Received: 18 November 2020 | Revised: 8 May 2023 | Accepted: 13 June 2023

DOI: 10.1002/smj.3541

RESEARCH ARTICLE

SMS | Strategic Management Journal

WILEY

Scaling nonhierarchically: A theory of conflict-free organizational growth with limited hierarchical growth

Eucman Lee[1] | **Ekin Ilseven**[2] | **Phanish Puranam**[3]

[1]Nanyang Technological University, Singapore, Singapore

[2]Católica Lisbon School of Business and Economics, Universidade Católica Portuguesa, Lisbon, Portugal

[3]INSEAD, Singapore, Singapore

Correspondence
Phanish Puranam, INSEAD, 1 Ayer Rajah Ave, Singapore 138676, Singapore.
Email: phanish.puranam@insead.edu

Funding information
The Desmairis Fund at INSEAD for the Organizations and Algorithms project

Abstract

Research Summary: We propose a theory that explains variations in the relationship between an organization's size and the extent of its authority hierarchy (as captured in managerial intensity). Conceptualizing authority hierarchy as a means to manage conflicts among subordinates, we formulate a model in which the number of managers required depends on the magnitude of conflicts generated between and within groups of workers. Our analysis shows that scaling non-hierarchically can be accomplished either by creating low conflict "self-managing" teams or reducing conflicts between many "self-contained" teams, but which path is more effective varies by situation. Small initial differences in terms of their emphasis on within vs. between team conflict mitigation can lead to large differences as firms scale over time in the extent of their authority hierarchies.

Managerial Summary: Managing without an extensive hierarchy can be attractive for a variety of reasons, but under what conditions is it possible in large scale organizations? We build on the premise that the managerial hierarchy of authority serves to resolve conflicts that employees cannot resolve peer-to-peer (i.e., there are limits to scaling groups that manage themselves consensually). We develop a formal theory that predicts

that there are three levers that can slow down the growth of managerial hierarchy even as the organization scales: investing in the technology and culture needed to (a) expand managerial capacity particularly toward the apex of the hierarchy (b) create "self-managed" teams that produce few conflicts in need of managerial resolution and (c) create "self-contained" teams that generate few conflicts between them that need escalation up the hierarchy for resolution. The third is likely to be the most effective lever as organizations grow.

KEYWORDS
formal modeling, microstructures, organizational design, scaling

1 | INTRODUCTION

When is an extensive multilayered hierarchy necessary in large organizations? While hierarchical structures based on chains of delegated authority have become a dominant template for organizing (Aghion & Tirole, 1997; Chandler, 1962; March & Simon, 1958), there appears to be heightened interest today in organizing without an elaborate authority hierarchy (Burton et al., 2017; Lee & Edmondson, 2017; Robertson, 2015). Observers have focused attention on open-source communities (Hippel & Krogh, 2003; Tushman et al., 2012), boss-less organizations (Burton et al., 2017; Puranam & Håkonsson, 2015) and holacracies (Robertson, 2015). Despite the diversity of industrial backgrounds where these structures are found, many are small organizations (∼500 employees), such as Valve (gaming software), FAVI (industrial materials), and Morningstar (food products) (Askin et al., 2016; Felin, 2015; Hamel, 2012; Laloux, 2014). Organizing without an authority hierarchy at a large scale may be challenging, it seems (Colombo & Delmastro, 2008; De Santola & Gulati, 2017).

At the same time, some larger organizations defy such expectations, including W.L. Gore, the Dutch nursing organization Buurtzorg, and the Chinese white goods maker Haier (Hamel, 2012; Laloux, 2014). Each has several thousands of employees, and yet is portrayed as operating without extensive multilayered hierarchies of authority. Such examples raise a fundamental theoretical question: Are there systematic factors that allow some organizations to scale without expanding their authority hierarchy, or should we treat these instances as lucky exceptions (Foss & Klein, 2022)? A rigorous inquiry into this question will help theoretically reconcile seemingly disparate empirical observations while offering practical insights into when non-hierarchical growth is and is not feasible.

In this paper, we develop a theoretical framework to investigate the conditions under which an organization can scale (i.e., grow in terms of the number of its production workers) without significantly increasing the extent of its authority hierarchy (i.e., the number of managers arranged in hierarchical layers). Our theory, embodied in a formal model, focuses on conflicts arising from lateral interactions among workers, which are resolved by managers in an authority hierarchy (March & Simon, 1958; Simon, 1947; Thompson, 1967). We conceptualize *conflicts* broadly as disagreements

and exceptions arising from the misalignment of interests and/or information among workers that consume managerial capacity for resolution (Puranam, 2018). To be sure, there are other useful functions of hierarchy that do not necessarily involve conflict resolution—as in sequential screening of proposals (Christensen & Knudsen, 2010), problem-solving based on a hierarchy of expertise (Garicano, 2000) and one-to-one supervision based on the superior knowledge of the supervisor (Demsetz, 1988). However, our focus on the conflict resolution function proves sufficient for our conclusions, and these additional considerations do not qualitatively alter our findings.

