Title

The Role of Interdependence in the Micro-Foundations of Organization Design: Task, Goal, and Knowledge Interdependence

Journal

Academy of Management Annals, 14(2)

ISSN

1941-6520

Authors

Raveendran, Marlo
Silvestri, Luciana
Gulati, Ranjay

Publication Date

2020-07-01

DOI

10.5465/annals.2018.0015

THE ROLE OF INTERDEPENDENCE IN THE MICROFOUNDATIONS OF ORGANIZATION DESIGN: TASK, GOAL, AND KNOWLEDGE INTERDEPENDENCE

Forthcoming at Academy of Management Annals

Marlo Raveendran
School of Business
University of California, Riverside
900 University Ave, Riverside, CA, 92521
marlo.raveendran@ucr.edu

Luciana Silvestri
Harvard Business School
Harvard University
Soldiers Field, Boston, MA, 02163
lsilvestri@hbs.edu

Ranjay Gulati
Harvard Business School
Harvard University
Soldiers Field, Boston, MA, 02163
rgulati@hbs.edu

Acknowledgements: We thank our Associate Editor, Madan Pillutla, for his excellent guidance and feedback, as well as our Editor, Daan van Knippenberg, and two anonymous reviewers for their constructive comments on an earlier version. We are grateful to Carliss Baldwin, Phanish Puranam, Linda Argote, Nilanjana Dutt, Olga Hawn, Amandine Ody-Brasier, Reuben Raveendran, Elena Vidal, and Elaine Wong for their thoughtful feedback.

Corresponding author: Marlo Raveendran, School of Business, Area of Management, University of California, Riverside, Anderson Hall 233, 900 University Ave, Riverside, CA, 92521, USA. Email: marlo.raveendran@ucr.edu.

THE ROLE OF INTERDEPENDENCE IN THE MICROFOUNDATIONS OF ORGANIZATION DESIGN: TASK, GOAL, AND KNOWLEDGE INTERDEPENDENCE

ABSTRACT

Interdependence is a core concept in organization design, yet one that has remained consistently understudied. Current notions of interdependence remain rooted in seminal works, produced at a time when managers' near-perfect understanding of the task at hand drove the organization design process. In this context, task interdependence was rightly assumed to be exogenously determined by characteristics of the work and the technology. We no longer live in that world, yet our view of interdependence has remained exceedingly task-centric and our treatment of interdependence overly deterministic. As organizations face increasingly unpredictable workstreams and workers co-design the organization alongside managers, our field requires a more comprehensive toolbox that incorporates aspects of agent-based interdependence. In this paper, we synthesize research in organization design, organizational behavior, and other related literatures to examine three types of interdependence that characterize organizations' workflows: task, goal, and knowledge interdependence. We offer clear definitions for each construct, analyze how each arises endogenously in the design process, explore their interrelations, and pose questions to guide future research.

INTRODUCTION

Interdependence lies at the core of all organizations. By their nature, organizations contain agents—individual workers, teams, or business units—that perform different parts of the overall work and are therefore bound to one another by interdependence. This interdependence among agents rests on three aspects of their work: what they *do* (i.e., *task* interdependence), what they *want* (i.e., *goal* interdependence), and what they *know* (i.e., *knowledge* interdependence).

Interdependence is a central concept in the research on organization design, which studies the consequences of the division of labor and how to build effective organizational structures. Structuring the organization around interdependencies facilitates the coordination of agents who have different tasks, goals, and knowledge.

The organization design literature has focused traditionally on task interdependence. In the mid-20th century, when many seminal works were published, it was natural for researchers to gravitate toward task interdependence. At that time, managers knew much about the nature of the work at hand and technology was often (close to) deterministic. This enabled managers to divide work into interdependent subtasks that could later be assigned to agents through job design. In this context, the agents' reward structure (goals) and specialization (knowledge) were intimately tied to the tasks for which they were responsible. Consequently, scholars viewed goal and knowledge interdependence as essentially congruent with task interdependence.

However, the nature of work has shifted over time. Workflows have become more unpredictable, and technology now enables a greater variety of ways to organize work. As a result, task interdependence is often not fully known *ex ante*. These developments have two notable implications. First, it is now virtually impossible to design an entire organization before agents actually conduct the work; indeed, novel elements arise constantly while work is being

performed. Second, job design can no longer be treated as deterministic; modern-day job descriptions are broad and contain high-level responsibilities. In the absence of clearly defined tasks to guide organization and job design, task interdependence becomes both a less prominent signpost for organizing and less tightly coupled with goal and knowledge interdependence. Here, agents gain the freedom to follow broader goals and apply their knowledge in ways that reflect their own preferences rather than predefined requirements. As a result, goal and knowledge interdependence become salient in their own right as indispensable components of organization and job design.

This shift in the nature of work implies that agents have become involved in the design process as co-designers rather than recipients. In other words, employees increasingly create and select their own tasks; individual expertise transcends functional specialization, directly influencing design decisions; and broader goal structures encourage agent interactions that would not otherwise exist. The direct result of this shift is a proliferation of organizations in which relatively permanent, manager-designed structures coexist with more fluid, agent-designed elements.

This altered organizational reality has prompted calls for the organization design literature to complement the knowledge of formal organization design by exploring worker-driven design processes. Consequently, scholars are increasingly turning their attention to the *microfoundations* of organization design, that is, the microlevel processes, behaviors, and interactions that aggregate to yield the organization's overall structure. Examining these microfoundations is critical to understanding in greater depth the involvement of agents in the design process and the role that interdependence plays.

As the field begins to build theory on the microfoundations of organization design, we continue to see a strong tendency for studies to examine the design process through the traditional lens of task interdependence. Such a task-centric view is problematic because many of the worker-driven interactions that constitute these microfoundations are not based on predictable work streams or fully fleshed-out task structures that participants know *ex ante*. These interactions are based instead on agents' efforts to make sense of and act upon unclear demands and uncertain opportunities. Hence, our focus on task interdependence can provide, at best, an imperfect view of their nature and outcomes.

We believe the field of organization design needs a more extensive toolbox to properly explore its microfoundations. We must expand our view of interdependence by complementing our trusted focus on task interdependence with the richness that a deeper understanding of other types of interdependence can bring to the analysis. Goal and knowledge interdependence so far have played a subordinate role in our theorizing. They merit greater attention, however, as the analysis shifts to agent-driven interactions in scenarios in which the tasks are not clear cut. Goal interdependence helps explain why and how agents collaborate in the absence of incentives that are closely tied to the performance of pre-defined tasks. Knowledge interdependence allows us to explore how agents' capabilities create opportunities to make contributions that exceed their formally assigned responsibilities. Managers and designers, then, can selectively manipulate goal and knowledge interdependence to create structures nimble enough to take on uncertain and ambiguous work streams. In sum, our field needs to acknowledge and understand interdependence, in all its complexity, as a steppingstone to capturing the true richness of the microfoundations of organization design.

Our review synthesizes numerous organization design studies that expand our conceptualization of interdependence beyond the realm of tasks. We complement this effort with insights from an extensive range of work in organizational behavior, which has studied goal interdependence in great depth. Theory on knowledge interdependence is sparse in the organization theory and organizational behavior literatures, but its presence is stressed in numerous studies of emergent organizing in which agents' behavior is analyzed in depth. We synthesize these strands of literature to present the current state of the field and to identify gaps in our understanding that provide opportunities for future research.

Overall, this review makes three contributions. First, we summarize different conceptualizations of task interdependence to bring coherence to our understanding of this important construct. Second, we emphasize the importance of goals as fundamental sources of interdependence in organizing work and position goal interdependence as instrumental in the design process. Third, we summarize the literature on knowledge interdependence, a concept that requires deeper examination. Taken together, the three types of interdependence we map in this review offer an integrated (albeit preliminary) look at the internal forces that shape the design of today's organizations. Management scholars at all levels of analysis are keenly interested in studying contemporary phenomena such as flat organizations, self-organizing teams and organizations, and the self-selection of tasks at the individual and unit level. We hope that our review provides a fruitful starting point for future research across these areas, both through the lens of microfoundations and organization design at large.

METHODOLOGY: REVIEWING THE LITERATURE ON INTERDEPENDENCE

Interdependence is a central construct in organization studies. The term is mentioned across the fields of organization theory, organizational behavior, and social psychology. Hence, it is surprising that, as a construct, interdependence remains poorly defined and conceptualized. Only a handful of studies have focused specifically on interdependence at the organizational level (e.g., McCann & Ferry, 1979; Kelley & Thibaut, 1978; Pennings, 1975; Victor & Blackburn, 1987). Furthermore, our predominant definition and conceptualization dates to the 1960s; little novel theorizing has been published since then (for a recent analysis, see Puranam & Raveendran, 2013). These circumstances led to our two-pronged strategy for defining the boundaries of this review.

First, we systematically searched prominent journals to identify articles for which variations of "interdepend*" (interdependence, interdependencies, interdependent, etc.) appeared in the title, abstract, or keywords. Table 1 lists our targeted journals, which yielded 397 potentially useful articles. Among these, about two-thirds were disqualified because they used the term merely to describe relationships or did not contribute to the literatures on organizations, teams, or job design.

[[INSERT **TABLE 1** ABOUT HERE]]

Next, we identified the most impactful studies on the division of labor, organization, team, and job design, as well as the organization's approach to managing the interdependencies that result from these processes. We found the research to be extensive, ultimately spanning three levels of analysis. At the *organization* level, the organization design literature (including the literatures on modularity, information processing, and contingency theory) analyzes the effects of the division of labor and examines managers' top-down efforts to create structures that help

the organization cope with internal interdependence. In parallel, macro-level research on new forms of organizing and organizing processes also analyzes agent-driven, emergent, and bottom-up structures. At the *group* level, the literatures on group and team effectiveness, transactive memory systems, and group processes explore how work can be designed to cope with interdependence. Studies on situated practice and self-managing teams complement that research by taking an agent-centric perspective. At the *individual* level, the literature on job design examines how characteristics of work affect individual outcomes and is further supplemented with the literatures on job crafting and extra-role behavior. Among these literatures, we considered not only foundational studies but also leading examples of more recent work.

Our searches yielded a list of 236 published articles in addition to several dozen books, which we analyzed closely for their definitions and conceptualizations of interdependence. These works form the basis of our review. While the majority is referenced in this manuscript, an online supplement lists the remaining articles and books we analyzed but do not reference directly here, as well as a comprehensive analysis of all the conceptualizations of interdependence we studied, together with their verbatim definitions.

The net we cast for studies on internal interdependence was a wide one; however, it naturally excluded several related literatures that also study interdependence from different perspectives. For example, our review did not include studies that focus on organizational decision-making and attention (e.g., Clement & Puranam, 2017; Gavetti, Levinthal, & Ocasio, 2007; Joseph & Wilson, 2018; Puranam & Swamy, 2016); complementarities in organizational search (e.g., Levinthal, 1997; Posen, Keil, Kim, & Meissner, 2018; Rahmandad, 2019; Rivkin & Siggelkow, 2003); resource dependence theory (e.g., Emerson, 1962; Gulati & Sytch, 2007; Pfeffer, 1972; Thibaut & Kelly, 1959); how the organization manages its interdependencies with

the environment (e.g., Argote, 1982; Cyert & March, 1963); or on interdependence at the ecosystem level (e.g., Adner & Kapoor, 2010; Dobrev, Ozdemir, & Teo, 2006). We also excluded articles from a vast literature that explores inter-organizational interdependence in the context of mergers and alliances (e.g., Aggarwal, Siggelkow, & Singh, 2011; Gulati, 1995; Gulati & Gargiulo, 1999; Pfeffer, 1972; Pfeffer & Nowak, 1976; Steensma & Corley, 2000), open innovation (Tushman, Lakhani, & Lifshitz-Assaf, 2012), or the design of meta-organizations (Gulati, Puranam, & Tushman, 2012).

As we reviewed the selected manuscripts, we first noted the types of interdependence they featured, their conceptualization and operationalization of those types, and the interrelations among them. We identified three distinct types of interdependence that characterize the organizational workflow: task, goal, and knowledge interdependence. We also noted that earlier work tended to interpret interdependence as exogenously given, whereas more recent work suggested that interdependence is, instead, endogenous to the organization design process, either because managers can manipulate it and/or because it arises during agent interactions.

As a result, we arranged our review by analyzing task, goal, and knowledge interdependence in two distinct contexts of organization design: (1) classic organization design (a top-down effort to create an efficient organizational structure by managing exogenously-given interdependencies) and (2) contemporary organization design (characterized by greater bottom-up agent involvement in the design effort and where interdependence is endogenous). The contrast in our review between these two contexts is certainly a caricature, and we do not intend to suggest that all (or even many) organizations fall squarely into either category. Indeed, the real world is more complicated. We do, however, see value in distinguishing between these two extremes because it allows us to show clearly (1) how different types of interdependence matter

for organization design and (2) why, and under what conditions, each type becomes more prevalent and critical to the organization design process. Table 2 summarizes the assumptions that underlie organization design in these two contexts and the implications that follow for the three types of interdependence examined, which we will develop in detail in the next section.

[[INSERT **TABLE 2** ABOUT HERE]]

Finally, we combine the contrast between the classic and contemporary contexts of organization design with a focus on the microfoundations of organization design. At its core, organization design is a macro-level phenomenon: it is a theory about a system and about how best to structure the system so that it optimizes—or at least satisfices (Simon, 1945)—performance. However, all the fundamental questions studied in the organization design literature are essentially individual- or group-level issues: human behavior is involved in achieving effective coordination, coping with interdependence, aligning incentives, facilitating information processing and communication, and integrating efforts. Although each of these issues could be addressed simply and effectively by studying agent dyads (or triads), the extant theory of organization design relies on aggregation (Puranam, 2018). It follows that, in order to appreciate why and when certain design levers are effective, we must identify their underlying mechanisms. Understanding how the fundamental questions are resolved at the interpersonal and group level, and how these interactions and processes aggregate to form macro-level outcomes, defines the study of the microfoundations of organization design (Barney & Felin, 2013).

The implication of our focus on microfoundations is that we draw on literature beyond organization design. Only by integrating insights from the group- and individual-level literatures on team and job design, and thereby studying the design process from different perspectives, can we generate a more complete picture of what the three types of interdependence entail. We now

describe the dynamics that characterize the classic and contemporary contexts of organization design and then examine each type of interdependence.

THE STUDY OF ORGANIZATION DESIGN AND THE NATURE OF WORK

The formal study of organization design is rooted in multiple theories and perspectives that range from the early exploration of organizations as social systems (e.g., Barnard, 1938; Roethlisberger & Dickson, 1939), contexts for administrative behavior (e.g., Gulick & Urwick, 1937; Simon, 1945) and providers of hierarchies (e.g., Taylor, 1911; Weber, 1946) to contingency and congruence theory (e.g., Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Woodward, 1965). A common factor in these foundational works is the presumption that task interdependence (1) is *exogenously determined* by the nature of the work and by available technology and (2) must be *managed (i.e., controlled or minimized)* – an idea that dates back to Adam Smith's (1776) seminal study of the pin factory.

Under these assumptions about work and technology, tasks were divided into a fixed number of interdependent subtasks that, when taken together, constituted the organization's *task structure*. Managers (or designers) then took sets of highly interdependent subtasks and grouped them to form jobs such that task interdependence was higher within jobs and lower between jobs. The strongest interdependencies would then be clustered together and allocated to a single agent (i.e., the job's occupant), who would resolve any coordination needs between them in a fairly straightforward manner. The remaining interdependencies, linking the subtasks pertaining to two or more different jobs, would naturally be weaker. Coordination between them could be managed across agents using coordination mechanisms tailored to the type of interdependence at play (for a review, see Nadler & Tushman, 1997). For example, *pooled* interdependence (in

which agents work independently until the end of the process, when their outputs are aggregated) required only that rules and procedures be followed, whereas *reciprocal* interdependence (whereby the output of each agent's work becomes the other agent's input) required feedback and/or mutual adjustment (March & Simon, 1958; Thompson, 1967).

The underlying assumption in these classic studies is that managers can understand the organization's task structure well enough to design effective structures to manage task interdependence across agents before the work is performed. Studies often equate the organization's workflow with a task sequence, which de-emphasizes other workflow components (viz., goals and knowledge) as sources of interdependence in their own right. Goals are understood to be embedded within job descriptions and reporting lines. In practice, this assumption translates into the expectation that agents, upon seeing how their clearly defined responsibilities fit within the organization's overall workflow, will act according to their job descriptions. Incentives and reporting lines are therefore assumed to generate goal interdependence that is congruent with task interdependence. In turn, knowledge is understood to be embedded within each focal job's skill requirements. Agents assigned to a job are assumed to have the knowledge and skills needed to perform that job satisfactorily. It follows that knowledge interdependence mirrors task interdependence and is managed to be high within agents and minimal across agents.

Yet in most present-day organizations, predictable and well-understood work streams coexist with unexpected, relentlessly shifting demands (Brown & Eisenhardt, 1998; Davis, Eisenhardt, & Bingham, 2009). Whereas well-understood workstreams tend to be supported by organizational features that managers formally design, rapidly shifting ones are supported by emergent features; that is, those that arise from workers' own actions. Boundary-spanning units

and individuals, who are well positioned to make sense of shifting work streams, participate in the design process by attempting to define tasks (Weick, Sutcliffe, & Obstfeld, 2005) and by progressively self-assembling, or crafting, critical components of their work (Wrzesniewski & Dutton, 2001; Bell & Staw, 1989).

