^{***}$ | 0.19$^{***}$ | 1.00 | | | | | |
| 5. *ManagerInvol* | 1.94 | 1.45 | 0.02$^{***}$ | 0.52$^{***}$ | 0.30$^{***}$ | 0.20$^{***}$ | 1.00 | | | | |
| 6. *Routine* | 0.75 | 0.44 | -0.23$^{***}$ | 0.42$^{***}$ | -0.01$^{***}$ | 0.37$^{***}$ | 0.39$^{***}$ | | | | |
| 7. *Importance* | 1.14 | 0.43 | 0.10$^{***}$ | -0.02$^{***}$ | -0.02$^{***}$ | -0.10$^{***}$ | -0.01$^{***}$ | -0.16$^{***}$ | | | |
| 8. *Department* | 2.71 | 2.09 | 0.10$^{***}$ | 0.52$^{***}$ | 0.52$^{***}$ | 0.28$^{***}$ | 0.64$^{***}$ | 0.20$^{***}$ | -0.00$^{**}$ | 1.00 | |
| 9. *Region* | 1.51 | 0.72 | 0.02$^{***}$ | 0.29$^{***}$ | 0.23$^{***}$ | 0.05$^{***}$ | 0.44$^{***}$ | 0.21$^{***}$ | 0.05$^{***}$ | 0.41$^{***}$ | 1.00 |
| 10. *Urge* | 0.06 | 0.29 | -0.02$^{***}$ | 0.25$^{***}$ | -0.07$^{***}$ | 0.03$^{***}$ | 0.15$^{***}$ | 0.06$^{***}$ | 0.00 | 0.15$^{***}$ | 0.12$^{***}$ |

**Table 1. Correlations and Descriptive Statistics**

Note: $N$ = 336,682, $^{***}$ $p < 0.01$, $^{**}$ $p < 0.05$, $^{*}$ $p < 0.1$.

# Empirical Results

## *Main Results*

We conducted data analyses using OLS regression in Stata and presented the results in Table 2. Asynchronous use negatively affects the average working time of each stage in a collaboration process ($\beta$ = -459.46, $p < 0.01$), that is, asynchronous use positively affects collaboration performance. On the contrary, synchronous use positively affects the average working time of each stage ($\beta$ = 1431.52, $p < 0.01$), indicating that synchronous use negatively affects collaboration performance. These results support H1 and H2. The results of the above analyses show that collective IS use has both positive and negative effects on collaboration efficiency. The collective IS use clarifies the requirements at each stage of the collaboration process, which can improve collaboration efficiency by reducing coordination costs and instilling discipline into the collaboration process, as reflected in asynchronous use. However, this normalization may lead to a loss of flexibility in the face of unexpected situations, resulting in a negative impact on collaboration efficiency, as can be seen in synchronous use.

| | (1) | (2) | (3) |
|---|---|---|---|
| | *ColPer* | *ColPer* | *ColPer* |
| *Asyn* | -2831.69*** | | -459.46*** |
| | (30.35) | | (43.46) |
| *Syn* | | 1561.76*** | 1431.52*** |
| | | (19.68) | (27.78) |
| *WorkerRepe* | -316.45*** | -4184.54*** | -3655.29*** |
| | (77.74) | (84.06) | (101.00) |
| *ManagerInvol* | 1799.38*** | 961.00*** | 1099.22*** |
| | (50.85) | (49.18) | (51.30) |
| *Routine* | -13380.15*** | -13509.61*** | -13284.15*** |
| | (175.28) | (170.94) | (172.12) |
| *Importance* | 4461.53*** | 4523.29*** | 4563.52*** |
| | (157.73) | (153.60) | (153.69) |
| *Department* | 2614.85*** | 37.87 | 310.58*** |
| | (52.57) | (38.07) | (52.26) |
| *Region* | 235.97*** | -671.07*** | -577.47*** |
| | (88.70) | (87.96) | (88.67) |
| *Urge* | 480.06*** | 828.32*** | 1073.09*** |
| | (128.57) | (127.19) | (126.01) |
| _cons | 13860.40*** | 16255.09*** | 15830.09*** |
| | (266.10) | (259.97) | (264.08) |
| *N* | 336682 | 336682 | 336682 |
| adj. $R^2$ | 0.10 | 0.12 | 0.12 |