The analysis of our model shows that the extent of authority hierarchy required for a given conflict-free scale of organization depends critically on how often conflicts are likely to arise *within* vs. *between* teams of production workers. The key intuition for this result is based on two factors. First, in an authority hierarchy, conflicts within a team are resolved by managers leading that team; but conflicts between teams must escalate to a higher level in the hierarchy, until they reach the first common manager. Second, as an organization scales, the number of *potential* conflicts grows much faster between members of different teams than between members of a given team.[1] This implies that for organizations to scale without significantly increasing the extent of their authority hierarchy (as captured by managerial intensity, the total number of managers relative to the total size of the organization, e.g. Baron et al., 1999), there are three basic levers: first, increasing managerial capacity at higher layers; second, reducing the likelihood of conflicts requiring managerial intervention within teams (creating self-managed teams); and third, reducing the likelihood of conflicts requiring managerial intervention between teams (creating self-contained teams). Further, as organizations scale, our results suggest that designs that produce self-contained teams become more effective at retarding the growth of the authority hierarchy than those that produce self-managed teams. We also analyze the adaptability of initial designs and the path dependence induced by costly and unexpected changes to the likelihood of conflicts in the organization.

We thus contribute a novel theory of the growth of hierarchies that takes firm-specific design choices (rather than industry-level forces such as competition, regulation, or technological progress) as antecedents and gives a central role to conflict management by managers. While it is intuitive that mitigating conflicts obviates the need for authority hierarchies, our analysis points out that all conflicts are not equivalent—where they occur (and where to prioritize efforts to mitigate them) matters for the successful scaling of the organization. Our theory builds on and complements a well-established literature on hierarchies as mechanisms of control and coordination (Simon, 1947; Williamson, 1967), as well as on technological properties such as modularity in allowing for the delegation of authority (Ethiraj & Levinthal, 2004; Rivkin & Siggelkow, 2003; Zhou, 2013), by deepening our understanding of the links between hierarchy and conflict.

As with any theoretical exercise, validation of our results requires carefully designed empirical tests. However, our results do enjoy some face validity in that they explain why larger less-hierarchical organizations tend to emphasize self-contained teams more than smaller such organizations do (Laloux, 2014; Puranam & Håkonsson, 2015). They also help to explain results across empirical studies within a common framework: for instance, why disparate factors such as technological interdependence (e.g. Lee, 2022; Zhou, 2013), social capital, and individual skills (Lawrence & Poliquin, 2019; Lee, 2022) may all have functionally equivalent effects on the growth of hierarchy as an organization scales. Finally, our paper contributes not only to the

[1]For instance, if there are M groups of size m each, the number of potential within-group conflicts is proportional to Mm^2, but the number of potential conflicts between groups is proportional to $M(M-1)m^2$. How these potential conflicts translate into realized conflicts that need managerial intervention is parametrized in our model.

literature on organization design but also to the field of strategy at large, as limits on firm scaling play a key—if implicit—role in inter-firm competition (Knudsen et al., 2014).

2 | PRIOR LITERATURE ON THE SHAPE OF HIERARCHIES OF AUTHORITY

Hierarchies of knowledge and skill (Garicano, 2000; Radner, 1992, 1993; Seshadri et al., 2015), of task/decision interdependence (Baldwin & Clark, 2000; Rivkin & Siggelkow, 2007) and of containment (Ravasz & Barabási, 2003; Simon, 1962) do not necessarily coincide with hierarchies of authority. Authority hierarchies, the focus of our analysis, involve asymmetric, transitive and acyclic influence relations (Ahl & Allen, 1996; Bunderson et al., 2016; Simon, 1968).

The literature related to organizational design recognizes the close relationships between scale, managerial span of control, and layers in an authority hierarchy (Mintzberg, 1979; Williamson, 1967).[2] This literature highlights managerial capacity and exogenous environmental factors as the key drivers of the shape of hierarchy (conditional on task attributes). The basic tradeoff recognized is that limits to managerial capacity restrict managerial spans (i.e., increasing the cost of bottlenecks), but lower spans imply more layers of hierarchy, creating control and information loss as well as delays (i.e., increasing the cost of layers) (Colombo & Delmastro, 2008; Williamson, 1967). As a result, if managerial capacity (and therefore the feasible span of managerial control) increases, then for a fixed number of employees, we should expect a reduction in the layers in the organization (Bloom et al., 2014; Bresnahan et al., 2002; Garicano, 2000). Alternately, a change in the organization's environment that makes control and information loss more expensive may lead to an expansion in managerial span and a reduction in hierarchical layers (Bloom et al., 2010; Guadalupe & Wulf, 2010; Kuwahata, 2015; Rajan & Wulf, 2006). It may also lead to greater delegation of decision making to subordinates to economize on the cost of delayed transmission of information to the apex, as formalized by Belenzon et al. (2019) and Cheng and Suen (2019).