In the presence of dynamic work streams, task division changes frequently and is influenced by the individuals and units involved in the organizing process (Freidson, 1976; Raveendran, Puranam, & Warglien, 2016). Therefore, situations where task interdependence is viewed as a deterministic input to managers' organization design coexist with situations in which task interdependence arises and is negotiated *while* workers make sense of and perform the work (Barley, 1986; Berg, Wrzesniewski, & Dutton, 2010; Cohen, 2013; Griffin, Neal, & Parker, 2007; Pentland, 1999). Into this category, we group the streams of literature on new forms of organizing (Puranam, Alexy, & Reitzig, 2014) and self-managing organizations—which have recently gained more traction—along with studies of job crafting at the individual and unit level (Silvestri, 2019).

In essence, the research streams described so far assume that the nature of work has become increasingly ill-defined. Thus, a complete job design (or a complete organizational design) is not given *ex ante*, either because the underlying task structure is unknown or because it changes too quickly to warrant a detailed design effort. Any pre-determined design would soon become outdated. As a result, fine-grained task division and allocation are not feasible until agents have actually performed the work. The agents themselves engage with one another to make sense of the work, identify emergent tasks, and allocate them. Agents' iterative efforts to understand and codify the work results in a flowing "structure as process" that changes shape with each iteration.

A logical conclusion from this line of reasoning, then, is that task interdependence cannot drive the design effort from the outset, because a clearly defined task division and allocation has yet to be established. Instead, goal and knowledge interdependence among participating agents come to the forefront to facilitate the design process. Task interdependence still plays an important role, but it temporally *follows* goal and knowledge interdependence. In this setting, (1) interdependence is *endogenously determined* through interactions among agents and (2) managers can *foster and guide* interdependence via artful manipulation. Specifically, managers and designers can generate goal interdependence by introducing broad incentives and reward structures. In that way, goal interdependence helps align agents' interests around a common "north" (Simons, 1994) as they make sense of and allocate the work. Managers and designers can also encourage knowledge interdependence by grouping agents with diverse and complementary backgrounds and skills (Leonard-Barton, 1995). In this way, knowledge interdependence enables agents to reach out to one another on a "who knows what" basis and support the process of sensemaking and task division. Thus, the active creation of goal and knowledge interdependence temporally precedes the discovery of an underlying task structure and creates, endogenously, task and agent interdependence.

Next, we discuss the types of interdependence and apply each to the organization design process and its microfoundations. Thereafter, we integrate our insights into how to recast the role of interdependence in organization design research.

TASK INTERDEPENDENCE

Task interdependence is a key concept in the organization design literature. Despite its ubiquity, or maybe because of it, our review has uncovered a dearth of direct theorizing about task

interdependence at the organizational level, as well as a plethora of definitions that confound task interdependence with other types of interdependence at the group and individual levels. Our aim in this section is to parse through these sources and synthesize a definition that captures task interdependence alone and can be used at all levels of analysis.

Our review highlights several properties of task interdependence that have received relatively little attention in the literature: (1) Interdependence between tasks may exist regardless of who performs the tasks, that is, task interdependence is agent-agnostic. (2) While much top-down research in organizational design has considered it to be an exogenous input to the design process, managers can actively manipulate task interdependence to influence the system's behavior, rendering it endogenous. This has important implications for the design of units and hierarchies. (3) The directionality of task interdependence (whether one task is unilaterally linked to another, or whether that link is bilateral) matters for efficiency and for agents' job satisfaction and motivation. Together, these insights point to the need for more careful theorizing and empirical measurement of task interdependence in our studies of organization design. We have structured the rest of this section to discuss each of these insights.

Defining Task Interdependence

In the organization design literature, the classic citation for task interdependence is Thompson (1967). He proposed a unified theory to explain the variation in structure observed across different complex organizations. Specifically, he noted that differences in structure stemmed from variations in how an organization's operations were set up to handle the uncertainty arising from its own interdependent components.

Thompson (1967) suggested that interdependence could be characterized by pooled, sequential, or reciprocal interactions, which capture interdependencies of increasing complexity

along a Guttman scale. The more complex the interdependence, the more costly the coordination mechanisms required, and the greater effort expended on communication and decision-making (see also March & Simon, 1958). In explaining the role interdependence plays in organization design, Thompson (1967) defined interdependence between *workflows*, not between tasks. He looked at an organization's overall operations and its units' broad sets of responsibilities to examine the degree to which different units were rendered interdependent as they performed their share of those operations (see Table 3 for more detail). He focused specifically on the interdependence among branches, plants, and operational units to convey the importance of minimizing interdependence across these organizational modules by containing the most complex forms of workflow interdependence within them.

The coordination mechanism employed to handle the most complex form of interdependence across agents (in Thompson's taxonomy, reciprocal interdependence) is mutual adjustment, which implies communication and information exchange—in effect, knowledge sharing. Hence, Thompson's notion of organizational workflows captures not only interdependent tasks but also the knowledge required to complete those tasks. Reciprocal interdependence in particular subsumes knowledge interdependence, although Thompson did not specify it as a separate construct (owing, perhaps, to the prevailing assumption at the time, of close congruence between specialization and task, see also Ven, Delbecq, & Koenig, 1976).

After initial efforts to explore task interdependence in its own right (e.g., McCann & Ferry, 1979; Pennings, 1975; Victor & Blackburn, 1987; Table 3 presents some definitions as exemplars) the organization design literature shifted its attention to other coordination and design issues.

[[INSERT **TABLE 3** ABOUT HERE]]

In parallel, team-level research studied the interaction between task interdependence and group design. Here, the conceptualization of task interdependence tends to incorporate the agents who perform the tasks rather than separating tasks from agents. Interdependence between tasks is therefore seen as inextricably bound to interdependence between the agents who perform those tasks. This observation yields a purposefully *relational* definition, one that incorporates not only the connection between tasks but also between actors performing those tasks (e.g., Alge, Wiethoff, & Klein, 2003; Bartel & Saavedra, 2000; Beersma, Homan, Kleef, & Dreu, 2013; Dailey, 1978; Grant & Patil, 2012; Greer, de Jong, Schouten, & Dannals, 2018; Janz, Colquitt, & Noe, 1997; Jehn, 1995; Jehn, Northcraft, & Neale, 1999; Liden & Mitchell, 1983; Mitchell & Silver, 1990; Swaab, Schaerer, Anicich, Ronay, & Galinsky, 2014).

In this literature, Wageman's research has made significant contributions toward clarifying the notion of task interdependence. As one of the most influential scholars studying interdependence in the context of designed organizing at the meso level, Wageman (1995) examined the effects of task (and outcome) interdependence as a function of different team compositions. Wageman's (2001) definition of task interdependence differs from Thompson's (1967) in two respects (see Table 3). First, Wageman considered interdependence in a context featuring group members who take on different subtasks. (Thompson's definition has often been applied *as if* it related to within-group processes but, as noted above, it was actually defined between workflows across units.) Second, she suggested that an organization has considerable freedom in how a team's work is arranged because the extent to which agents are rendered task interdependent can be manipulated (1995; for a similar notion at the macro level, see Levinthal & Warglien, 1999). By designing two team members' work in a way that they rely on each other for inputs or resources, the degree to which they are task interdependent is altered. Similar to

Thompson's approach, this conceptualization also conflates task with knowledge interdependence.

To sharpen the study of organization design and make the construct of task interdependence more actionable in the contemporary context, a more carefully specified definition is necessary. Such a definition needs to separate interdependence between tasks from interdependence between agents or their knowledge. This will provide us with a clear baseline from which to study the interrelationships between the different types of interdependence without confounding them. Recent work on interdependence provides such a clear definition of task interdependence: *two tasks are interdependent if the value generated from performing each is different when the other task is performed versus when it is not* (Puranam, Raveendran, & Knudsen, 2012). This definition captures task interdependence in both the classic and contemporary contexts of organization design and, we believe, provides a useful starting point for studying task interdependence. It is also precise, because it focuses on tasks (without including the agents performing interdependent actions) and allows for the unilateral existence of interdependence (where task A depends on task B but not necessarily vice versa). It is also broad enough to incorporate task interdependence between tasks allocated to individuals, teams, or organizational units.

Task Interdependence in the Classic Context of Organization Design

Task interdependence as an exogenous element of design

Thompson's (1967) work served as the foundation for much of what we call classic organization design research. Scholars quickly focused on *task* interdependence as the most visible result of the division of labor and sought to test Thompson's taxonomy (e.g., Buenger, Daft, Conlon, & Austin, 1996; Larsson & Bowen, 1989; Levitt et al., 1999). Thompson's ideas were also

instrumental in developing the conceptual underpinnings of contingency theory. Contingency theory suggests that organizational performance will be higher when there is fit between the organization's structure and several contingency factors, some of which are environmental (e.g., the degree of environmental dynamism and external uncertainty), whereas others are firm-specific (e.g., organization size, chosen technology, task complexity, task uncertainty, and task interdependence) (Blau & Scott, 1962; Burns & Stalker, 1961; Child, 1972; Lawrence & Lorsch, 1967; Woodward, 1965). In this context, *how* tasks are interdependent (using Thompson's notion of pooled, sequential, or reciprocal) should influence which structural features may improve or hinder firm performance. Research in this field has also documented the close connection between task interdependence and the degree to which an organization can generate effective integration and differentiation among its components (for a review, see Donaldson, 2001).

Another perspective that built on Thompson's early work is the information processing view (Burton & Obel, 1984; Daft & Lengel, 1986; Galbraith, 1973, 1977; Tushman & Nadler, 1978; see Joseph & Gaba, 2020 for a review), which explores how interdependence and various coordination mechanisms are connected. In this context, task interdependence was often perceived as a source of uncertainty that could only be addressed effectively with the aid of information exchange and coordination mechanisms. Several scholars have conducted empirical tests of the information processing view of interdependence (e.g., Adler, 1995; Ito & Peterson, 1986), albeit with mixed results (for reviews, see Capon, Farley, & Hoenig, 1990; Dalton, Todor, Spendolini, Fielding, & Porter, 1980).

Common across these organization-level literatures is that task interdependence is assumed to be exogenous. This assumption was suitable and accurate in a world where the task structure was known *ex ante* and managers could therefore design the organizational chart before

work was performed. In this context, task interdependence was viewed as a property of the organization workflow that could not be altered but might be managed effectively through structural interventions. In practice, the aggregation of interdependence to the organizational level led researchers to theorize as if the underlying task structure was fixed and task interdependence was given. As organization-level research assumed exogeneity, however, group-level studies suggested that task interdependence within team design could be manipulated (e.g., Wageman, 1995).

Despite pursuing complementary questions, these macro- and meso-level research streams have remained largely separate. However, as our study of organization design begins to pursue a deeper understanding of its microfoundations, it becomes critical to examine the degree to and level at which task interdependence could be treated as endogenous to the design process. We therefore examine task interdependence in the context of group and job design to refine our understanding of task interdependence at the organizational level.

Task interdependence as an endogenous (or manipulable) element of design

The classic context of organization design assumes that the manager has reasonably accurate knowledge of the underlying task structure (Simon, 1962), and that this structure, as well as the task interdependencies it contains, are deterministic. In contrast, the idea that task interdependence can be manipulated suggests that the underlying task structure is malleable and reflects the particular division of labor chosen (Raveendran et al., 2016). Research on team design acknowledges this by considering task interdependence as a factor that can be manipulated to improve team performance (Wageman, 2001). Similarly, the modularity literature focuses on this property to actively minimize interdependence across subparts of the system.

We first refine our understanding of task interdependence as a manipulable element in design by considering insights from the literature on team design and effectiveness (e.g., Gladstein, 1984; Guzzo & Dickson, 1996; Hackman, 1983; Harrison & Humphrey, 2010; Kozlowski & Bell, 2003; Marks, Mathieu, & Zaccaro, 2001; Mathieu, Maynard, Rapp, & Gilson, 2008). Fundamentally, team-level research on task interdependence is concerned with the interaction between task interdependence and group design. As a result, this literature suggests that task interdependence can be manipulated and is therefore endogenous to the team design process. For example, Wageman (1995) examined how different degrees of task interdependence affect team performance in a field study of Xerox maintenance and repair teams. She asserts,

> Task design is manipulable. Manufacturing work may be designed so that individuals with distinct skills execute their part of the task—one input into the final product—independent of other workers. Alternatively, group members may be cross-trained and work simultaneously and, at times, interchangeably, on completing the whole. And finally, one might create a hybrid form in which members sometimes work alone at independent tasks and sometimes work together as a team." (1995: 147).

Across various studies, Wageman found that task design has a measurable effect on the *behavior* of team members, such that greater task interdependence among members is associated with cooperative, learning, and helping behaviors.

Wageman's manipulation of task design assumes that the underlying task structure is relatively decomposable and can be allocated to individuals in different configurations, depending on the individuals' degree of specialization (i.e., the knowledge held). However, it does not actively explore how the effectiveness of task design is influenced by the underlying task structure's degree of decomposability. To explore this more deeply, we turn to the modularity literature (e.g., Baldwin & Clark, 2000; Simon, 1962).

The modularity literature has significantly influenced how organization design is studied by translating its view of product design and production processes to the design of organizations

and tasks (Campagnolo & Camuffo, 2010; Colfer & Baldwin, 2016; Sanchez & Mahoney, 1996; Sosa, Eppinger, & Rowles, 2004; von Hippel, 1990). It posits that a complex system can be arranged into modules to maximize interdependence within modules, while minimizing interdependence across modules (Parnas, 1972; Simon, 1962). This research mirrors Thompson's (1967) assertion that task interdependence can be minimized across agents (or modules) by keeping highly interdependent tasks contained within agents. From a modularity perspective, task interdependence is represented in a design structure matrix that maps dependencies among all subcomponents or tasks (Baldwin & Clark, 2000; Garzarelli & Langlois, 2008). This approach then generates a microscopic network view of dependencies (Baldwin, 2019),[1] which traces every unilateral and bilateral relationship between subtasks and modules. Simple examples of these design structure matrices are given in Figure 1, which translates the task interdependence patterns of Thompson's (1967) pooled, sequential, and reciprocal types into design structure matrices. This visual representation can serve as a guide to manipulating, reducing, or changing organization-level interdependencies by clustering task interdependencies into different modules. Even if we take all interdependencies as exogenously given, the matrix representation's rows and columns (i.e., subtasks) can be re-arranged to generate modules that exhibit high within-module interdependence but little across-module interdependence (e.g., Baldwin, MacCormack, & Rusnak, 2014; Ethiraj & Levinthal, 2004).

[[INSERT **FIGURE 1** ABOUT HERE]]

By facilitating this microscopic network view of all (first-order) interdependencies, the modularity literature enables us to see how task interdependence can be managed and

[1] We thank Carliss Baldwin for generously allowing us to incorporate into our review previously unpublished insights on modularity as a microscopic network view and her translation of Thompson's (1967) work into design structure matrices (included in Figure 1).

manipulated. Visualizing all known task interdependencies in the underlying task structure allows the manager or designer to assess current coordination requirements. At the same time, this visualization provides the tool to redesign the way task clusters are grouped and linked. Thus, when we visualize the organization's task structure in a design structure matrix, we can use it as both a diagnostic and a design tool. As a diagnostic tool, key interdependencies can be identified and possibly managed; as a design tool, certain interdependencies can be reshuffled and clustered to change or reduce interdependence in search for better performance.

Overall, the teams and modularity literatures highlight that task interdependence can be manipulated. Instead of viewing subtasks as exogenous and determined by technological constraints, we find a context in which subtasks can be clustered together and allocated or altered to affect performance and behavior in specific ways. However, more research is required to fully understand these dynamics: At the team level, a more careful distinction between task interdependence (which should remain agent-agnostic) and agent-based interdependence (such as goal and knowledge interdependence) may help improve the accuracy of laboratory experiments. At the organization level, recognizing that task interdependence itself can be manipulated can broaden our study of the microfoundations of organization design and open new areas of research currently left underexplored.

Directionality of Task Interdependence

The second refinement to our conceptualization of task interdependence, derived from the literature on job design, relates to the directionality of task interdependence. Generally, the organization design literature is inclined to view all dependence relationships as bilateral, in which both parties in a dependence relationship need each other. Indeed, that tendency eases the exposition, but it can also obscure the vital distinction between unilateral dependence (i.e. when

A depends on B) and bilateral interdependence (i.e. A depends on B *and* B depends on A). This directionality of interdependence was present in Thompson's (1967) definition (in terms of sequential and reciprocal interdependence), but subsequent research on organization and team design has been less explicit about the distinction.