**Table 2. Results of main analyses**

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

## *Moderating Effects Analyses*

The results of the analyses for moderating effects were shown in Table 3. As shown in Column (3) in Table 3, the interaction of worker repetitiveness and asynchronous use positively affects collaboration performance ($\beta$ = 1326.07, $p$ < 0.01), indicating that worker repetitiveness negatively moderates the positive influence of asynchronous use on collaboration performance and H3 is supported. The interaction of manager involvement and synchronous use negatively affects collaboration performance ($\beta$ = -71.18, $p$ < 0.01), that is, the manager involvement negatively moderates the negative influence of synchronous use on collaboration performance and H4 is supported. In conclusion, worker repetitiveness weakens the positive effects of asynchronous use, and manager involvement alleviates the negative effects of synchronous use. Column (6) of Table 3 showed that the interaction of task routineness and asynchronous use positively affects collaboration performance ($\beta$ = 6626.48, $p$ < 0.01), that is, the task routineness weakens the positive influence of asynchronous use on collaboration performance and H5 is supported. The interaction of task routineness and synchronous use negatively affects collaboration performance ($\beta$ = -3277.60, $p$ < 0.01), indicating that task routineness weakens the negative influence of synchronous use on collaboration performance and H6 is supported.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | *ColPer* | *ColPer* | *ColPer* | *ColPer* | *ColPer* | *ColPer* |
| *Asyn* | -982.93*** | -513.25*** | -1044.99*** | -2676.82*** | -1439.52*** | -3078.34*** |
| | (44.88) | (44.39) | (45.85) | (68.04) | (38.46) | (65.68) |
| *Syn* | 1443.84*** | 1494.46*** | 1513.36*** | 1400.82*** | 900.99*** | 886.09*** |
| | (27.70) | (32.10) | (32.00) | (27.55) | (20.78) | (20.76) |
| *WorkerRepe* | -4345.65*** | -3686.90*** | -4384.10*** | -3602.69*** | -594.33*** | -601.31*** |
| | (108.99) | (101.12) | (109.15) | (100.68) | (85.55) | (85.52) |
| *Asyn * WorkerRepe* | 1319.26*** | | 1326.07*** | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (28.75) | | (28.80) | | | |
| *ManagerInvol* | 1457.81*** | 997.85*** | 1347.79*** | 1285.70*** | 1047.83*** | 1187.68*** |
| | (53.40) | (61.26) | (62.80) | (51.61) | (49.33) | (49.84) |
| *Syn* ManagerInvol* | | -64.49*** | -71.18*** | | | |
| | | (18.69) | (18.66) | | | |
| *Routine* | -12142.00*** | -13276.41*** | -12127.56*** | 208.48 | -13214.72*** | -3153.56*** |
| | (174.01) | (172.26) | (174.20) | (303.99) | (166.90) | (307.56) |
| *Asyn *Routine* | | | | 8885.58*** | | 6626.48*** |
| | | | | (206.02) | | (202.87) |
| *Syn * Routine* | | | | | -3327.83*** | -3277.60*** |
| | | | | | (43.23) | (43.16) |
| *Importance* | 4754.90*** | 4562.36*** | 4754.61*** | 4649.20*** | 3068.12*** | 3154.60*** |
| | (153.70) | (153.59) | (153.59) | (152.72) | (147.92) | (147.40) |
| *Department* | 165.16*** | 398.90*** | 261.88*** | 295.31*** | 399.16*** | 386.43*** |
| | (52.25) | (53.72) | (53.69) | (51.92) | (47.79) | (47.65) |
| *Region* | -418.67*** | -560.27*** | -398.87*** | -480.67*** | 418.38*** | 475.54*** |
| | (88.21) | (88.61) | (88.15) | (88.14) | (80.07) | (79.81) |
| *Urge* | 1190.26*** | 1053.34*** | 1169.06*** | 981.12*** | 802.03*** | 737.53*** |
| | (125.64) | (126.01) | (125.64) | (125.36) | (125.01) | (124.60) |
| _cons | 15864.27*** | 15865.03*** | 15903.01*** | 7760.78*** | 15977.49*** | 9957.52*** |
| | (263.71) | (265.03) | (264.69) | (296.13) | (253.02) | (289.80) |
| *N* | 336682 | 336682 | 336682 | 336682 | 336682 | 336682 |
| adj. $R^2$ | 0.13 | 0.12 | 0.13 | 0.13 | 0.18 | 0.19 |

**Table 3. Result of Mechanism Investigation**

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

## *Robustness Analyses*

We performed a series of endogeneity and robustness analyses, and the results were shown in Table 4. First, we exclude two alternative explanations for workload-related endogeneity. In this study, collaboration performance was measured by the average time spent on each stage, asynchronous use was measured by the number of stages in a collaboration process, and synchronous use was measured by the degree to which the number of collaborators working at the same stage deviates from 1. For the positive effect of asynchronous use on collaboration performance, an alternative explanation is that "the more stages of the process, the less work at each stage, and the shorter time spent at each stage ". Similarly, an alternative explanation for the positive effect of synchronous use on collaboration performance is that "since the heavy workload, more employees work simultaneously at the stage, and it takes longer". To rule out these explanations, we replaced the measure of collaboration performance with the proportion of overdue stages to total stages in a collaboration process (*OverdueRatio*). Overdue stages refer to stages at which the actual time spent by the employee exceeds the time required to complete the work, thus the variance in time efficiency due to workload is controlled. The results (see Column (1)) confirmed our findings.