Rather than focusing on managerial capacity or changes in the organization's environment, the literature on modularity in organizations highlights (as a determinant of the shape of the hierarchy) the burden on managers to coordinate interdependencies given the production tasks at hand. Researchers have been particularly interested in modularization as a strategy for managing complexity in partially decomposable systems with many (typically task-related) interdependencies (Baldwin & Clark, 2000; Ethiraj & Levinthal, 2004; Sanchez & Mahoney, 1996). By grouping tasks into discrete clusters that effectively ignore interdependencies with other clusters—or if possible, reducing them through the design of interfaces—local improvements within clusters may be obtained, but possibly at the expense of overall system performance in imperfectly decomposable systems (Parnas, 1972; Raveendran et al., 2015; Tee et al., 2019; Tee, 2019; also see Garicano & Wu, 2012, for a related argument on the relationship between specialization, knowledge attributes, and the need for coordination). When the task architecture is modularized to locate interdependencies mostly within rather than across individual subunits, extant theory predicts that organizations are likely to delegate authority down the hierarchy to the sub-unit level (Baldwin & Clark, 2000; Ethiraj & Levinthal, 2004; Felin &

[2]Research on self-managed teams (Bunderson & Boumgarden, 2010; Langfred, 2007; Morgeson, 2005) has typically focused on the intra-team processes that replace reliance on externally imposed (formal) authority, but not the extent of authority hierarchy itself.

Zenger, 2014; Rivkin & Siggelkow, 2003; Siggelkow & Levinthal, 2003). In line with this reasoning, Zhou (2013) shows that modularity in task interdependence is negatively associated with the number of hierarchical layers in the reporting structure, and Lee (2022) notes that increasing task complexity may contribute to an increase in hierarchical layers in gaming start-ups.

The literature on modularity thus usefully extends the discussion of the antecedents of the shape of hierarchy beyond managerial capacity and environmental factors by highlighting the role of internal organizational factors such as task interdependence. Yet there remains a crucial missing element: the role of organizational practices shaping culture and incentives that tune the potential for conflict. For instance, the focus of the modularity literature has been on task interdependencies between units. However, conflicts ultimately arise between people, not tasks. This implies that conflict mitigation practices and cultural norms can moderate the link between task modularity and the actual realized conflicts in powerful ways. Conflicts arising from residual and unanticipated interdependencies can be managed in a peer-to-peer manner by collocation, work procedures, incentives that promote cooperation and information exchange, and socialization and selection practices that sustain a culture of collaboration (Behfar et al., 2008; Tee et al., 2019). Further, such moderation of conflicts can occur not only between but also within organizational units.

Relatedly, a rich literature on incentives in organizations (Baker et al., 2002; Kretschmer & Puranam, 2008; Oxley & Pandher, 2016) describes how they can help promote cooperation and information exchange between and within units. Conversely, incentives that promote competition between units may exacerbate conflicts (Sengul et al., 2019). Design choices and interventions can affect not only the structure of interdependencies but also incentives and organizational culture itself, which ultimately affect the incidence of conflicts. Thus, a theory of the growth of hierarchy must link design choices and interventions to the way the authority hierarchy grows as the organization scales. In the next sections, we describe our attempts to develop such a theory.

3 | A THEORY OF CONFLICT AND HIERARCHICAL GROWTH: OVERVIEW

Our theorizing builds on the premise that organizations can be viewed as goal-directed systems of collaboration (Simon, 1947). Collaboration requires successful cooperation and coordination across multiple actors. When collaboration succeeds in creating the "unity of effort (required) by the demands of the environment" (Lawrence & Lorsch, 1967, p. 11), then effective integration of effort has occurred. Conversely, failures of integration arise in the form of insufficient motivation (agency problems and cooperation failures) and/or insufficient information (knowledge gaps or coordination failures) (Gulati et al., 2005). We conceptualize these as *conflicts*. For our theoretical purposes, we do not distinguish between different forms of conflict. We consider all breakdowns in collaboration to manifest as conflicts, which include disagreements and disputes that may be explicit (e.g., conflicts arising from coordination or cooperation failures) or implicit (e.g., free-riding or undetected misunderstandings). Research on conflict within groups suggests that finer parsing of conflict into sub-categories has not yielded robust empirical predictions (Behfar et al., 2008; De Wit et al., 2012).