In contrast, the literature on job design emphasizes the directionality of task interdependence as a key component of the design process (e.g., Wong & Campion, 1991). Interdependence was largely implicit in early research on job design, such as the time and motion studies Taylor initiated (1911). Within just a few decades, however, interdependence was acknowledged explicitly in studies examining job and role design in different industrial settings. Scholars examined interdependence as one of several factors connecting technological complexity and agents' functional or technical (requisite) knowledge (Trist & Bamforth, 1951). Furthermore, they assessed how job satisfaction is affected by the direction of agents' interactions (e.g., Thomas, 1957; Turner & Lawrence, 1965). Later, *relational* theories of job design focused on how jobs, roles, and tasks influence the job holder's attitudes and behaviors (e.g., Grant & Parker, 2009; Parker, Wall, & Cordery, 2001). Kiggundu (1981, 1983), for example, distinguished between "initiated" and "received" interdependence and applied that distinction to studying the effects of task interdependence. He theorized that initiated and received task interdependence are separate and independent job dimensions rather than opposite ends of a continuum. Kiggundu (1981) pointed to the potentially motivating effects of initiated task interdependence reported in prior research, which also found that *received* task interdependence is likely to have the *opposite* effect (Morgeson & Humphrey, 2006; Oldham & Hackman, 2010). The implication for effective team and organization design is that the directionality of interdependence can affect individuals' motivation and may also influence

organizational performance. A similar emphasis exists on directionality in the modularity literature—for example, the Parnas (1979) definition of dependence as an A uses B—and social interdependence theory (e.g., Victor & Blackburn, 1987).

The role of directionality is especially salient in stable contexts in which the task is clearly defined, and task interdependence is the essential driver of organization design efforts. As we move from classic organization design to the contemporary context, being able to pinpoint any directionality of interdependence and to design both jobs and structures around it may become even more important for knowledge interdependence than for task interdependence. We now turn to this contemporary context and describe how it alters our understanding of task interdependence.

Task Interdependence in the Contemporary Context of Organization Design

As discussed, the assumption that task interdependence can be taken as given is helpful when the nature of work is well understood. When the nature of work is ill-defined and managers lack a sufficiently clear understanding of the underlying task structure, organization design cannot be created *ex ante* to minimize task interdependence across agents. Several studies of these less well-defined settings have examined how task interdependence may *arise* via task division and allocation while the work is performed, rather than designed ex ante (e.g., Ketkar & Workiewicz, 2020; Puranam et al., 2014; Raveendran, Puranam, & Warglien, 2020). Yet, most studies on contemporary organization design still tend to focus on task interdependence as the main element in the design process. This task-centric view is a natural consequence of our field's tradition, but it precludes exploring the richness of organization design in contemporary settings and the breadth of the interdependencies contained therein. To illustrate this point, we describe three

exemplar studies featuring task-centric research questions in which the findings suggest the presence of other types of interdependence beyond tasks.

First, Gulati (2010) presents a field study of organizations seeking to shift their strategic focus to become customer centric. These organizations, however, tend to have strong legacy structures rooted in technologically determined interdependencies. Consequently, these firms face competing pressures that force them to make tough design choices. As the organizations moved away from the predictability and safety of their task-based configurations toward more uncertain yet more promising goal-based organizational designs, the study evidences how tasks (and, to a great extent, agents' knowledge) are redefined by those new organizational arrangements and how goal, knowledge, and task interdependence shift in support of a new organizational ethos.

Our second example is Cohen's (2013) study, which examined the process of task allocation in a field study of technological change. She analyzed how different task allocation decisions—and thus different configurations of task interdependence—were made after identical DNA sequencers were installed at nine healthcare organizations. Her study established that task allocation hinges less on managerial decisions or the technology itself than on agents' ideas that arise as the technology is implemented and used. These ideas create different notions of what the technology means, what purpose it should serve, and what demands it should fulfill. This resulted in idiosyncratic task division and allocation outcomes at the different health care organizations. Although Cohen's research question clearly relates to task interdependence, her analysis showed how agents' unique knowledge and their willingness to become involved in the organization design process significantly affected the work and the ultimate division of labor. In

short, interdependencies that transcended the task were present and had a meaningful effect on organization design outcomes.

In a third example of the task-centric nature of studies in the contemporary work context, Raveendran et al. (2016) used a series of behavioral laboratory experiments to investigate how task division and allocation emerge. The participants were instructed to assemble a toy model but were allowed to decide how they wanted to divide and allocate the tasks involved. The authors found that self-organizing groups tended to be strongly influenced by prior shared work experience but this influence worked to the detriment of task allocation. In this sense, the knowledge interdependence of groups affected their perceived task interdependence. Goal interdependence, while not highlighted separately, was incorporated into this study through shared monetary incentives that strongly drove group performance. Consequently, goal interdependence was a primary motivator for groups to engage in the process of task division and allocation.

Findings from these and similar empirical accounts suggest that task interdependence is not the only important type of interdependence to be examined to understand organization design choices and processes. The contemporary context highlights that other types of interdependence beyond task—specifically, agent-driven types—warrant attention in the design process. This shift in our focus originates both in the greater demand for meaningful work (Berg, Dutton, & Wrzesniewski, 2013; Bunderson & Thompson, 2009; Carton, 2018) and in the greater *need* for agent input in the design process. When the overarching task is not understood well enough *ex ante* to generate a stable task division and allocation, minimizing task interdependence can no longer be the main driver of organization design.

Summary: Microfoundations of Task Interdependence

In reviewing the literature, we found a rich body of research that conceptualized task interdependence as being exogenously given and managed by organization structure in a way that facilitates worker interactions. We also found insights that can expand and refine our conceptualization in two ways.

First, greater care could be taken to clarify and track the directionality of task interdependence; indeed, workers' behavior and motivation are impacted by the direction of the task interdependence experienced. Second, more attention can be paid to the designer's ability to manipulate task interdependence and the resulting freedom to reduce task and agent interdependence when the work is performed. By paying more attention to how task interdependence can be manipulated, we widen the purview of organization design and its ability to manage uncertain and complex environments. We now explore how broadening the interdependence construct will help us recognize the complexity of agent involvement in the organization design process. This discussion will facilitate our sensemaking of these processes and their microfoundations.

GOAL INTERDEPENDENCE

In organizations, goal interdependence (also referred to as reward or outcome interdependence) captures the extent to which members' interests are aligned or compatible. Workers have their own respective motivations and interests, but goal interdependence creates a shared focus that connects workers through a jointly desired outcome. Goal interdependence is distinct from task interdependence in that the former connects agents through their motivation or interests, whereas

the latter connects complementary subtasks. Note that two agents can be goal interdependent regardless of whether their respective tasks are interdependent.

The classic organization design literature has paid little attention to goal interdependence per se. It assumed that the structures and coordination mechanisms implemented to manage task interdependence would naturally serve to align members' interests, suggesting that, across the organization, "who *wants* what" is intimately connected to "who *does* what." This is a fair assumption in a world where tasks are well understood and where the structures of work and incentives can be designed before the work is actually performed. If jobs are clearly delineated, efficiently grouped, and adequately linked, workers will know their purpose and position in the organization's workflow and perform accordingly. Incentives are thus aligned with job descriptions and reporting lines, causing goal interdependence to follow and remain congruent with task interdependence. Because task interdependence was seen as exogenously determined, this classic approach views goal interdependence in the same deterministic manner. Only a few studies have examined goal interdependence as a design element that managers can actively manipulate, regardless of the division of labor. As managers group individuals into business units, their design choices regarding unit- versus individual-level rewards may generate different goal interdependence that aligns members' interests around common or individual goals. Still, the majority of studies in the classic context ignores the potential use of goal interdependence as a design element separate from task interdependence.

In contrast, more recent studies of organization design focus on situations in which the nature of the work is not well defined. In this scenario, *ex ante* task division and allocation become problematic. As agents engage with one another to make sense of their work, goal interdependence comes to the foreground and helps guide their interactions and the organization

design process itself. By implementing reward and incentive structures that encourage collaboration in the midst of task ambiguity, managers can foster goal interdependence that brings together individuals who need to interact effectively yet lack a clear blueprint to structure such interactions. In the absence of clearly defined task structures, formulating a shared goal is a good way to motivate the relevant individuals toward mutual engagement. Only when common goals are in place can agents collaborate to devise effective task division and allocation. As a result, goal interdependence (understood as an endogenous design element) has become a cornerstone of organization design in the contemporary context.

Although studies of goal interdependence are relatively sparse at the organization level, the topic has been studied enthusiastically at the group and individual levels. We next draw on the latter two research streams, parse numerous definitions, and summarize and refine the conceptualization of goal interdependence in both the classic and contemporary views of organization design. In so doing, we draw attention to how other streams of literature can refine our notion of goal interdependence and contribute to our understanding of its role in shaping the microfoundations of organization design.

Defining Goal Interdependence

Over time, goal interdependence has been identified with various labels, definitions, and operationalizations. The labels used most commonly are "goal," "reward," and "outcome" interdependence, but these terms are seldomly defined or applied consistently. While all of these are associated with the appraisal of joint work, our review suggests that goal interdependence is the most comprehensive construct, while reward and outcome interdependence can be interpreted as subcategories. Because distinguishing among these three constructs can only improve theory

development, we provide clear definitions for each before moving to a broader discussion of goal interdependence in the classic and contemporary contexts.

Goal interdependence is the broadest construct for capturing the degree to which agents' interests are aligned or complementary. The goal-setting literature states that two agents are goal interdependent if they *"share a common goal, whether or not they actually work together"* (adapted from Mitchell & Silver, 1990: 186). This type of interdependence can vary from high to low; it also entails combinations of individual- and group-level goals.

Research across the teams and job design literatures, however, has tended to conflate goal interdependence with task interdependence by suggesting that the former is characterized by both "shared significant consequences" and "collective performance" (e.g., Wageman, 2001: 201). Because it suggests joint *interests*, the notion of "shared consequences" falls in the realm of goal interdependence as defined above and is therefore accurate. However, "collective performance" incorporates a sense of joint *action*, which implies task interdependence. Note that, although task and goal interdependence are often linked, task interdependence is not required for goal interdependence to exist. The definition we present above focuses on "shared significant consequences" while omitting the need for "collective performance"—in other words, it centers on the results agents wish to achieve, without specifying whether agents complete their tasks alone or together. In fact, the distinction between agent interdependence and task interdependence presupposes that the former can be created in the absence of the latter by making the agents goal interdependent (via the "broad incentives" described in Puranam et al., 2012: 423). Our definition therefore provides a clearer delineation between task and goal interdependence.

Turning to the second term, *reward* interdependence focuses on the monetary outcomes of individuals' work. For this, Wageman and Baker (1997: 142) offer a succinct definition: Reward interdependence is "*the extent to which the rewards that accrue to an individual depend upon the performance of coworkers.*" This type of interdependence likewise ranges from low to high. Under low reward interdependence (as opposed to independence), each individual's remuneration would reflect the pooled contributions of all workers. In contrast, high reward interdependence reflects the joint assessment of everyone's contribution without regard to individual effort or input. These reward types can be combined to generate levels of individual- and group-based reward interdependence that lie between those two extremes. Note, however, that reward interdependence need not imply joint *action*, which depends instead on group members' *task* interdependence. The difference between reward and goal interdependence is that rewards consist of the tangible, yet malleable payments made to agents who undertake these activities, whereas goals reflect agents' desired results, regardless of their nature. Hence, reward interdependence is a subset of the broader concept of goal interdependence, which is understood to be the ultimate objective of joint activity. While reward and goal interdependence are often congruent, they need not be. For example, two workers in Adam Smith's pin factory, one producing heads the other producing tails, may be goal interdependent in that they want to produce a whole pin, but not reward interdependent if they are paid on a piece-rate basis for their individual output.

Lastly, *outcome* interdependence captures the level at which individuals' goal interdependence is appraised. Synthesizing across a variety of papers with varying definitions of this construct, we define it as *the extent to which agents' work is measured at the individual versus the group level*. Our survey of the research on outcome interdependence, however,

exposed some inconsistencies in definitions and applications, which requires further discussion. In some studies, outcome interdependence is interpreted as the extent to which employee rewards are based on joint work versus an aggregate of their individual contributions (which are produced and assessed independently) (e.g., Gully, Incalcaterra, Joshi, & Beaubien, 2002; Van der Vegt, Emans, & van de Vliert, 2000; Wageman, 2001). This is in line with the definition of goal interdependence outlined above—both relate to the *intensity* of the interdependence between agents. However, in a separate set of studies rooted in social interdependence theory (e.g., Deutsch, 1949; Johnson & Johnson, 2005), outcome interdependence signals the *quality* of individuals' behavior and its consequences over joint performance. This interpretation of outcome interdependence allows for a more nuanced analysis but presents some conceptual challenges. Here, scholars often speak of positive (or high) and negative (or low) outcome interdependence. Positive (respectively negative) outcome interdependence is associated with group members adopting a collaborative (respectively competitive) mindset and then exhibiting a high (respectively low) level of group performance (e.g., Beersma et al., 2013; Lee, Pitesa, Thau, & Pillutla, 2015; Tjosvold, 1988; Van der Vegt, Emans, & van de Vliert, 1998). This interpretation of outcome interdependence implies that groups will perform well under positive interdependence but that any individual-level rewards or goals will lead to a zero-sum game that negatively affects performance. There is some empirical support for this perspective (Alper, Tjosvold, & Law, 1998; Stewart & Barrick, 2000), but its underlying conceptualization of outcome interdependence—as a trade-off between competitive and collaborative behavior—is suspect because it conflates the design of tasks with that of incentives.

To complicate matters, the two aforementioned interpretations of outcome interdependence are sometimes conflated. This arises from scholars' assumption that high and

low outcome interdependence corresponds to (respectively) positive and negative outcome interdependence. This association appears to be consistent in the case of positive outcome interdependence (i.e., "I do well when others do well"), but there is a crucial difference between *negative* outcome interdependence ("I do well when others do poorly") and *low* outcome interdependence ("I do well when my results depend little on others"). Negative interdependence, which Thomas (1957) called hindrance interdependence, and its associated competitive mindset are not always present when outcome interdependence is "low", that is, defined at the individual rather than the group level.

Hence, two important questions remain to be addressed. First, how, exactly, *is* the distinction between high and low levels of outcome interdependence related to the assessment of group- versus individual-level outcomes? Second, what are the behavioral implications for group members in contexts of high versus low levels of outcome interdependence in combination with positive or negative outcome interdependence? The answers will bear heavily on the theory and measurement of these constructs. More research is needed to clarify how these two conceptualizations of outcome interdependence are related.

Given the variety and relative inconsistency of labels applied across studies and literatures, we will use "goal interdependence" throughout this paper when referring to any interdependence among agents that derives from their goals, rewards, and/or outcomes. (We will distinguish among these cases as needed.)

Goal Interdependence in the Classic Context of Organization Design

Recall that the classic organization design literature's nearly singular focus on task interdependence left an important factor—goal interdependence—understudied. It assumed that issues concerning agents' *alignment of interests* had been resolved via the same mechanisms

used to address *alignment of actions*, in connection with task interdependence. The idea of grouping workers together into business units based on functions, markets, geographies, or customers presumes that the reward structure among workers *within* a unit is congruent (e.g., Galbraith, 1973; Gulick & Urwick, 1937; Thompson, 1967). One effect of such a reward structure is to create goal interdependence among workers within the unit. The notion that an organization chart's boxes are stronger than the linkages that connect them follows directly from this assumption; that is, workers' goal interdependence, which results from incentive design, reflects grouping choices and reporting lines. The resulting alignment is strongest within business units and weaker across units.

In turn, studies of reorganization have implicitly captured goal interdependence by studying situations in which the bases for both task and goal interdependence change or are at stake (e.g., Gulati & Puranam, 2009; Jacobides, 2007; Karim 2006; Nickerson & Zenger, 2002; Raveendran, 2020). For example, in his study of companies that reorganize around a new goal (customer centricity), Gulati (2007, 2010) showed that managers enhanced collaboration *across* subunits by breaking or bridging extant task-based siloes inside organizations. Because these siloes induced employees to act according to antiquated structures and incentives, they limited their ability to work towards the organization's new goal. Managers ultimately enhanced collaboration by simultaneously pursuing two distinct interventions, altering the mechanisms that foster coordination (to manage task interdependence) and cooperation (to manage goal interdependence) (also see Fjeldstad, Snow, Miles, & Lettl, 2012; Gulati, Wohlgezogen, & Zhelyazkov, 2012).

Another way in which prior research has captured goal interdependence implicitly is seen in discussions of the inducements/contributions contract. Early research assumed that the

employment contract stipulated the conditions under which (1) an individual is willing to participate in the organization and (2) the organization would choose to include that agent (e.g., Barnard, 1938; March & Simon, 1958; Simon, 1945). This contract, however, set limits on individual behavior and therefore increased workforce homogeneity (Gouldner, 1957; Weber, 1946). It also imposed a degree of goal interdependence between the individual and the organization through the widely assumed alignment of incentives and agreement on certain behaviors. This said, the classic approach proceeded as if goal interdependence had been aligned with task interdependence. As a result, goal interdependence received little attention as a construct.

Later work on the microfoundations of organization design has underscored the need to examine goal interdependence as an element of organizational design (e.g., Puranam et al., 2014). However, more research is required to understand how the joint manipulation of task and goal interdependence affects performance. In the meantime, valuable insights can be gained from studies at the group and individual levels, which we discuss next.

Goal Interdependence as Reward Structure

We can refine our understanding of goal interdependence by referring to the literatures on teams and job design. These streams feature extensive research on how goal interdependence can be manipulated to align interests and how it interacts with task interdependence to affect group performance. A common thread in these research streams follows the goal-setting literature (Locke & Latham, 1990) and interprets goals as a tool for aligning individuals' interests. This literature focuses on the performance implications of individual- versus group-level goals (see also Campion, Medsker, & Higgs, 1993; Campion, Papper, & Medsker, 1996; Shaw, Duffy, & Stark, 2000; Van der Vegt et al., 2000) and views goal (or outcome) interdependence as the level

at which the completion of a task or goal was measured and rewarded (Hertel, Konradt, & Orlikowski, 2004; Wageman & Gordon, 2005; Wageman & Baker, 1997). Shaw et al. (2000) studied how task and reward interdependence, as well as preferences for group work, affect individual-level satisfaction and performance. Similarly, Campion and colleagues (1993, 1996) examined goal interdependence as a separate factor influencing group effectiveness.