To verify the robustness of our findings, we then replaced the measurement of the dependent variable, independent variable, and moderators in turn, and controlled the task type. For collaboration performance, we first replaced the original natural time-based calculation method with a work time-based calculation method to measure it more accurately. The natural time includes holiday time and nighttime, and including them in the calculation of collaboration performance leads to inaccurate results, specifically, the completion time of workflow is sometimes overestimated. In such cases, the finding of synchronous use negatively affecting collaboration performance may be incorrect. In robustness analyses, we replace the natural time with the working time that the enterprise sets, that is, only the time between 9 am and 6 pm is calculated (*ColPer_w*), and the results (see Column (2) supported our findings were robust. Further, to eliminate as much heteroskedasticity as possible and to enhance the economic significance of the regression parameters, we replaced the measure of collaboration performance with the logarithmic form of *ColPer (ln_ColPer)*. The results (see Column (3)) supported our findings. For the independent variable, we replace the measure of synchronous use with the maximum number of collaborators working at the same stage in a collaboration process (*Syn_m*) (see Column (4)). With regard to moderators, we replaced the measure of worker repetitiveness was replaced with the average frequency at which collaborators participate in a collaboration process (*WorkerRepe_a*), and the measure of manager involvement with the highest job level among collaborators in a collaboration process (*ManagerInvol_h*) (see Column (5)). The results all confirmed our findings.

Finally, considering that the specific type of task can impact collaboration performance, we further controlled for task type. According to enterprise managers, collaboration processes can be divided into four types of tasks based on the process titles recorded in the system: customer and community task (28.58%), research and development task (13.19%), operation and management task (4.182%), and other tasks (16.42%). Task type was controlled as a categorical variable. After removing records where the task type could not be identified (i.e., the process title was empty), 275,305 records of collaboration processes remained for analysis. The results of the analysis support our hypotheses (see Column (6)).

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | *Overdue Ratio* | *ColPer_w* | *ln_ColPer* | *ColPer* | *ColPer* | *ColPer* |
| *Asyn* | -0.12*** | -103.55*** | -0.04*** | -1408.30*** | -1286.07*** | -1000.28*** |
| | (0.00) | (9.97) | (0.00) | (38.24) | (42.56) | (44.69) |
| *Syn* | 0.01*** | 348.38*** | 0.11*** | | 1286.91*** | 1658.58*** |
| | (0.00) | (6.39) | (0.00) | | (25.98) | (31.50) |
| *WorkerRepe* | 0.01*** | -862.70*** | 0.11*** | -2900.01*** | | -17.16 |
| | (0.00) | (23.17) | (0.01) | (100.60) | | (185.72) |
| *ManagerInvol* | -0.01*** | 268.01*** | 0.43*** | 1466.56*** | | 1648.39*** |
| | (0.00) | (11.79) | (0.00) | (50.95) | | (55.91) |
| *Routine* | 0.03 | -3128.16*** | -0.53*** | -13592.97*** | -13436.41*** | -12842.12*** |
| | (0.04) | (39.88) | (0.01) | (174.82) | (174.33) | (196.02) |
| *Syn_m* | | | | 736.24*** | | |
| | | | | (18.08) | | |
| *WorkerRepe_a* | | | | | 444.13*** | |
| | | | | | (167.06) | |
| *Asyn * WorkerRepe_a* | | | | | 1666.27*** | |
| | | | | | (54.28) | |
| *ManagerInvol_h* | | | | | 986.58*** | |
| | | | | | (56.17) | |
| *Syn * ManagerInvol_h* | | | | | -130.15*** | |
| | | | | | (19.18) | |
| *Importance* | -0.03*** | 1003.53*** | 0.17*** | 4591.51*** | 4825.90*** | 3917.19*** |
| | (0.00) | (35.18) | (0.01) | (155.84) | (154.22) | (171.05) |
| *Department* | 0.00*** | 82.19*** | -0.07*** | 1057.73*** | 839.32*** | 512.65*** |
| | (0.00) | (12.02) | (0.00) | (52.91) | (54.21) | (64.27) |
| *Region* | -0.00*** | -180.22*** | 0.16*** | -161.74* | 55.44 | -641.89*** |
| | (0.00) | (20.33) | (0.00) | (88.29) | (87.66) | (103.49) |
| *Urge* | -0.00 | 242.13*** | 0.18*** | 1013.42*** | 1631.11*** | 1451.99*** |
| | (0.00) | (28.93) | (0.01) | (127.25) | (125.72) | (133.51) |
| _cons | 0.99*** | 3741.62*** | 6.44*** | 15999.53*** | 8161.04*** | 9413.04*** |
| | (0.04) | (60.82) | (0.02) | (268.24) | (345.17) | (390.81) |
| *Task_type* | | | | | | Controlled |
| *N* | 88829 | 335475 | 336682 | 336682 | 336682 | 275305 |
| adj. $R^2$ | 0.62 | 0.13 | 0.13 | 0.11 | 0.12 | 0.14 |