Goal interdependence from this perspective is, in effect, viewed as a design tool that directs individuals' efforts toward their own actions or their group's work. Here, goal interdependence (set either at individual or group level) can be low or high, but hybrid designs (which set individual and group goals simultaneously) are also feasible. Research has established that the *design* of goal interdependence significantly affects performance and motivation (Cleavenger, Gardner, & Mhatre, 2007; Fuller, Marler, & Hester, 2006; Kiggundu, 1981; van der Vegt et al., 1998).

The interplay between task and goal interdependence is of particular interest to scholars who study teams (e.g., Barua, Lee, & Whinston, 1995; Goldman, Stockbauer, & McAuliffe, 1977; Harrison & Humphrey, 2010; Miller & Hamblin, 1963; Rosenbaum et al., 1980). For example, Wageman conducted a series of studies on the interactions between task and goal interdependence. In her field study of Xerox maintenance and repair teams, Wageman (1995) found that interdependent *task* design is followed by more cooperative, learning, and helping behaviors. In contrast, the manipulation of high or low *goal* interdependence influenced team members' motivation but had no (independent) effect on cooperative behavior. In this study, Wageman also found that the congruence between task and outcome interdependence is important for group performance (see also Wageman & Baker, 1997). This idea of congruence suggests that optimal performance depends on pairing team-level task interdependence with

team-level goal interdependence (Saavedra, Earley, & Dyne, 1993). Following further studies, however, Wageman (2001: 205) suggested that "the argument that tasks and outcomes must be congruent is too simple" and acknowledged conclusive evidence for only two claims: (1) hybrid designs tend to perform poorly and (2) high task interdependence among group members requires high goal interdependence to yield favorable group performance.

These insights have useful implications for our study of organization design. First, they show that certain design choices may reinforce each other, whereas others may have detrimental interactions. Second, they highlight the need for manipulating goal *and* task interdependence in order to optimize performance. Third, they suggest that the relationship between goal and task interdependence is not a simple one and therefore requires deeper theorizing and further empirical enquiry. As Dosi et al. (2003: 433) argued, "[t]he problem of specifying task decomposition intimately relates to the problem of incentives and to issues of power." Hence, studying these constructs separately ignores important interactions that will affect any conclusions drawn regarding effective organization design.

Goal Interdependence in the Contemporary Context of Organization Design

Our review of the team and job design literatures demonstrates that goal interdependence can be manipulated by rewards or incentive structures to affect the motivation, behavior, and task performance of individual workers. It follows that manipulating goal interdependence could serve as a design tool for aligning workers' interests even in the absence of interdependent tasks. This property will prove to be valuable in work environments characterized by task structures that are poorly defined and agents who are actively involved in the design process. Here, goal interdependence is a reliable mechanism for aligning interests so that agents are motivated to engage in the joint processes of defining and managing task division and allocation.

Several theory papers have explored the importance of bringing goal interdependence into the study of organization design. For example, Puranam et al. (2012) argued that the presumed link between greater task interdependence and more complex coordination mechanisms is too simplistic. According to these authors, coordination mechanisms should not be needed unless agents must exchange information. Yet task interdependence is not a sufficient condition for this need to arise. Hence, Puranam and colleagues decoupled task interdependence from the need to coordinate and showed that coordination is necessary only if agents are goal interdependent *and* must act before observing the other agent's actions. These conditions can be met in the presence *or* absence of task interdependence. It follows then that (1) task interdependence is not the only crucial aspect of organization design and (2) goal interdependence plays a leading role in determining whether agent interdependence becomes stronger or weaker.

In studies of self-organizing teams and organizations, we see that goals are intentionally designed to facilitate cooperation among workers. Rather than merely following some preconceived reporting lines, goal interdependence is manipulated to enable the necessary interactions to create effective task division and facilitate (self-)allocation. It is interesting that goal interdependence is created deliberately to *generate* coordination needs. This practice stands in stark contrast to the classic focus of organization design, which aimed to minimize task interdependence to *avoid* the need for coordination. In particular, Puranam et al. (2014) suggested that our understanding of the division of labor (i.e., task division and task allocation) be complemented by carefully studying the factors that allow for the successful integration of efforts; namely, reward structures (e.g., the manipulation of goal interdependence) and providing information. Cooperation cannot be generated absent the effective manipulation of goal

interdependence, and coordination requires that there be viable systems of information sharing and processing. The organization design literature has examined coordination in the context of task interdependence. Cooperation, however, with its focus on incentives and conflicts of interest, has by and large been left to other literatures (see e.g., Grossman & Hart, 1986; Holmstrom & Tirole, 1989; Laffont & Tirole, 1993).

Even so, many solutions to the organization design problem exhibit strong complementarities (Milgrom & Roberts, 1990, 1995; Puranam et al., 2014). For example, the organization derives more value from allowing agents to self-select their tasks when there is greater task transparency and when observability enables the broader provision of knowledge. These complementarities imply that the *joint* study of rewards, information provision, and the division of labor (i.e., goal, knowledge, and task interdependence) is a necessary step toward truly understanding the organization design process as experienced by today's organizations; indeed, a type of study that would echo efforts in research conducted at the group level.

Summary: From Simplified Separation to Necessary Integration of Goal Interdependence

As we have highlighted previously, research on organization design would benefit from the joint study of task and goal interdependence and their interactions. The need for such an approach reflects the possibility of significant complementarities in manipulating task and goal interdependence, a notion that is mirrored in the congruence hypothesis that other literatures have advanced. Theory papers have likewise hinted at the complexity of interactions between these two types of interdependence (Dosi et al., 2003; Puranam & Raveendran, 2013). If a clear task division is neither given nor feasible, then a commonly shared goal can allow agents to select appropriate actions that ultimately generate the desired outcome. In these circumstances, then, cooperation can actually precede the need for coordination.

Overall, a rich literature exists on goal (outcome and reward) interdependence in the organization behavior literature, research that vastly increases our understanding of goal interdependence and advances research on its implications for the organization design process. Focusing in particular on the interactions between task and goal interdependence, the organization design literature will be in a better position to make sense of a design process that (1) must manage with less *ex ante* information about the underlying task structure (which prevents formal organization design before work is performed) and (2) features greater agent involvement in the design process. We now turn to the final aspect of an organization's workflow—what agents know, that is, knowledge interdependence—and assess how prominently it might augment an expanded conceptualization of interdependence.

KNOWLEDGE INTERDEPENDENCE

Although knowledge is a fundamental component of organizations (Birkinshaw, Nobel, & Ridderstråle, 2002; Kogut & Zander, 1996; Nickerson & Zenger, 2002; Tsoukas, 1996), we know little about how knowledge interdependence arises or how it shapes the organization design process.

In classic studies, agents' knowledge is strongly associated with three job-related elements: (1) the skills noted in the job description, (2) the job's functional specialization, and (3) the job's position in the organization's hierarchy. These elements have an intimate connection with the tasks that formal roles entail. As a result, knowledge interdependence tends to follow the literature's dominant construct, that is, task interdependence, in the sense that task division and allocation are what determine "who knows what" across the organization. Since task interdependence was assumed to be exogenously given, the literature's approach to knowledge interdependence was equally deterministic.

However, as the degree to which managers understand the nature of work before it is performed *declines*, individual workers and units assume a more central and active role in organization design. Greater uncertainty in the tasks to be performed, combined with a lack of clarity regarding who shall perform them, creates a context in which task interdependence (derived from the organization's formal structure) provides an imperfect blueprint for determining how, when, and to what extent agents should interact. Under modern day conditions, the result is that knowledge interdependence is only loosely connected to managers' perceived task interdependence. Instead, knowledge creates the conditions for worker-driven task interdependence to *follow* from knowledge interdependence, so that both are endogenous to the design process.

When tasks are not well understood, job descriptions are broad and incomplete. Therefore, agents' actual behavior often deviates from what is established on paper. These circumstances lead agents to develop knowledge and skills beyond those connected to their formally assigned tasks, to adopt informal roles that exceed their formal job descriptions, and to occupy informal positions in the hierarchy that differ from the position their formal responsibilities indicate. Hence, interactions are driven primarily by what agents know, by the fluid roles they play, and by their own understanding of "who may contribute what" to the emergent system in which they work. For these reasons, agents' knowledge is rightfully viewed as a separate factor and input into the organization design process, aiding the division of labor in ways that task interdependence, in this context, cannot.

Our review of the literature yielded insights into three distinct knowledge-based forms of interdependence: *knowledge interdependence* itself (based on the knowledge, skills, and capabilities agents possess); *role interdependence* (based on agents' formal and informal roles);

and *epistemic interdependence* (based on their understanding of the organization's formal and informal structure and their ability to predict what other agents may contribute to the overall effort). Each of these knowledge-based forms of interdependence adds nuances and complexities to our study of the organization design process. In particular, knowledge interdependence emphasizes agents' ability to develop skills beyond those required to perform their formal jobs; role interdependence speaks to agents' ability to craft idiosyncratic roles for themselves; and epistemic interdependence captures agents' perceptions of the emergent system in which they are embedded.

In this section, we discuss each type of knowledge-based interdependence. The classic organization design literature has paid scant attention to these knowledge-based forms of interdependence, yet more recently scholars have started to incorporate knowledge-based insights into their studies. These efforts indicate the need for deeper theorizing about, and a richer understanding of, knowledge, role, and epistemic interdependence, so that they can be more clearly positioned within the organization design process. Here, we synthesize scholarly contributions from both classic and contemporary studies in a broad set of literatures. This approach is intended to yield clear definitions that may serve as the starting point for a more thorough study of the microfoundations of organization design. As we point to the relative paucity of organization design theorizing about these constructs, we pose questions to guide future research.

Defining Knowledge Interdependence

Our review of the existing literature on knowledge interdependence in organization design establishes the need for more theorizing and exploration of this core construct. Although scholars who study emergent organizing have made some headway in describing how knowledge

independence contributes to the design process, the literature lags in establishing a solid theoretical basis on which to build new insights. Definitions of knowledge interdependence do not abound, but enough variation exists to warrant a brief discussion. We shall therefore start by reviewing the extant definitions in organization design and adjacent literatures and then synthesize the results to propose a working definition on which to build future work.

The few existing definitions of knowledge interdependence can be divided into two sets. The first set views knowledge as a distinct entity or static property of organizations. This view results in knowledge interdependence being defined from a systems theory perspective (Kauffman, 1993; Simon, 1962) as *the intensity of the interactions between the subcomponents of a piece of knowledge*. According to Sorenson, Rivkin, and Fleming (2006: 995), for example,

> …interdependence arises when a subcomponent significantly affects the contribution of one or more other subcomponents to the functionality of a piece of knowledge. When subcomponents are interdependent, a change in one may require the adjustment, inclusion or replacement of others for a piece of knowledge to remain effective.

The emphasis here is on the *structure* of knowledge, which the authors demonstrate is related to how easily knowledge can be shared and used across the organization.

In contrast, definitions in the second set suggest that knowledge resides in and is enacted by the agents who constitute the organization (for a detailed analysis, see Orlikowski, 2002). This perspective considers that knowledge interdependence stems from complementarities among knowledgeable agents. The most comprehensive definition among these is provided by Pennings (1975), who linked knowledge interdependence with agent specialization. He noted that, from a knowledge perspective, specialization differentiates agents because of their varied training, expertise, and/or experience. Specialization generates “complementarity”, which “is vested in individuals” given that workers possess “different skills or knowledge” regardless of the organizational roles they perform or the tasks to which they have been assigned

(Pennings,1975: 827-828). The emphasis here is on knowledge as a differentiating factor among agents and on the complementarities that may arise between them by virtue of the knowledge they hold.

Both sets of definitions are useful in their specific contexts, but each one has shortcomings for the study of knowledge interdependence in organization design and its microfoundations. The first set emphasizes the complexity of knowledge while assuming that, for knowledge to remain effective, it must be transferred and recombined to produce novel outcomes. This set of definitions, however, reduces the problem of knowledge transfer and recombination to characteristics of the knowledge itself, thus losing sight of the social system within which that knowledge is embedded. The second set emphasizes the role of agents as holders of knowledge but does not adequately explain how or why knowledge can be transferred and recombined. Simply put, definitions in the second set fail to reflect the generative potential inherent to the concept of knowledge interdependence. Neither approach disputes that knowledge interdependence is rooted in specialization; however, we believe that a complete definition of the construct must also reference the value that agents derive from combining the knowledge that makes them interdependent in the first place. In other words, knowledge interdependence is a powerful construct because it points to differences in agents' knowledge and skills and because it reveals what may be achieved when agents combine their knowledge.

Our definition of knowledge interdependence integrates insights from both camps: *two agents are knowledge interdependent if the value they could generate from combining their knowledge differs from the value they could obtain from applying their knowledge separately.* This definition has several advantages: (1) it can be applied to different sources and types of knowledge, such as access to specialized information, skills, or capabilities; (2) it applies equally

well to knowledge agents hold at all levels of analysis (individuals, groups, knowledge held in transactive memory systems, organizational knowledge); (3) it can be used to assess the presence of knowledge interdependence in a steady state and explain the process by which knowledge interdependence may arise; and (4) it clarifies that knowledge interdependence connects two agents who hold the knowledge, not two pieces of knowledge independently of who activates it (such as accessing an instruction manual). This last characteristic is a key issue in a world where organizing is increasingly agent-driven. Finally, this definition is broad yet specific enough to be used easily in an empirical context, because "value" can be operationalized in several ways and need not be binary. The quality of knowledge combination or integration can vary substantially: it depends on the effort exerted, the degree of understanding between knowledge-interdependent agents, and the complexity of the knowledge being combined or integrated.

This working definition provides a steppingstone to study how knowledge interdependence arises in organizations and how it drives the organization design process. Despite knowledge interdependence being relatively understudied, we outline its place in classic and contemporary organization design by reviewing the research in this field and adjacent literatures. We next synthesize their respective views of knowledge interdependence so that additional theorizing about this construct can proceed on a solid foundation.

Knowledge Interdependence in the Classic Context of Organization Design

In the classic organization design literature, the relative lack of research on knowledge interdependence is not surprising. When the nature of work and the underlying task structure are well understood, a close link exists between knowledge interdependence and task interdependence; because the nature of the work is clear, the organization's workflows are predictable. In this environment, task decomposition and task allocation are relatively

straightforward endeavors that generate subtasks linked by task interdependence. Here, specialized knowledge is simply a prerequisite for performing the tasks assigned to each agent. Thus, knowledge becomes almost an afterthought because the task-performing agents are assumed to have the necessary knowledge (e.g., Galbraith, 1977; Perrow, 1967, 1986).

At the same time, it is assumed that agents will perform their functions or tasks exactly as outlined in their job descriptions (Hackman & Oldham, 1980). Hence, any deviation from formally assigned work is viewed as agents' efforts to correct the job's dysfunctional elements or to overcome productivity barriers (Frese, Kring, Soose, & Zempel, 1996; Staw & Boettger, 1990). Managers are expected to intervene quickly and redesign the job to restore congruence between job design and agent behavior (Campion & McClelland, 1993; Hackman & Oldham, 1980). However, the presumably needed congruence between tasks and requisite knowledge does not leave much room for generating knowledge beyond the job's formal skill requirements. Consequently, agents have little opportunity to establish interactions in which knowledge interdependence would deviate from the blueprint proposed by task interdependence.

Knowledge Interdependence in the Contemporary Context of Organization Design

The *ex ante* division and allocation of tasks is challenging when the task environment features dynamic work streams that make the nature of work less predictable. In this case, agents must be directly involved in the work if they are to develop a true understanding of its nature and of how best to organize it. The result is a flowing "structure as process" in which agents interact to make sense of the work, collaborate, and negotiate as they infer their place in the organization and their role in the workflow (Freidson, 1976; Raveendran et al., 2016; Strauss, 1985; Weick, 1977).

Instead of observing agents interact according to a preestablished organization chart, we now see a broader set of agents—not limited to managers—interacting to define what needs to be

done, at what time, and by whom. In this context, agents' idiosyncratic knowledge becomes a touchstone by which knowledge interdependence *precedes* task interdependence. This dynamic is evident in various studies on organization design processes. Although most studies do not speak explicitly of knowledge interdependence, the phenomena they describe strongly suggests that agents' knowledge plays an important role in shaping the way work is approached and structured in contemporary organizations.

At the organization level, for example, Mintzberg (1979: 432) posited that *adhocracies* (structures built for innovation rather than execution) "fuse experts drawn from different disciplines into smoothly functioning ad hoc project teams." Because the nature of the work is novel rather than routine, adhocracies exhibit three characteristics: (1) an organic structure with little formalization, (2) knowledge-based job specialization coupled with minimal role clarity, and (3) a reliance on mutual adjustment for coordination within and across project teams. It is difficult to demarcate *roles* precisely in these settings, but agents' *expertise* in different fields tends to be clearer. Hence, Mintzberg (1979: 435) argued that coordination "must be effected by those with the knowledge" and that such coordination among knowledge-interdependent agents enables adhocracies to produce innovative outcomes.

Stark (2011) made a similar argument in his description of *heterarchies*, which he defined as systems of "distributed intelligence" (p. 19) or "distributed cognition" (p. 132). Heterarchies rely on integrating knowledge across heterogeneous domains. Where these domains intersect, agents encounter ambiguity: a state in which conditions may be interpreted in different ways and be valued differently by different people. Interpretative disagreements create friction that the heterarchy leverages in constructive ways to produce innovative outcomes—a process that relies also, when defining and organizing the work, on agents' knowledge interdependence.

In his ethnography of a Wall Street firm, Stark (2011: 132) observed that a trader who devises new trading patterns will likely run them by peers with complementary knowledge: "An idea is given form by trying it out, testing it on others, talking about it with the 'math guys'…and discussing its technical intricacies with the programmers." Those math guys and programmers are typically in the same room as the traders in order to facilitate such knowledge-based exchanges. As such, the workflow design assumes and encourages knowledge interdependence.

Arguments similar to those just described have been made regarding how agents interact in other knowledge-intensive forms of organizing (Alvesson, 1993; Foss, 2003; Krackhardt & Hanson, 1998; Nonaka & Takeuchi, 1995; Starbuck, 1992). These studies show how critical knowledge interdependence becomes in settings in which a clear division and allocation of tasks is not given *ex ante*. Here, organizations function and create value mostly by relying on their agents' idiosyncratic knowledge (and alignment of interests around common goals) to negotiate the tasks and coordinate their efforts to produce an effective division of labor.

The insights from organization-level studies have counterparts in unit-level studies. In the latter, research reinforces the generative nature of knowledge interdependence (i.e., the ability of organizations to obtain novel outcomes from combining knowledge held by different agents). They also note the fact that knowledge interdependence need not be congruent with task interdependence, as most classic studies would suggest. In a study of product development teams at Nissan, for example, Leonard-Barton (1992, 1995) noted the prominent role knowledge interdependence played in guiding interactions among agents at unit intersections, which are rife with ambiguity. She defined the capabilities essential for product development as "an interrelated, interdependent knowledge system" (1992: 114) in which knowledge is embodied in individual employees and embedded in technical systems. Leonard-Barton's (1995: 63) concept

of "creative abrasion" suggests that the energy created by contrasting ideas, mindsets, and skills can be channeled in positive ways to produce novel outcomes. She remarked that managers might deliberately select workers with divergent knowledge in order to activate knowledge interdependence at unit intersections and thereby foster creative abrasion. These findings document just how useful a design tool the manipulation of knowledge interdependence can be in such ill-defined contexts. If the task-related expertise requirements are not known *ex ante*, then team composition and agents' idiosyncratic knowledge are the factors most predictive of organization performance.

As these and many related studies show (e.g., Adler, 1995; Gray, Siemsen, & Vasudeva, 2015; Kleinbaum & Tushman, 2007; Silvestri, 2019), organization design scholars recognize that knowledge interdependence affects the organization design process in cases in which tasks are poorly understood or not well defined. Yet knowledge interdependence has largely been taken for granted, and research has instead flourished in the related areas of transferring, integrating, and recombining knowledge (e.g., Argote & Ingram, 2000; Carlile, 2002, 2004; Hansen, Mors, & Lovas, 2005; Okhuysen & Eisenhardt, 2002). However, insights from the literatures on emergent organizing suggest that knowledge interdependence is important enough to drive critical outcomes in organizations. By supporting the organization and coordination of knowledge-based work, knowledge interdependence affects how well the organization can mobilize and use knowledge in productive ways. Of course, such mobilization of knowledge seldom occurs in isolation; more often, it is linked to agents' formal and informal roles and to their understanding of "who knows what" across the organization. To explore these latter aspects in more detail, we wrap up this part of the review by discussing role and epistemic interdependence.

Role Interdependence

Roles are inherent to organizational life. A *role* is an expected pattern or set of behaviors associated with a given position in a social system (Ashforth, 2000; Biddle, 1979; Ebaugh, 1988). Organizations are "systems of roles" (Katz & Kahn, 1966: 187; see also Cheng, 1983) in which each member is socialized into a particular role. Expectations about a role's behaviors may be based on norms the organization sets or on the beliefs or preferences the role's occupant and associates hold, including managers and peers (Fondas & Stewart, 1994). Individuals learn the expectations of a role through their experience performing it (Biddle, 1986; Davis & Taylor, 1979; Ilgen & Hollenbeck, 1991;). Role *interdependence*, then, involves the expectations related to inter-role interaction and collaboration.

In a classic work context, the task structure is well understood before the work is performed; the social system in which roles are embedded is the organization's formal structure; the roles agents play mirror their respective formal jobs; and the expectations underlying each role are based on norms. When viewed as formal jobs, roles reflect the functional specialization of the organization's members and entail expectations concerning certain knowledge requirements and certain tasks to be performed. Roles are linked to the norms that govern them (Bates and Harvey, 1975), regardless of who occupies them, and are therefore "divorced from the personalities of role incumbents" (Katz and Kahn, 1966: 43-45).

Indeed, in these structured work contexts, roles exist independently of and prior to the individuals who perform them (Baron, 1984; Ilgen & Hollenbeck, 1991; Mooney & Reiley, 1937; Weber, 1946). Role occupants are nearly interchangeable, provided they maintain satisfactory performance (Scott, 1981). Role interdependence is captured by the notion of a "role set" (Merton, 1957: 110), which contains the neighboring role players with whom the focal role's

incumbent must work closely. These neighbors include the incumbent's direct supervisor and subordinates, as well as members of other units. All the members of an individual's role set have a stake in that person's performance and affect it through their own behavior and decisions (Katz & Kahn, 1966). The degree of interdependence a role set exhibits depends on technical and functional factors, such as the organization's workflow and technology (e.g., Trist & Bamforth, 1951; Turner & Lawrence, 1965) and social factors such as the role's position in the hierarchy (Katz & Kahn, 1966).

In contrast, if the nature of work is ill-defined, workers' roles tend to exceed the responsibilities specified in their formal job descriptions. Here, the work carried out combines elements from those job descriptions with self-created, negotiated elements. Among the latter are self-generated tasks that reflect proactive behavior (Crant, 2000; Grant & Ashford, 2008; Wrzesniewski & Dutton, 2001), as well as tasks "thrust upon the role occupant by other people in the social network" (Ilgen & Hollenbeck, 1991: 174). In addition, the knowledge, capabilities, and skills acquired while working *outside* a formal role's boundaries expand that role's effective domain (Berg et al., 2010; Leana, Appelbaum, & Shevchuk, 2009).

Silvestri's (2019) study of a unit's self-driven evolution over seven years at a social media company sheds light on these dynamics. The focal unit in her study was formally created to carry out a simple set of tasks and to interface with a small number of other agents. All members of the unit shared the same formal role, but derived little meaning and satisfaction from it. Motivated by the desire to contribute more to the organization, they moved proactively to identify and seize opportunities to make an impact. Members developed unique knowledge and took on novel tasks in such a way that, individually, each created their own idiosyncratic role within the unit, enhancing the boundaries of their formal job in different yet complementary

ways. Taken together, their efforts collectively expanded the unit's informal domain and transformed it into one of the most interconnected groups at the company. Internally, members were bound to one another by role-, knowledge-, and task-based interdependencies that reflected the altered or 'crafted' nature of their work. In turn, the unit as a whole shared new role-, knowledge-, and task-based interdependencies with other units, based on a reimagined group-level identity.

When individuals expand their roles, the expectations associated with their repertoire of behaviors reflect a blend of the formal job's norms and the unique beliefs and preferences of that job's occupant (Bell & Staw, 1989; Morgeson & Humphrey, 2008). As a result, the role becomes inseparable from the individual who performs it: it is subjective, idiosyncratic, created while being enacted, and may change from day to day (Miner, 1987). Under these circumstances, role interdependence retains a functional or technical flavor and is still closely tied to interactions between roles due to technology and the workflow's overall design. Nonetheless, we see evidence that the role's knowledge component takes a more prominent place alongside the task component, with knowledge often determining which tasks agents will undertake as part of their roles (Berg et al., 2010; Silvestri, 2019).

For example, Barley (1986) examined the changes in responsibility between radiologists and technicians that were brought on by the introduction of CT scanners. The new technology created occasions to redefine interactions among members of these two occupations according to their respective knowledge. With the old technology, technicians traditionally waited to receive instructions from radiologists; conversely, with the new technology in place, technicians acted proactively and did not validate their initiatives with radiologists until after the fact. Inexperienced radiologists tended to accept technicians' proactive behavior without resistance

because there was no other way for them to learn how the new machines worked. Thus, changes in knowledge interdependence led to changes in role interdependence and likewise supported changes in the work's underlying task division, task interdependence, and in the organization's social structure.

This contrast in how a role is imagined and enacted in contexts where the nature of work is well understood versus ill-defined has significant implications for organization design. When the nature of work is well understood, roles and their interdependencies closely map the task structure that results from the division of labor. Much like task and knowledge interdependence, role interdependence is viewed as stemming from the characteristics of the organization's workflow, from the technology on which it relies, and from the lines of authority that bind the role to others in the hierarchy (Katz & Kahn, 1966). When the nature of work is ill-defined, however, the role becomes inextricably entangled with its occupant and takes on a different shape when occupied by another. Thus, role interdependence no longer reflects pre-existing links among formal roles but rather an emergent web of complementarities among informal, idiosyncratic roles (Silvestri, 2019).

The implications of role interdependence for the organization design process—and for its interactions with task, goal, and knowledge interdependence—have been broached in the literature (see Murnighan & Conlon, 1991 and Valentine & Edmondson, 2015 for illustrative examples) but have not been studied in depth. Our review of role interdependence across literatures uncovered some interesting results. In both classic and contemporary contexts, roles (formal or informal) revolve around task and knowledge requirements; moreover, their performance depends on the expectations that arise from job design and from ongoing interactions with agents who hold other roles. Three paramount factors that underlie role

interdependence are the characteristics of work, the technology employed, and the organization's hierarchy when understood as an evolving social system. We have shown how roles and role interdependence arise and are shaped in different ways depending on these three factors. This said, these constructs share a common ground that serves as a useful starting point from which to develop an integrated definition.

In this spirit, we propose that *two roles are interdependent if the value generated from performing each differs when the other role is performed as expected than when it is not.* As agent-driven roles become more prevalent in organizations, we hope this definition serves to propel studies that (1) examine agents' goals and motivations for altering their current roles or furnishing novel ones; (2) explore agents' efforts in negotiating and legitimizing emergent roles or; (3) analyze how these roles affect the structure of agents' respective units and of organizations at large. In its close connection with knowledge, role interdependence encompasses a particular combination of task and knowledge interdependence in both classic and contemporary settings. The main differences are found in the formality of the roles and in the type of knowledge (required vs. self-driven) that each setting entails.

To finalize our discussion of knowledge interdependence, we briefly review the concept of *epistemic* interdependence. This concept relates a role's occupant to that individual's place in the organization as a social system. We will see that this type of interdependence is a natural consequence of a clearly defined organization structure in the classic context. Yet the situation is more complicated in contemporary settings, in which a role's position in the enacted structure may evolve according to its occupant's behavior.

Epistemic Interdependence

Although epistemic interdependence is a relatively new construct, we believe it could usefully connect the classic and contemporary contexts of organization design and open up promising research avenues for the study of its microfoundations. Defined by Puranam et al. (2012) in their study of task interdependence and coordination mechanisms, two agents are linked by *epistemic interdependence when agent A's optimal action depends on a prediction of agent B's behavior and vice versa* (see also Camerer, 2003; von Neumann & Morgenstern, 1944). In the presence of epistemic interdependence, agents require *predictive knowledge* of one another's behavior in order to work together effectively.

In settings where the nature of the work is well understood, designers may configure the system's architecture to minimize the need for predictive knowledge between agents. For example, a designer can create independent modules that group highly interdependent agents (Baldwin & Clark, 2000). In this case, agents in module 1 may operate with complete disregard to the behavior of agents in module 2. Because their modules are independent, the agents in module 1 do not need predictive knowledge of what the module 2 agents will do. Indeed, they only require predictive knowledge of their module 1 peers' actions.

One way to build such predictive knowledge within module 1 is by encouraging the development of transactive memory systems (or TMS) (Hollingshead, 1998; Mell, van Knippenberg, & Ginkel, 2014; Ren & Argote, 2011; Wegner, 1987; Wegner, Giuliano & Hertel, 1985). For example, groups that develop a TMS are better equipped to translate their learned skills into their work setting (Liang, Moreland & Argote, 1995) and are more effective in carrying out multifaceted, dynamic, and highly interdependent tasks (Zajac, Gregory, Bedwell, Kramer, & Salas, 2013). Hollingshead (2001) showed that both knowledge *and* goal

interdependence are necessary for the successful creation of such a system. In particular, different group members need to have their own area of relative expertise, *and* the group needs to face high goal interdependence to create a differentiated TMS, that is, a system in which each member holds unique knowledge (see also Shiflett, 1973 on knowledge redundancy).

When grouping highly interdependent agents into modules is neither feasible nor practical, facilitating the creation of predictive knowledge between epistemically interdependent agents effectively ensures that the organization's tasks and roles are configured as transparently as possible. In this way, agents would enjoy what Thompson (1967) termed *domain consensus*: a situation in which the organization's overall goals are clear, the task at hand is well understood, and an organization's members have an unambiguous sense of their roles. In other words, all agents are aware of their respective purposes in the system and have predictive knowledge about those agents, even if they cannot observe them directly. In these settings, therefore, epistemic interdependence results directly from the transparent division of labor and is consistent with task, knowledge, and role interdependence.

In settings characterized by dynamic work streams, where the work's nature is less predictable, domain consensus becomes impermanent. Indeed, it is negotiated actively among members of the organization as they make sense of new tasks, generate and apply skills to tackle them, and create new roles for themselves. In these settings, epistemic interdependence reflects an agent's need to predict others' behavior in terms of the contributions they *might* (as opposed to *will*) make to the collective effort. This distinction is captured by the relative certainty of predictive knowledge in the design structure matrix used to model this construct in Puranam et al. (2012). Agents' sense of emergent knowledge, role, and task interdependence aids epistemic interdependence to the extent that it helps agents understand "who's who," "who knows what,"

and "who may do what" within the organization's incipient structure. In concert with task, knowledge, and role interdependence, epistemic interdependence can help structure the interactions that underlie agent-driven design processes.

Studies of emergent organizing have implicitly acknowledged the presence of epistemic interdependence. For example, Orlikowski (2002) referred to "knowing" as a *collective* capability, shared by organizational units, that provides the basis for interactions among them, and thereby facilitates organizing. In her study of global product development teams at a large software company, Orlikowski (2002) described knowing in terms of several dimensions that jointly amount to gaining predictive knowledge of the organization as an evolving system. Hatch's (1999) interpretation of organizing as an improvisational jazz performance suggests that epistemic interdependence facilitates players' anticipation of how the "melody" will evolve through others' actions, while also helping them craft their own contributions. The author described players "feeling" the structure as it is constructed through action (see also Murnighan & Conlon, 1991).

Still, much remains to be learned about how epistemic interdependence operates in settings in which the task structure is not clear cut. The purpose of our brief introduction is to connect this organization design construct to studies of emergent organizing and to highlight the usefulness of facilitating the generation of predictive knowledge as a design tool. By encouraging research in this area, the field will be better positioned to understand the place of epistemic interdependence in the broad context of organization design and, at a more fine-grained level, in the microfoundations of that design process.

Knowledge Interdependence: From Task-Determined to Independent Expertise

Taken together, the three knowledge-based forms of interdependence we have reviewed (knowledge interdependence per se, role interdependence, and epistemic interdependence) point to different ways in which knowledge may influence the organization design process. Although the potential of these types of interdependence has been downplayed in classic studies of organization design, contemporary studies are revealing interesting research avenues on all three fronts. The extant literature contains some intuition about how knowledge interdependence operates; however, more research is required to understand how it arises and how it shapes agent interactions. Specifically, we need to explore under what circumstances agents feel empowered to develop and apply idiosyncratic knowledge, and what effects this may have on their ability to intervene in the organization design process. How do agents identify and capture opportunities to generate idiosyncratic knowledge at work? How do they signal knowledge that goes beyond the formal job requirements to the rest of the organization? How do they self-select into processes of sensemaking, task definition, and task allocation based on their unique knowledge? What effect do knowledge-based interactions of this nature have on the formation of emergent structures? And how can an organization designer influence these processes?

When it comes to role interdependence, the job crafting literature has laid the groundwork for understanding what motivates agents to create informal roles for themselves, but more research is needed to explore how role interdependence takes shape and affects agents' interactions and jurisdictions over time. Analyzing how informal roles create emergent structures and webs of complementarity among agents could be a fruitful research avenue for scholars interested in exploring the microfoundations of organization design from a roles perspective. Concretely, how do agents approach the creation of informal roles? To what extent is this

process opportunistic versus planned? How do agents discover interconnections among their roles, when they are not mapped on the organization's formal structure? If jurisdictional disputes among agents with overlapping roles arise, how are they addressed and resolved? And what implications does the coexistence of formal jobs and informal roles bring to organization design?