**Table 4. Result of Robustness Analyses**

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

## Discussion and Conclusion

This study aims to understand whether collective IS use always improves collaboration performance and what forms of collective IS use will be better. We developed a research model drawing on literature on coordination theory and collaboration technology use, and examined the model by analyzing real objective data recorded in the collaboration system in a leading high-tech company. Our finds are as follows.

First, collective IS use does not always enhance collaboration performance, its impact on collaboration performance is two-sided. Our data supported that asynchronous use enhances collaboration performance while synchronous use reduces collaboration performance. Asynchronous use divides the stage of a collaboration process, reduces the coordination cost between collaborators, and instills discipline into collaboration practices, through which the collaboration performance is improved. On the other hand, synchronous use impeded collaboration performance. With more collaborators working at the same stage, the work at the stage will be more likely to be delayed, and the collaboration performance will be reduced.

Second, we further investigated investigate under what human participation and task type collective IS use can play to its advantages and avoid disadvantages. For asynchronous use, we found that it is more advantageous in non-routine tasks, but the positive impact is weakened when employees appear in a process repeatedly. Since non-routine tasks bring high coordination demands (Levitt et al., 1999), the advantage of asynchronous use will be more obvious in more non-routine tasks. In addition, worker repetitiveness scattered collaborators' time and energy, and they may not be able to link up to the process seamlessly. Thus, it is not effective to increase the number of stages of the collaboration process by repeatedly engaging employees in a collaboration process. For synchronous use, it is more suitable when supervisors are involved and for routine tasks. The negative influence of synchronous use on collaboration performance is weaker when higher-level supervisors participate in the process since manager involvement may act as a stressor that forces employees to reduce possible delays. These outcomes reinforce the findings of Kim and Jung (2018), who also recognize the influence of supervision in adjusting group performance. Additionally, task routineness alleviates the negative effects of synchronous use. There may be fewer unexpected delays in routine tasks, and the rigidity due to technology may not be apparent.

### *Theoretical Contributions*

This study focuses on collective IS and has the following theoretical contributions. First, while empirical evidence on collective IS use is very limited, this study provides an in-depth empirical investigation of the emerging IS use. The field of IS use has devoted much effort to individual use of collaboration technology in organizations, such as the frequency, breadth, and depth of use (Anderson et al., 2018; Cummings et al., 2009), or the extent to which a feature was used (Bala et al., 2017; Mani et al., 2014; Zhang et al., 2011), but the interdependence of instances of individual IS use and their impacts are largely ignored. Scholars are calling for moving from a focus on individual IS use to collective IS use to better explain the current situation of IS use in organizations (Burton-Jones & Gallivan, 2007; Negoita et al., 2018). A few existing studies have recognized the importance and definition of collective IS use (Burton-Jones & Gallivan, 2007; Negoita et al., 2018), but quantitative and detailed investigations based on objective data are rare. Our study proposes the objective measure of collective use and first examines the impacts of collective IS use on collaboration performance statistically.

Second, we identify the effects of two basic forms of collective IS use on collaboration performance to understand the pros and cons of collective IS use. Although interdependence is critical for identifying collective use, previous research has not adequately reflected and tested this in their classification of collective use (e.g., Burton-Jones & Gallivan, 2007). Our study categorizes collective IS use by identifying two types of interdependence and examines their impacts on collaboration performance, which respond to the claim of (Negoita et al., 2018) to investigate the impacts of different forms of collective IS use. Also, by considering interdependence from a process perspective, this paper helps provide a natural, complete, and in-depth view of how collaboration technology functions in collaborative work, as called by Burton-Jones and Gallivan (2007). Specifically, we find that asynchronous use enhances collaboration performance by lowering coordination costs, which provides empirical evidence for the belief that collaboration technology is supposed to enhance collaboration efficiency (Gattiker & Goodhue, 2005; Malone & Crowston, 1994), and that technology has the potential to manage interdependence and enable coordination (Crowston, 2003; Crowston et al., 2004). On the contrary, synchronous use reduces collaboration performance due to the rigidity of the process, which validates the possible situation where the application of collaboration technology leads to a loss of organizational flexibility (Strong & Volkoff, 2010; Volkoff et al., 2007).