Finally, regarding epistemic interdependence, the fact that organizations are increasingly codesigned from the bottom up highlights how crucial it is for agents to understand the system as it is being shaped through their actions and interactions. However, we know little about how epistemic interdependence arises in contemporary settings and how it supports agents' behavior. For organization design scholars, epistemic interdependence opens the door to interesting research questions dealing with cognitive aspects of design—a still understudied aspect of the design process. What are the cognitive challenges of "knowing" a structure that contains an increasing number of fluid or impermanent components? How do agents understand themselves, who they are and what they are expected to do, as they, in turn, seek to understand others? How does epistemic interdependence support coordination and cooperation among agents? And how does epistemic interdependence aid the continuous emergence of structure?

DISCUSSION: RECASTING THE ROLE OF INTERDEPENDENCE IN THE ORGANIZATION DESIGN PROCESS

Our review of interdependence in organization design and related literatures has revealed some areas of deep insight and several opportunities for future research. Much of our knowledge about interdependence was developed when managers understood the organization's work stream well enough to design its structure before work was performed. That setting led organization design studies to focus on task interdependence while relegating goal and knowledge interdependence to the background. Yet as organizations face increasingly dynamic and unpredictable work streams

and agents intervene in the organization of work as co-designers, all three types of interdependence are moving to the foreground. By examining task, goal, and knowledge interdependence on equal footing, this review seeks to expand our research toolkit so that we are better equipped to understand and assess organization design in contemporary settings and to explore its microfoundations. Table 4 synthesizes our insights.

[[INSERT **TABLE 4** ABOUT HERE]]

This review seeks to make three contributions. First, this study offers a refined understanding of task interdependence. In close to a century of work, the organization design literature has generated deep knowledge on this construct. However, classic studies portray task interdependence as exogenously given, determined by inescapable task and technology characteristics. This view creates restrictions in a world where the nature of the work is unclear, and technology can be configured in multiple ways. To expand our understanding of task interdependence beyond what is exogenously given, our review draws on related streams of research that explore managers' and workers' ability to manipulate interdependence between tasks. These studies evidence the malleable nature of today's task structures, as well as the importance of directionality in task-dependent interactions. Informing the manager's perspective, organization design scholars have borrowed design structure matrices from the modularity literature to examine how task interdependence can be manipulated to different ends. Informing a worker's perspective, we are seeing research efforts to understand the role of task interdependence in a context in which agents themselves are deeply involved in organization design, defining their tasks, self-selecting into them, and exploring interdependencies with other agents. However, these promising developments must be complemented by increased knowledge about how task interdependence—when arising endogenously during the design process—relates

to goal and knowledge interdependence. We have suggested that endogenous task interdependence logically and temporally follows goal and knowledge interdependence. When the nature of the work is unclear, agents' coming together around common goals and shared knowledge provides a lens through which they can understand what needs to be done, who will do it, and what interactions are necessary to support the work.

Second, our review establishes the importance of understanding goal interdependence as a factor that can be manipulated using the organization's incentive and reward structure as a fundamental design tool. Because the organization design literature has not examined this construct thoroughly, most of our insights are borrowed from adjacent literatures on team and job design. We identify various labels and conceptualizations, including goal, reward, and outcome interdependence. Parsing the sometimes contradictory interpretations of these constructs and applying them to the organization design process allowed us to draw attention to the role of goal interdependence in aligning agents' interests and affecting organization performance. It is high time that the organization design literature seriously undertook the *joint* study of task and goal interdependence as two equally malleable design tools. Initial evidence suggests that these two concepts may exhibit complementarities and interact in intriguing ways, but more research is needed. In particular, great potential exists in examining how manipulating goal interdependence may lead to different understandings of the nature of the task and to different intensities, frequencies, and natures of agent interactions.

Third, we shed light on three knowledge-based forms of interdependence: knowledge interdependence, role interdependence, and epistemic interdependence. Little attention has been devoted to these constructs on their own; yet their effects permeate organization design studies in both classic and contemporary settings. Furthermore, most research acknowledges (at least

implicitly) their role in facilitating agent-driven interactions. Agents' idiosyncratic knowledge and skills, which often exceed the requirements of their formal jobs, enables agents to contribute to the organization in novel ways. In their interactions with other agents, knowledge interdependence supports sensemaking, task definition, and task allocation efforts in the presence of dynamic work streams. While clusters of interdependent subtasks and their requisite knowledge are still contained within jobs, their boundaries are more permeable, less well-defined, and more broadly captured in agents' roles that go beyond their formal jobs. Informal roles arise when self-driven or crafted tasks and knowledge persist over time and are associated with particular organizational agents. Role interdependence, then, arises between holders of different jobs or roles whose domains require deeper coordination and knowledge exchange. Lastly, epistemic interdependence speaks to agents' understanding of who can or will contribute what to the organization. It is rooted in predictive knowledge about others' behaviors, skills, and roles and captures the notion that an agent may need to know what another is likely to do to complete her task. Taken together, these three forms of interdependence illuminate crucial elements that lie at the core of the microfoundations of organization design: agents' desire to learn, to grow, and to contribute to the overall organization's effort beyond set expectations.

The combination of a poorly understood task structure and agents' resulting involvement in the design process brings the richness of the interdependence construct to the forefront. Task interdependence alone is insufficient to create a design process in which agents actively make sense of the work as they perform it. In the past, goal and knowledge interdependence were presumed to align with task interdependence; therefore, they did not receive special attention. However, today's context requires a greater awareness of the multiple ways in which agents can be encouraged to interact. This is not to say that classic notions of organizational design are

inferior or now superfluous. Quite the opposite is true: a world in which task structures are fully known is far preferable to one in which design choices must be negotiated. Yet in the certain *absence* of a full understanding, organizations can manipulate goal and knowledge interdependence until agents reach a level of consensus that allows them to integrate task interdependence into the process. In doing so, they may unearth new ways to understand their work, of relating to one another, and of co-creating nimble and effective organizational designs.

CONCLUSION

The nature of organization design is undergoing profound changes. We are moving from a context in which interdependence is seen as a challenging organizational element to be *managed* to one where interdependence emerges as a generative element to be *encouraged* and *directed*. Dynamic work streams are opening up the design process to managers and agents as co-designers of the organization's structure. These developments require a careful reassessment of how interdependence, in all its complexity, shapes the organization design process. As Weick (1969: 33) rightly pointed out, "interdependence is the crucial element from which a theory of organizations is built." We trust that expanding research on the interdependence construct beyond its past focus on task interdependence—to encompass also the aspects of goal and knowledge interdependence (and, within the latter, role and epistemic interdependence)—will inspire renewed efforts to restore interdependence to its rightful place: at the crux of a more complete understanding of organization design and its microfoundations.

REFERENCES

Adler P. S. 1995. Interdepartmental Interdependence and Coordination: The Case of the Design/Manufacturing Interface. *Organization Science*, *6*(2), 147–167.

Adner R. & Kapoor R. 2010. Value Creation in Innovation Ecosystems: How the structure of technological interdependence affects firm performance in new technology generations, Strategic Management Journal, 31: 306-333.

Aggarwal V. A., Siggelkow N., & Singh H. 2011. Governing collaborative activity: interdependence and the impact of coordination and exploration. *Strategic Management Journal*, *32*(7), 705–730.

Alge B. J., Wiethoff C., & Klein H. J. 2003. When does the medium matter? Knowledge-building experiences and opportunities in decision-making teams. *Organizational Behavior and Human Decision Processes*, *91*, 26–37.

Alper S, Tjosvold D., & Law K. S. 1998. Interdependence and Controversy in Group Decision Making: Antecedents to Effective Self-Managing Teams. *Organizational Behavior and Human Decision Processes*, *74*(1), 33–52.

Alvesson M. 1993. Organizations as rhetoric: Knowledge-intensive firms and the struggle with ambiguity. *Journal of Management Studies*, *30*(6), 997–1015.

Argote L. 1982. Input Uncertainty and Organizational Coordination in Hospital Emergency Units. *Administrative Science Quarterly*, *27*, 420.

Argote L & Ingram P. 2000. Knowledge transfer: A basis for competitive advantage in firms. *Organizational behavior and human decision processes*, *82*(1), pp.150-169.

Ashforth, B. 2000. *Role Transitions in Organizational Life: An Identity-based Perspective*.

Baldwin C. May 2019. *Personal Correspondence.*

Baldwin C & Clark K. B. 2000. *Design rules: The power of modularity*. *1*.

Baldwin C., MacCormack A., & Rusnak J. 2014. Hidden structure: Using network methods to map system architecture. *Research Policy*, *43*, 1381–1397.

Barley S. R. 1986. Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments. *Administrative Science Quarterly*, *31*(1), 78.

Barnard C. I. 1938. *The functions of the executive*.

Barney J. & Felin T. 2013. What Are Microfoundations? *Academy of Management Perspectives*, *27*(2), 138–155.

Baron J. N. 1984. Organizational Perspectives on Stratification. *Annual Review of Sociology*, *10*(1), 37–69.

Bartel C. A. & Saavedra R. 2000. The Collective Construction of Work Group Moods. *Administrative Science Quarterly*, *45*, 197–231.

Barua A., Lee H. C., & Whinston A. B. 1995. Incentives and Computing Systems for Team-Based Organizations. *Organization Science*, *6*(4), 487–504.

Bates F. L. & Harvey C. 1975. *The Structure of Social Systems*.

Beersma B., Homan A. C., Van Kleef G. A., & De Dreu C. 2013. Outcome interdependence shapes the effects of prevention focus on team processes and performance. *Organizational Behavior and Human Decision Processes*, *121*, 194–203.

Bell N. E. & Staw, B. M. 1989. People as sculptors versus sculpture: The roles of personality and personal control in organizations. *Handbook of Career Theory*, *232*, 251.

Berg J. M., Dutton J. E., & Wrzesniewski A. 2013. Purpose and meaning in the workplace. *Purpose and Meaning in the Workplace*, 81–104.

Berg J. M., Wrzesniewski A., & Dutton J. E. 2010. Perceiving and responding to challenges in job crafting at different ranks: When proactivity requires adaptivity. *Journal of Organizational Behavior*, *31*(2-3), 158–186.
Biddle B. J. 1986. Recent Developments in Role Theory. *Annual Review of Sociology*, *12*(1), 67–92.
Biddle B. J. 1979. *Role Theory: Expectations, Identities, and Behaviors*.
Birkinshaw J., Nobel R., & Ridderstråle J. 2002. Knowledge as a Contingency Variable: Do the Characteristics of Knowledge Predict Organization Structure? *Organization Science*, *13*(3), 274–289.
Blau P. & Scott R. W. 1962. *Formal organizations: A comparative approach*.
Brown S. L. & Eisenhardt K. M. 1998. *Competing on the Edge: Strategy as Structured Chaos*.
Buenger V., Daft R. L., Conlon E. J., & Austin J. 1996. Competing Values in Organizations: Contextual Influences and Structural Consequences. *Organization Science*, *7*(5), 557–576.
Bunderson S. J. & Thompson J. A. 2009. The Call of the Wild: Zookeepers, Callings, and the Double-edged Sword of Deeply Meaningful Work. *Administrative Science Quarterly*.
Burns T. E. & Stalker G. 1961. *The management of innovation*.
Burton R. M. & Obel B. 1984. *Designing efficient organizations: Modelling and experimentation.* Amsterdam: North-Holland.
Camerer C. 2003. *Behavioral game theory: Experiments in strategic interaction*.
Campagnolo D. & Camuffo A. 2010. The Concept of Modularity in Management Studies: A Literature Review. *International Journal of Management Reviews*, *12*, 259–283.
Campion M. A., Medsker G. J., & Higgs C. A. 1993. Relations between work group characteristics and effectiveness: implications for designing effective work groups. *Personnel Psychology*, *46*(4), 823–847.
Campion M. A. & McClelland C. L. 1993. Follow-up and extension of the interdisciplinary costs and benefits of enlarged jobs. *Journal of Applied Psychology*, *78*(3), 339.
Campion M. A., Papper E. M., & Medsker G. J. 1996. Relations between work team characteristics and effectiveness: a replication and extension. *Personnel Psychology*, *49*(2), 429–452.
Capon N., Farley J. U., & Hoenig S. 1990. Determinants of Financial Performance: A Meta-Analysis. *Management Science*, *36*(10), 1143–1159.
Carlile P. R. 2002. A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. *Organization Science*, *13*(4), 442–455.
Carlile P. R. 2004. Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization science*, *15*(5), pp.555-568.
Carton A. M. 2018. "I'm Not Mopping the Floors, I'm Putting a Man on the Moon": How NASA Leaders Enhanced the Meaningfulness of Work by Changing the Meaning of Work. *Administrative Science Quarterly*, *63*(2), 323–369.
Cheng J. L. 1983. Interdependence and Coordination in Organizations: A Role-System Analysis. *Academy of Management Journal*, *26*, 156–162.
Child J. 1972. Organizational Structure, Environment and Performance: The Role of Strategic Choice. *Sociology*, *6*(1), 1–22.
Cleavenger D., Gardner W. L., & Mhatre K. 2007. Help-seeking: testing the effects of task interdependence and normativeness on employees' propensity to seek help. *Journal of Business and Psychology*, *21*(3), 331–359.

Clement J. & Puranam P. 2017. Searching for structure: Formal organization design as a guide to network evolution. *Management Science, 64*(8), 3879-3895.
Cohen L. E. 2013. Assembling Jobs: A Model of How Tasks Are Bundled Into and Across Jobs. *Organization Science*, *24*(2), 432–454.
Colfer L. J. & Baldwin C. Y. 2016. The Mirroring Hypothesis: Theory, evidence, and exceptions, *Industrial and Corporate Change*, 25(5): 709-738.
Crant M. J. 2000. Proactive Behavior in Organizations. *Journal of Management*, *26*(3), 435–462.
Cyert R. M. & March J. G. 1963. *A behavioral theory of the firm*.
Daft R. L. & Lengel R. H. 1986. Organizational Information Requirements, Media Richness and Structural Design. *Management Science*, *32*, 554–571.
Dailey R. C. 1978. The Role of Team and Task Characteristics in R&D Team Collaborative Problem Solving and Productivity. *Management Science*, *24*, 1579–1588.
Dalton D. R., Todor W. D., Spendolini M. J., Fielding G. J., & Porter L. W. 1980. Organization Structure and Performance: A Critical Review. *Academy of Management Review*, *5*(1), 49–64.
Davis J. P., Eisenhardt K. M., & Bingham C. B. 2009. Optimal Structure, Market Dynamism, and the Strategy of Simple Rules. *Administrative Science Quarterly*, *54*(3), 413–452.
Davis L. E. & Taylor J. C. 1972. *Design of Jobs: Selected Readings*.
Deutsch M. 1949. A Theory of Co-operation and Competition. *Human Relations*, *2*(2), 129–152.
Dobrev S. D., Ozdemir S., & Teo A. C. 2006. The Ecological Interdependence of Emergent and Established Organizational Populations: Legitimacy Transfer, Violation by Comparison, and Unstable Identities. *Organization Science*, *17*, 577–597.
Donaldson L. 2001. *The Contingency Theory of Organizations*.
Dosi G., Levinthal D., & Marengo L. 2003. Bridging contested terrain: linking incentive-based and learning perspectives on organizational evolution. *Industrial and Corporate Change*, *12*(2), 413–436.
Ebaugh H. 1988. *Becoming an ex: The process of role exit*.
Emerson R. M. 1962, "Power-dependence relations," American Sociological Review, Vol. 27, pp. 31-40.
Ethiraj S. K. & Levinthal D. 2004. Modularity and Innovation in Complex Systems. *Management Science*, *50*, 159–173.
Fjeldstad Ø. D., Snow C. C., Miles R. E., & Lettl C. 2012. The architecture of collaboration. *Strategic Management Journal*, *33*, 734–750.
Fondas N. & Stewart R. 1994. Enactment in managerial jobs: A role analysis. *Journal of Management Studies*, *31*(1), 83–103.
Foss N. J. 2003. Selective Intervention and Internal Hybrids: Interpreting and Learning from the Rise and Decline of the Oticon Spaghetti Organization. *Organization Science*, *14*(3), 331–349.
Freidson E. 1976. The Division of Labor as Social Interaction. *Social Problems*, *23*(3), 304–313.
Frese M., Kring W., Soose A., & Zempel J. 1996. Personal Initiative at Work: Differences Between East and West Germany. *Academy of Management Journal*, *39*(1), 37–63.
Fuller J., Marler L. E., &Hester K. 2006. Promoting felt responsibility for constructive change and proactive behavior: exploring aspects of an elaborated model of work design. *Journal of Organizational Behavior*, *27*(8), 1089–1120.
Galbraith J. R. 1973. *Designing Complex Organizations (Addison-Wesley series on organization development)*.

Galbraith J. R. 1977. *Organization design*.
Garzarelli G. & Langlois R. 2008. Of Hackers and Hairdressers: Modularity and the Organizational Economics of Open-Source Collaboration. *Industry and Innovation*, *15*(2), 125–143.
Gavetti G., Levinthal D., & Ocasio W. 2007. Perspective—Neo-carnegie: The carnegie school's past, present, and reconstructing for the future. *Organization Science, 18*(3), 523- 536.
Gladstein D. L. 1984. A Model of Task Group Effectiveness. Administrative Science Quarterly, 29(4): 499-517.
Goldman M., Stockbauer J. W., & McAuliffe T. G. 1977. Intergroup and intragroup competition and cooperation. *Journal of Experimental Social Psychology*, *13*(1), 81–88.
Gouldner A. W. (1957). Cosmopolitans and Locals: Toward an analysis of latent social roles. *Administrative Science Quarterly*, *2*, 281–306.
Grant A. M. & Ashford S. J. 2008. The dynamics of proactivity at work. *Research in Organizational Behavior*, *28*, 3–34.
Grant A. M. & Parker S. K. 2009. 7 Redesigning Work Design Theories: The Rise of Relational and Proactive Perspectives. *The Academy of Management Annals*, *3*, 317–375.
Grant A. M. & Patil S. V. 2012. Challenging the Norm of Self-Interest: Minority Influence and Transitions to Helping Norms in Work Units. *Academy of Management Review*, *37*, 547–568.
Gray J. V., Siemsen E., & Vasudeva G. 2015. Colocation Still Matters: Conformance Quality and the Interdependence of R&D and Manufacturing in the Pharmaceutical Industry. *Management Science*, *61*(11), 2760–2781.
Greer L. L., de Jong B. A., Schouten M. E., & Dannals J. E. 2018. Why and When Hierarchy Impacts Team Effectiveness: A Meta-Analytic Integration. *Journal of Applied Psychology*.
Griffin M. A., Neal A., & Parker S.K. 2007. A New Model of Work Role Performance: Positive Behavior in Uncertain and Interdependent Contexts. *Academy of Management Journal*, *50*(2), 327–347.
Grossman S. & Hart O. 1986. The costs and benefits of ownership: a theory of vertical and lateral integration. *Journal of Political Economy*, *94*, 691–719.
Gulati R. 1995. Social Structure and Alliance Formation Patterns: A Longitudinal Analysis. *Administrative Science Quarterly*, *40*(4), 619.
Gulati R. 2007. Silo busting: How to execute on the promise of customer focus. *Harvard Business Review*, 85(5): 98-+.
Gulati R. 2010. *Reorganize for Resilience.* Harvard Business School Press.
Gulati R & Gargiulo M. 1999. Where do interorganizational networks come from? *American Journal of Sociology*, 104(5): 1439-1493.
Gulati R. & Puranam P. 2009. Renewal through Reorganization: The value of inconsistencies between formal and informal organization, Organization Science, 20(2): 281-480.
Gulati R., Puranam P., & Tushman M. 2012. Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal, 33*(6), 571-586.
Gulati R. & Sytch M. 2007. Dependence Asymmetry and Joint Dependence in Interorganizational Relationships, *Administrative Science Quarterly*, 52(1): 32-69.
Gulati R., Wohlgezogen F., & Zhelyazkov P. 2012. The Two Facets of Collaboration: Cooperation and coordination in strategic alliances, *Academy of Management Annals, 6: 531-583.*

Gulick L. & Urwick L. 1937. Paper on the Science of Administration. *New York: Institute of Public Administration*.
Gully S. M., Incalcaterra K. A., Joshi A., & Beaubien J. M. 2002. A Meta-Analysis of Team-Efficacy, Potency, and Performance: Interdependence and Level of Analysis as Moderators of Observed Relationships, *Journal of Applied Psychology, 87(5): 819-832.*
Guzzo R. A. & Dickson M. W. 1996. Teams in organizations: Recent research on performance and effectiveness. *Annual Review of Psychology, 47,* 307–338.
Hackman R. .J. 1983. *A normative model of work team effectiveness*.
Hackman R J & Oldham G. R. 1980. *Work redesign*.
Hansen M. T., Mors M. L., & Løvås B. 2005. Knowledge sharing in organizations: Multiple networks, multiple phases. *Academy of Management journal*, *48*(5), pp.776-793.
Harrison D. A. & Humphrey S. E. 2010. Designing for diversity or diversity for design? Tasks, interdependence, and within-unit differences at work. *Journal of Organizational Behavior*, *31*(2-3), 328–337.
Hatch M. 1999. Exploring the Empty Spaces of Organizing: How Improvisational Jazz Helps Redescribe Organizational Structure. *Organization Studies*, *20*(1), 75–100.
Hertel G., Konradt U., Orlikowski B. 2004. Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology*, *13*(1), 1–28.
Hollingshead A. B. 1998. Communication, Learning, and Retrieval in Transactive Memory Systems. *Journal of Experimental Social Psychology*, *34*, 423–442.
Hollingshead A. B. 2001. Cognitive interdependence and convergent expectations in transactive memory. *Journal of Personality and Social Psychology*, *81*, 1080.
Holmstrom B. & Tirole J. 1989. *The Theory of firm*. *1*, 61–133.
Ilgen D. R. & Hollenbeck J. R. 1991. The structure of work: Job design and roles. *Handbook of Industrial and Organizational Psychology*, *2*, 165–207.
Ito J. K. & Peterson R. B. 1986. Effects of Task Difficulty and Interunit Interdependence on Information Processing Systems. *Academy of Management Journal*, *29*, 139–149.
Jacobides M. .G. 2007. The inherent limits of organizational structure and the unfulfilled role of hierarchy: Lessons from a near-war. *Organization Science, 18*(3), 455-477.
Janz B. D., Colquitt J. A., & Noe R. A. 1997. Knowledge worker team effectiveness: The role of autonomy, interdependence, team development, and contextual support variables. *Personnel Psychology*, *50*, 877–904.
Jehn K. A. 1995. A Multimethod Examination of the Benefits and Detriments of Intragroup Conflict. *Administrative Science Quarterly*, *40*, 256.
Jehn K. A., Northcraft G. B., & Neale M. A. 1999. Why Differences Make a Difference: A Field Study of Diversity, Conflict and Performance in Workgroups. *Administrative Science Quarterly*, *44*, 741–763.
Johnson D. W. & Johnson R. T. 2005. New Developments in Social Interdependence Theory. *Genetic, Social, and General Psychology Monographs*, *131*(4), 285–358.
Joseph J. & Wilson A. J., 2018. The Growth of the Firm: An attention-based view, Strategic Management Journal, 39(6): 1779-1800.
Joseph J. & Gaba V. 2020. Organizational Structure, Information Processing, and Decision Making: A retrospective and roadmap for research, *Academy of Management Annals.*
Karim S. 2006. Modularity in organizational structure: the reconfiguration of internally developed and acquired business units, *Strategic Management Journal***,** 29(7): 799-823.

Katz D. & Kahn R. L. 1966. *The social psychology of organizations*.
Kauffman S. A. 1993. *The Origins of Order: Self-Organization and Selection in Evolution*.
Kelley H. H. & Thibaut J. W. 1978. *Interpersonal relations: A theory of interdependence.* New York: Wiley.
Ketkar H. & Workiewicz M. 2020. Power to the People: Decentralized Project Selection and Employee Self-allocation in Organizations. *Working Paper*.
Kiggundu M. N. 1981. Task Interdependence and the Theory of Job Design. *Academy of Management Review*, *6*(3), 499–508.
Kiggundu M. N. 1983. Task interdependence and job design: Test of a theory. *Organizational Behavior and Human Performance*, *31*, 145–172.
Kleinbaum A. M. & Tushman M. L. 2007. Building bridges: the social structure of interdependent innovation. *Strategic Entrepreneurship Journal*, *1*(1-2), 103–122.
Kogut B. & Zander U. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, *3*(3), 383–397.
Kogut B. & Zander U. 1996. What Firms Do? Coordination, Identity, and Learning. *Organization Science*, *7*(5), 502–518.
Krackhardt D. & Hanson Jr. 1993. Informal networks: the company behind the chart. *Harvard Business Review* 71(4): 104–111.
Laffont J. J. & Tirole J. 1993. *A Theory of Incentives in Procurement and Regulation*.
Larsson R. & Bowen D. E. 1989. Organization and Customer: Managing Design and Coordination of Services. *Academy of Management Review*, *14*(2), 213–233.
Lawrence P. R. & Lorsch J. W. 1967. *Organizations and Environment: Managing Differentiation and Integration*.
Leana C., Appelbaum E., & Shevchuk I. 2009. Work Process and Quality of Care in Early Childhood Education: The Role of Job Crafting. *Academy of Management Journal*, *52*(6), 1169–1192.
Lee S., Pitesa M., Thau S., & Pillutla M. M. 2015. Discrimination in Selection Decisions: Integrating Stereotype Fit and Interdependence Theories. Academy of Management Journal, 58(3), 789–812.
Lee E. & Puranam P. 2016. The implementation imperative: W hy one should implement even imperfect strategies perfectly. *Strategic Management Journal, 37*(8), 1529-1546.
Leonard-Barton D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, *13*(S1), 111–125.
Leonard-Barton D. 1995. *Wellsprings of knowledge: Building and sustaining the sources of innovation*.
Levinthal, D. A. 1997. Adaptation on rugged landscapes. *Management Science,* 43(7):934–950.
Levinthal D. A. & Warglien M. 1999. Landscape Design: Designing for Local Action in Complex Worlds. *Organization Science*, *10*(3), 342–357.
Levitt R. E., Thomsen J., Christiansen T. R., Kunz J. C., Jin, Y., & Nass, C. 1999. Simulating Project Work Processes and Organizations: Toward a Micro-Contingency Theory of Organizational Design. *Management Science*, *45*(11), 1479–1495.
Liang D., Moreland R., & Argote L. 1995. Group Versus Individual Training and Group Performance: The Mediating Role of Transactive Memory. *Personality and Social Psychology Bulletin*, *21*, 384–393.
Liden R. C. & Mitchell T. R. 1983. The effects of group interdependence on supervisor performance evaluations. *Personnel Psychology*, *36*, 289–299.

Locke E. A. & Latham G. P. 1990. *A theory of goal setting and task performance*.
March J. G. & Simon H. 1958. *Organizations*.
Marks M. A., Mathieu J. E., & Zaccaro S. J. 2001. A Temporally Based Framework and Taxonomy of Team Processes. *Academy of Management Review*, *26*, 356–376.
Mathieu J, Maynard T. M., Rapp T., & Gilson L. 2008. Team Effectiveness 1997-2007: A Review of Recent Advancements and a Glimpse Into the Future. *Journal of Management*, *34*, 410–476.
McCann J. E. & Ferry D. L. 1979. An Approach for Assessing and Managing Inter-Unit Interdependence. *Academy of Management Review*, *4*(1), 113–119.
Mell J. N., van Knippenberg D, & van Ginkel W. .P. 2014. The Catalyst Effect: The Impact of Transactive Memory System Structure on Team Performance. *Academy of Management Journal*, *57*, 1154–1173.
Merton R. K. 1957. *Social Theory and Social Structure*.
Milgrom P. R. & Roberts B. M. 1990. The economics of mod- ern manufacturing technology, strategy and organization. *American Economic Review*, *80*, 511–528.
Milgrom P. R & Roberts B. M. 1995. Complementarities and fit: Strategy, structure and organizational change in manufacturing. *Journal of Accounting and Economics*, *19*, 179–208.
Miller L. K. & Hamblin R. L. 1963. Interdependence, differential rewarding and productivity. *American Sociological Review*, *28*, 768–778.
Miner A. S. 1987. Idiosyncratic Jobs in Formalized Organizations. *Administrative Science Quarterly*, *32*(3), 327.
Mintzberg H. 1979. *The Structuring of Organizations*.
Mitchell T. R. & Silver W. S. 1990. Individual and group goals when workers are interdependent: Effects on task strategies and performance. *Journal of Applied Psychology*, *75*(2), 185.
Mooney J. D. & Reiley A. C. 1937. *The principles of organization*.
Morgeson FP, Humphrey SE. 2008. *Job and team design: Toward a more integrative conceptualization of work design*. 39–91.
Murnighan K. J. & Conlon D. E. 1991. The Dynamics of Intense Work Groups: A Study of British String Quartets. *Administrative Science Quarterly*, *36*(2), 165.
Nadler D. A. & Tushman M. L. 1997. *Competing by design: The power of organizational architecture*.
Nickerson J. A. & Zenger T. R. 2002. Being Efficiently Fickle: A Dynamic Theory of Organizational Choice. *Organization Science*, *13*(5), 547–566.
Nonaka I. & Takeuchi H. 1995. *The knowledge-creating company: How Japanese companies create the dynamics of innovation*.
Okhuysen G. A. & Eisenhardt K. M, 2002. Integrating knowledge in groups: How formal interventions enable flexibility. *Organization science*, *13*(4), pp.370-386.
Oldham G. R. & Hackman R. J. 2010. Not what it was and not what it will be: The future of job design research. *Journal of Organizational Behavior*, *31*, 463–479.
Orlikowski W. J. 2002. Knowing in Practice: Enacting a Collective Capability in Distributed Organizing. *Organization Science*, *13*(3), 249–273.
Parker S. K., Wall T. D., & Cordery J. L. 2001. Future work design research and practice: Towards an elaborated model of work design. *Journal of Occupational and Organizational Psychology*, *74*, 413–440.

Parnas D. 1972. On the criteria to be used in decomposing systems into modules. *Communications of the ACM*, *15*(12), 1053–1058.
Parnas D. 1979. Designing Software for Ease of Extension and Contraction. *IEEE Transactions on Software Engineering*, SE-5(2): 128-138.
Pennings J. .M. 1975. Interdependence and Complementarity-The Case of a Brokerage Office. *Human Relations*, *28*(9), 825–840.
Pentland B T. 1999. Building Process Theory with Narrative: from Description to Explanation. *Academy of Management Review*, *24*(4), 711–724.
Perrow C. 1967. A Framework for the Comparative Analysis of Organizations. *American Sociological Review*, *32*(2), 194–208.
Perrow C. 1986. *Complex Organizations: A Critical Essay*.
Pfeffer J. 1972. Merger as a Response to Organizational Interdependence. *Administrative Science Quarterly*, *17*(3), 382.
Pfeffer J & Nowak P. 1976. Joint Ventures and Interorganizational Interdependence. *Administrative Science Quarterly*, *21*(3), 398.
Posen H. E, Keil T, Kim S, & Meissner F. D. 2018. Renewing Research on Problemistic Search—A Review and Research Agenda, Academy of Management Annals, 12(1):251.
Puranam P. 2018. *The microstructure of organizations*. Oxford: Oxford University Press.
Puranam P, Alexy O, Reitzig M. 2014. What's "New" About New Forms of Organizing? *Academy of Management Review*, *39*(2), 162–180.
Puranam P & Raveendran M. 2013. Interdependence and Organization Design, in A. Grandori (ed.) *Handbook of Economic Organization*, Chapter 11: 193–209.
Puranam P, Raveendran M, & Knudsen T. 2012. Organization Design: The Epistemic Interdependence Perspective. *Academy of Management Review*, *37*(3), 419–440.
Puranam P & Swamy M. 2016. How initial representations shape coupled learning processes. *Organization Science, 27*(2), 323-335.
Rahmandad, H. 2019. Interdependence, Complementarity, and Ruggedness of Performance Landscapes, *Strategy Science,* 4(3): 175-249.
Raveendran M. 2020. Seeds of Change: How current structure shapes the type and timing of reorganizations" M. Raveendran, *Strategic Management Journal, 41(1): 27-54.*
Raveendran M, Puranam P, Warglien M. 2016. Object Salience in the Division of Labor: Experimental Evidence. *Management Science*, *62*(7), 2110–2128.
Raveendran M, Puranam P, & Warglien M. 2020. Division of Labor through Self-selection, *Working Paper.*
Ren Y & Argote L. 2011. Transactive Memory Systems 1985–2010: An Integrative Framework of Key Dimensions, Antecedents, and Consequences. *The Academy of Management Annals*, *5*, 189–229.
Rivkin J. W. & Siggelkow N. 2003. Balancing Search and Stability: Interdependencies Among Elements of Organizational Design. *Management Science*, 49, 290–311.
Roethlisberger F. J. & Dickson W. J. 1939. *The Early Sociology of Management and Organizations: Management and the Worker*. *V*.
Rosenbaum M. E.., Moore D L. , Cotton J. L., Cook M. S., Hieser R. A., Shovar N. M., & Gray M. J. 1980. Group productivity and process: Pure and mixed reward structures and task interdependence. *Journal of Personality and Social Psychology*, *39*(4), 626.
Saavedra R, Earley C. P., & Dyne L. 1993. Complex interdependence in task-performing groups. *Journal of Applied Psychology*, *78*(1), 61.