Third, this work contributes to the literature on IT-supported collaboration process optimization by revealing how human participation and task characteristics moderate the impact of collective IS use on collaboration performance. Previous efforts on how virtual processes should be designed have often focused on the system perspective, while the roles of participants and tasks have been neglected, leading to limited insights on managing collaboration (Fan et al. 2017). Our study demonstrates that human participation and task characteristics play critical roles in collaboration coordinated by technology, which corroborates Van Fenema's integrative framework for coordination modes comprising technology-, human-, and work-based coordination (Van Fenema, 2002). Specifically, our findings indicate that supervisor involvement mitigates inefficiencies associated with synchronous use, which echoes and provides empirical evidence for Fan et al.'s (2017) argument that managers in IT-supported collaboration can proactively choose their involvement to drive collaboration progress. Additionally, we identified that worker repetitiveness reduces the positive effect of asynchronous use on collaboration performance, contributing to a better understanding of how to effectively design human participation in IT-supported collaboration processes. In terms of tasks, while the few existing studies have focused on the different impacts of collaboration technology use in different collaboration processes across orientation (Bala et al., 2017) or goals (Dennis et al., 2008), or between bug-fixing issues and other issues (Fan et al., 2017), we supplement the literature by investigating the moderating role of task routineness in IT-supported collaboration process.

Finally, the real data of IS use and collaboration performance from a major high-tech company we used in this paper provides convincing evidence for the findings. Most prior empirical studies on IS use gathered data through surveys of employees or leaders on their perceived IS use and performance (e.g., Harrison & Windeler, 2020; Mani et al., 2014; Sarker et al., 2018). Other studies used laboratory experiments to simulate IS use and performance, (e.g., Barlow & Dennis, 2016; Robert et al., 2018; Zhang et al., 2007), while the limited realism hinders fully understanding the real use and the impact of IS use. This paper used real, objective, and detailed data of collaboration processes recorded in the collaboration system in a leading high-tech company for a whole year, allowing us to depict the detailed process of IS use in collaboration and provide reliable conclusions.

### *Practical Implications*

Our findings have several key practical implications. First, we encourage organizations to apply collaboration technology but be mindful of potential drawbacks such as rigidity. Our results suggest that appropriate collective use of collaboration technology can improve collaborative efficiency by reducing coordination costs between employees and instilling discipline in collaborative practices. However, it is worth noting that too many people working in parallel in collective use can reduce collaboration efficiency. Understanding the different effects of asynchronous and synchronous use can help organizations consider different modes of use when designing collective information system use. We suggest that organizations apply different types of collective use flexibly to achieve efficient collaboration.

Second, our research provides suggestions for optimizing workflow design by mindful and agile orchestration of digital technologies with human assets and business requirements. Systems can be designed to support asynchronous or synchronous use to improve collaboration performance depending on the type of task and the characteristics of the participants. From a task perspective, asynchronous use is more advantageous in non-routine tasks while synchronous use is preferable in routine tasks to avoid delays. We also emphasize the importance of supervisors in supporting collaboration processes when multiple collaborators are working simultaneously with the system. In addition, organizations can pay attention to reducing redundant employee involvement to avoid the negative impact of worker repetitiveness in collective IS use. Finally, we suggest that flexibility in collective IS use can be improved by allowing participants to adjust the sequence of processes in certain circumstances.

### *Limitations and Future Work*

We acknowledge the limitations of this study. First, we depict collective IS use from a process perspective, while there may be other classifications of collective IS use. For example, there may exist reciprocal use where people often discuss and interact online in R&D processes (Negoita et al., 2018). Future research could depict and investigate collective IS use from other perspectives. Secondly, our analysis is based on system-recorded data, which may not capture all employee characteristics or behaviors that can affect collaboration performance. Future research could conduct field experiments to establish better causal inferences. Third, future studies are expected to measure collaboration performance more comprehensively by considering various metrics, such as the number of bugs and time taken to fix them (Zhang et al., 2011), sales volume (De Luca & Atuahene-Gima, 2007), and market share (Tsai & Hsu, 2014).

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