Sanchez R &Mahoney J. T. 1996. Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal*, *17*, 63–76.
Scott, W. R. 1981. Organizations: Rational, Natural and Open Systems. Englewood Cliffs, NJ: Prentice-Hall.
Shaw J. D., Duffy M. K., & Stark E. M. 2000. Interdependence and Preference for Group Work: Main and Congruence Effects on the Satisfaction and Performance of Group Members. *Journal of Management*, *26*, 259–279.
Shiflett S. C. 1973. Performance Effectiveness and Efficiency under Different Dyadic Work Strategies. *Journal of Applied Psychology*, 57(3): 257-263.
Silvestri L. 2019. Collective job crafting: how groups shape their identity and work over time. Harvard Business School dissertation.
Simon H. A. 1962. The Architecture of Complexity. *Proceedings of the American Philosophical Society*, *106*(6), 467–482.
Simon H. A. 1945. *Administrative behavior*.
Simons R. 1994. How new top managers use control systems as levers of strategic renewal. *Strategic Management Journal*, *15*(3), 169–189.
Smith A. 1776. *The Wealth of Nations*.
Sorenson O, Rivkin J. W., & Fleming L. 2006. Complexity, networks and knowledge flow. *Research Policy*, *35*(7), 994–1017.
Sosa M. E., Eppinger S. D., &Rowle, C. M. 2004. The Misalignment of Product Architecture and Organizational Structure in Complex Product Development. *Management Science*, *50*, 1674–1689.
Swaab R. I., Schaerer M, Anicich E. M., Ronay R, & .Galinsky A. D. 2014. The Too-Much-Talent Effect: Team Interdependence Determines When More Talent Is Too Much or Not Enough. *Psychological Science*, *25*, 1581–1591.
Starbuck W. H. 1992. Learning by knowledge-intensive firms. *Journal of Management Studies*, *29*(6), 713–740.
Stark D. 2011. *The sense of dissonance: Accounts of worth in economic life*.
Steensma K. H. & Corley K. G. 2000. On the Performance of Technology-Sourcing Partnerships: The interaction between partner interdependence and technology attributes. *Academy of Management Journal*, *43*(6), 1045–1067.
Stewart G. L. & Barrick M. R. 2000. Team Structure and Performance: Assessing the Mediating Role of Intrateam Process and the Moderating Role of Task Type. *Academy of Management Journal*, *43*(2), 135–148.
Strauss A. 1985. Work and the division of labor. *The Sociological Quarterly*, *26*(1), 1–19.
Taylor F. 1911. The principles of scientific management. *New York: Harper Bros*, *1911*, 5–29.
Thibaut J & Kelley H. H. 1959. The Social Psychology of Groups. New York: Wiley
Thomas E. J. 1957. Effects of Facilitative Role Interdependence on Group Functioning. *Human Relations*, *10*(4), 347–366.
Thompson J. D. 1967. *Organizations in action: Social science bases of administrative theory*.
Tjosvold D. 1988. Cooperative and Competitive Interdependence. *Group & Organization Management*, *13*(3), 274–289.
Trist E & Bamforth K. 1951. Some Social and Psychological Consequences of the Longwall Method of Coal-Getting. *Human Relations*, *4*(1), 3–38.
Tsoukas H. 1996. The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal*, *17*(S2), 11–25.

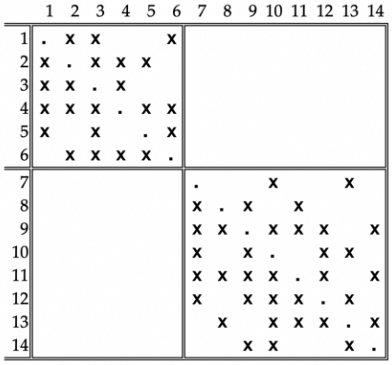
Turner A. N. & Lawrence P. R. 1965. *Industrial jobs and the worker*.
Tushman M, Lakhani K. R., & Lifshitz-Assaf H. (2012). Open Innovation and Organization Design. *Journal of Organization Design*, *1*, 24–27.
Tushman M. L. & Nadler D. A. 1978. Information Processing as an Integrating Concept in Organizational Design. *Academy of Management Review*, *3*(3), 613–624.
Valentine M. A. & Edmondson A. C. 2015. Team Scaffolds: How Mesolevel Structures Enable Role-Based Coordination in Temporary Groups. *Organization Science*, *26*(2), 405–422.
Van de Ven A. H., Delbecq A. L., & Koenig R. 1976. Determinants of Coordination Modes within Organizations. *American Sociological Review*, *41*(2), 322.
Van der Vegt G, Emans B, & van der Vliert E. 1998. Motivating Effects of Task and Outcome Interdependence in Work Teams. *Group & Organization Management*, *23*(2), 124–143.
Van der Vegt G, Emans B, & Van de Vliert E, 2000. Team Members' Affective Responses to Patterns of Intragroup Interdependence and Job Complexity, *Journal of Management,* 26(4): 633-655.
Victor B & Blackburn R. S. 1987. Interdependence: An Alternative Conceptualization. *Academy of Management Review*, *12*(3), 486–498.
Von Hippel, E. 1990. Task partitioning: An innovation process variable. *Research Policy,* 19: 407–418.
von Neumann J & Morgenstern O. 1944. *Theory of games and economic behavior.*
Wageman R. 1995. Interdependence and Group Effectiveness. *Administrative Science Quarterly*, *40*, 145.
Wageman R. 2001. *Chapter 7: The Meaning of Interdependence* in Groups at Work: Theory and Research (ed. M.E. Turner): 197–217, Lawrence Erlbaum Associates: New Jersey, London.
Wageman R & Gordon FM. 2005. As the Twig Is Bent: How Group Values Shape Emergent Task Interdependence in Groups. *Organization Science*, *16*(6), 687–700.
Wageman R & Baker G. 1997. Incentives and cooperation: the joint effects of task and reward interdependence on group performance. *Journal of Organizational Behavior*, *18*(2), 139–158.
Weber M. 1946. Bureaucracy. *From Max Weber: Essays in Sociology*, *196*, 232–235.
Wegner D. M., Giuliano T, & Hertel P.T. 1985. *Compatible and Incompatible Relationships*. 253–276.
Wegner D. M. 1987. Transactive Memory: A Contemporary Analysis of the Group Mind. In: Mullen B., Goethals G.R. (eds) *Theories of Group Behavior. Springer Series in Social Psychology.* Springer, New York, NY
Weick K. E. 1969. *The social psychology of organizing*.
Weick K. E. 1977. Organization design: Organizations as self-designing systems. *Organizational Dynamics*, *6*(2), 31–46.
Weick K. E., Sutcliffe K, & Obstfeld D. 2005. Organizing and the Process of Sensemaking. *Organization Science*, *16*(4), 409–421.
Wong C & Campion M. A. 1991. Development and test of a task level model of motivational job design. *Journal of Applied Psychology*, *76*, 825.
Woodward J. 1965. *Industrial Organization: Theory and Practice*.
Wrzesniewski A & Dutton J. E. 2001. Crafting a Job: Revisioning Employees as Active Crafters of Their Work. *Academy of Management Review*, *26*(2), 179–201.

Zajac S, Gregory M. E., Bedwell W. L., Kramer W. S., & Salas E. 2013. The cognitive underpinnings of adaptive team performance in ill-defined task situations. *Organizational Psychology Review*, *4*, 49–73.

Figure 1. Design Structure Matrices of Thompson's Interdependence Typology
- Figures reproduced with permission from personal correspondence with Carliss Baldwin -

1. Pooled interdependence

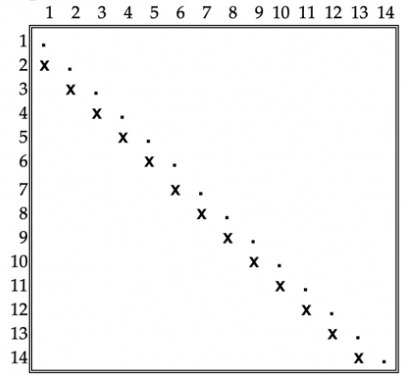
Independent Block Task Structure



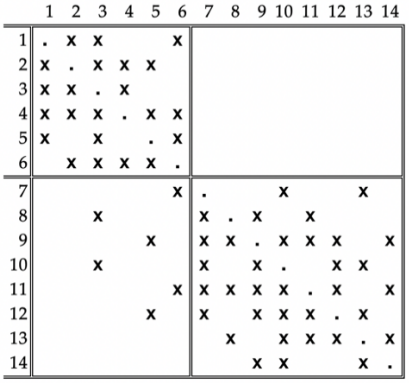
Pooled interdependence has no links/dependencies between tasks across the two business units. Hence this notion corresponds to the economic concept of complementarity: the products of the two units A and B are more valuable when used together than separately, but the technologies are independent. However, it is likely that units A and B must share some common knowledge; for example, they might adhere to the same set of standards. In that case, pooled interdependence corresponds to a modular task structure with perfect information hiding.

2. Sequential interdependence

Strict Sequential Task Structure



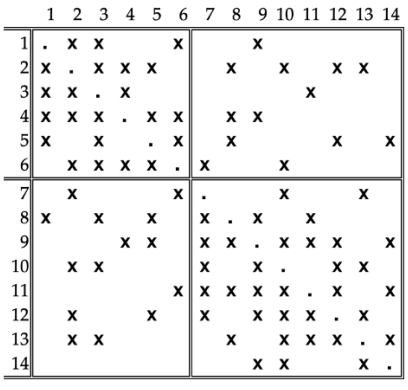
Hierarchical Block Task Structure



Sequential interdependence suggests a hierarchical (one-way) relationship: Downstream uses Upstream's output but not vice versa. Yet probably something (e.g., money, a confirmation of receipt) would flow from Downstream to Upstream. In this case the task structure is "near-decomposable" with only a "thin crossing point" between the two units.

3. Reciprocal interdependence

Integral Task Structure



Reciprocal interdependence implies a two-way cyclical relationship between units. The task structure is non-modular, or "integral", with transfers in both directions.

** These examples show the same tasks (1 through 14) on the rows and columns. An "x" in a given cell indicates that the row-task is dependent on the column-task. For example, under sequential interdependence, task 2 (row) is dependent on task 1 (column), while the opposite is not true (there is no x in the cell of row 1, column 2).*

Table 1. Reviewed Journals by Subject Area

Subject area	Journals
Management and Industrial organization psychology	Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, Journal of Applied Psychology, Management Science, Organization Science, Organizational Behavior and Human Decision Processes, Personnel Psychology, Strategic Management Journal
Social psychology	Journal of Experimental Social Psychology, Journal of Personality and Social Psychology, Personality and Social Psychology Bulletin, Psychological Science

Table 2. Organization Design Studies: Classic versus Contemporary Context

	Classic context	Contemporary context
Nature of work	Well understood.	Ill defined.
Task structure	Known or a good estimate is available.	Unknown, poorly estimated, or frequently changing.
Design process	Manager designs the organization structure, then agents perform the work.	Agents are directly involved in the design process because their knowledge and actions are needed to inform task division and task (self-)allocation.
Role of task interdependence	Task interdependence is generated by the division of labor (task division and task allocation), which in turn is informed by the task structure. It is taken as exogenously given. Task interdependence is viewed as the basis for organization design, which aims to minimize task interdependence across agents while using coordination mechanisms to manage any residual task interdependence.	Task interdependence is secondary because the lack of a clearly defined task structure precludes the *ex ante* task division and allocation that would traditionally generate task interdependence. Other types of interdependence are designed to facilitate the design process. Task interdependence is the final outcome of that process, but neither the associated subtasks nor their allocations are known initially.
Role of goal interdependence	Goal interdependence is presumed to support and conform with the organization structure already implemented for managing task interdependence. It is assumed to be congruent with task interdependence.	Goal interdependence is manipulated via incentive and reward structures and used as one of the main design tools to create "buy-in" among workers. By creating common goals, the manager or designer can engage those agents needed for the organization design process.
Role of knowledge interdependence	The clear organization structure generates prescriptive job descriptions that closely link the requisite expertise and skills to tasks that have been clustered to maximize within-agent task interdependence. As a result, knowledge interdependence and task interdependence are practically isomorphic.	Knowledge interdependence is a key criterion when selecting individuals to participate in the sensemaking and design process. It is critical to ensure that the required expertise and skills are present and engaged in the organization design process itself, since the individuals involved in the process will shape the outcome through their idiosyncratic knowledge and perspectives on the goal to be accomplished.

Table 3. Selected Definitions of Task Interdependence in Organization Design

Author(s)	Year	Definition
Thompson	1967: pp. 54-55	*"Internal interdependence" is associated with the directionality of the workflow between organizational units:* To assume that an organization is composed of interdependent parts is not necessarily to say that each part is dependent on, and supports, every other part in any direct way. The Tuscaloosa branch of an organization may not interact at all with the Oshkosh branch, and neither may have contact with the Kokomo branch. Yet, they may be interdependent in the sense that unless each performs adequately, the total organization is jeopardized; failure of any one can threaten the whole and thus the other parts. We can describe this situation as one in which each part renders a discrete contribution to the whole and each is supported by the whole. We will call this pooled interdependence. […] Interdependence may also take serial form, with the Keokuk plant producing parts which become inputs for the Tucumcari assembly operation. Here both make contributions to and are sustained by the whole interdependence, and so there is a pooled aspect to their interdependence. But, in addition, direct interdependence can be pinpointed between them, and the order of that interdependence can be specified. Keokuk must act properly before Tucumcari can act; and unless Tucumcari acts, Keokuk cannot solve its output problem. We will refer to this as sequential interdependence, and note that it is not symmetrical. A third form of interdependence can be labeled reciprocal, referring to the situation in which the outputs of each become inputs for the others. This is illustrated by the airline which contains both operations and maintenance units.
Pennings	1975: p. 827	*Pennings applies Thompson's concept of internal interdependence to the task level, regardless of the unit or worker performing each task:* Task interdependence is the interrelatedness of a set of discrete operations such that each operation may have consequences for the completion of some of the other ones. Any operation or task which is partitioned into subtasks result in some dependency; the interdependence is rooted in the task level.
McCann & Ferry	1979: p. 113	*Task interdependence is associated with the transactions or exchanges that occur between work units.* Interdependence exists when actions taken by one referent system affects the actions or outcomes of another referent system.
Victor & Blackburn	1987: p. 488	*"Interunit interdependence" represents the extent to which a unit's outcomes are either contingent on or controlled directly by the actions of another unit.* Interdependence theory proposes that the relationship between one work unit and another work unit(s) can be described in terms of three requirements for action: requirements for one's own actions, requirements for the actions of others, and requirements for joint action as dictated by the technological, environmental, organizational, and interpersonal determinants of work flow specified by the division and assignment of labor.
Wageman	2001: p. 201	*Task interdependence as a relational construct to be manipulated.* Task interdependence refers to interdependence that derives from task inputs, including task definition, task technology, the distribution of task resources among individuals, and the instructions about how to carry out the work. That is, the task is interdependent when multiple individuals must act to complete it. Under conditions of no interdependence, a task can be executed entirely by one person. A highly interdependent task, by contrast, requires every group member to contribute something to the collective output; the overall task is not accomplished until each has contributed his or her part. (2001: 201)

Table 4. The Role of Task, Goal, and Knowledge Interdependence in Organization Design

	Task interdependence	Goal interdependence	Knowledge interdependence
Ethos	**Who does what?**	**Who wants what?**	**Who knows what?**
Our proposed definition	Two tasks are interdependent if the value generated from performing each is different when the other task is performed versus when it is not. (cf. Puranam et al., 2012: 421).	Two agents are goal interdependent if they share a common goal, whether or not they actually work together (adapted from Mitchell & Silver, 1990: 186).	Two agents are knowledge interdependent if the value they could generate from combining their knowledge differs from the value they could obtain from applying their knowledge separately.
Related forms of interdependence		*Reward:* The extent to which the rewards that accrue to an individual depend upon the performance of coworkers (Wageman & Baker, 1997: 142) *Outcome:* The extent to which agents' work is measured and appraised at the individual versus the group level.	*Role:* Two roles are interdependent if the value generated from performing each differs when the other role is performed as expected than when it is not. *Epistemic:* Two agents are linked by epistemic interdependence when agent A's optimal action depends on a prediction of agent B's behavior, and vice versa (Puranam et al., 2012).
Classic Organization Design Context			
Place in the organization design process	Seen as the main design tool.	Subordinate to task interdependence.	Subordinate to task interdependence.
Nature	Exogenously given by the nature of the task and the technology at hand. Assumes task structure is known before work is performed.	Mirrors task interdependence. Embedded in grouping choices and reporting lines.	Mirrors task interdependence. Tied to skill requirements of each job.
Approach	Task interdependence is a problem to be managed and minimized through select coordination mechanisms.	If task interdependence is adequately managed, then goal interdependence is managed.	If task interdependence is adequately managed, then knowledge interdependence is managed.
Manager (M) vs. agent (A) intervention	M: Design/manipulation by grouping and linking, based on given task structure. A: Execution by aligning behavior to task specifications.	M: Design/manipulation by establishing unit and job incentives and rewards. A: Execution by aligning behavior to pre-established incentives and rewards.	M: Design/manipulation by specifying job requirements. A: Execution by applying knowledge required to perform the job in prespecified ways.

Contemporary Organization Design Context			
Place in the organization design process	Arises after goal and knowledge interdependence, as agents make sense of, define, and allocate tasks out of a dynamic workstream.	Incentive and reward structures manipulate goal interdependence as a main design tool; aligns agents' interests ahead of and during sense-making of the work, task definition and allocation.	Collocation and grouping manipulate knowledge interdependence as a main design tool; facilitates agent participation and collaboration during sense-making of the work, task definition, and allocation.
Nature	Endogenous to the organization design process; temporally follows goal and knowledge interdependence.	Endogenous to the organization design process.	Endogenous to the organization design process.
Approach	If goal and knowledge interdependence are adequately encouraged, an understanding of task interdependence will emerge.	Goal interdependence is generative; it must be fostered and encouraged.	Knowledge interdependence is generative; it must be fostered and encouraged.
Manager vs. agent intervention	M: Codesign/ manipulation by codifying known aspects of the work; division and allocation of known task components. A: Co-design/ manipulation during execution by identifying new tasks and proactively assuming responsibility for them.	M: Co-design/manipulation by creating overarching goals that provide a 'north' for agent behavior. A: Co-design/manipulation during execution by ascribing personally significant meanings to organizational goals .	M: Co-design/manipulation by engineering background and skill diversity of workforce. A: Co-design/manipulation during execution by applying existing knowledge in novel ways or self-generating new knowledge.