We focus on the conflict resolution role that managers perform in authority hierarchies. To be sure, managers perform other important functions. They act as channels and aggregators of information from the bottom toward the top of the hierarchy. In network terms, a tree-like

structure of information flows may help aggregate information from the bottom to the top in a manner that avoids overwhelming the apex, and each layer might be characterized by a span that reflects the aggregation capacity and load on that node. While this function of information aggregation does not necessitate authority, it is often combined with the exercise of authority in a hierarchy. Nevertheless, as we elaborate below, adding on the functions of information aggregation, problem solving, and one-to-one supervision does not alter our results qualitatively.

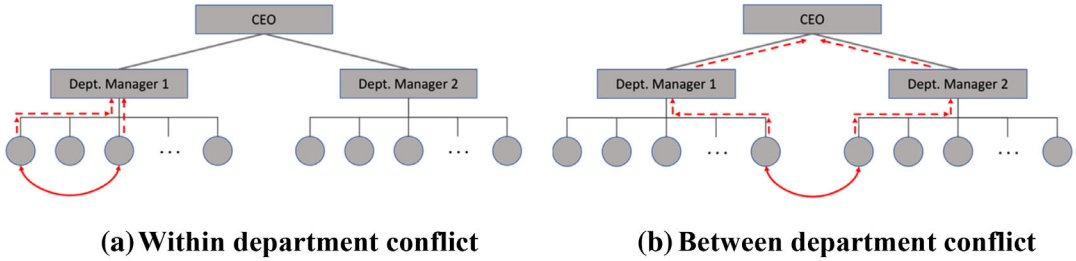
The prior literature shows that the extent to which conflicts (that require managerial intervention) might arise between agents will depend on (a) the allocation of tasks among agents, the nature of interdependence that arises between the agents as a function of this task allocation, and the associated reward structure (e.g., on group output or individual output); and (b) the extent to which the agents are able to resolve these conflicts themselves through their shared prior experiences, trust, and mutual understanding without having to involve a superior. Design choices to mitigate conflicts can operate through either of these channels (Puranam et al., 2012; Thompson, 1967).

We develop a model in which these choices are instantiated in reduced form as conflict mitigation parameters. For instance, the agents can be made independent by allocating them independent tasks and rewarding them just on their own narrow goals, effectively reducing any chances of conflict between them (Puranam et al., 2012). This is the task redesign channel for conflict mitigation that modularizes an organization. Alternatively, rather than modifying the task allocation or the incentive structure, one might invest in staffing positions that have high dependencies and potential conflicts with individuals who have a substantial track record of shared working, trust, and collaboration. The organization may then benefit from these individuals' capacity for peer-to-peer dispute resolution or create such conditions (Carroll & Harrison, 1998, 2002; Chatman & O'Reilly, 2016). Prior literature shows that such cultural factors can be influenced through two primary design mechanisms (Carroll & Harrison, 1998, 2002; Chatman & O'Reilly, 2016; Harrison & Carroll, 1991; Schein, 2004): (a) sorting through the selection of individuals into and out of the organization based on their fit (either by employees themselves, or managers, or both); and (b) socialization through the top-down and peer-to-peer influences among members of the organization. This channel of cultural intervention based on socialization and selective hiring can promote cooperative norms that can serve to mitigate conflict.

Despite these measures, conflicts may persist. We assume that these are then resolved by managers with the authority to do so, within the limits of their conflict resolution capacity. For instance, inexperienced managers may lack the necessary hard and soft skills that lead to effective conflict management in teams, and even experienced managers have finite capacities. This capacity limit determines how large a manager's span can be, shaping the overall authority hierarchy (number of managers, layers, and spans). In our model, we explore the implications of these three aspects—production scale, measures to mitigate conflicts, and managerial capacity—and how they jointly influence the extent of the authority hierarchy as an organization increases its scale of production.

4 | MODEL

We assume that an organization consists of production workers who are managed by an authority hierarchy of a fixed number of managerial layers determined by factors outside of the model (for instance, due to equity concerns or to limit control and information



(a) Within department conflict **(b) Between department conflict**

FIGURE 1 Within and between department conflict resolution (three-layered hierarchy). Assuming the conflict arises among the production workers, there are two types of conflicts that are to be mitigated. (a) Within team (department) conflict is resolved without any escalation in the hierarchy either by workers directly or the team head. (b) Between team (department) conflict requires escalation to the first common manager head (CEO) who can mitigate cross-team (cross-department) conflict.

transmission losses). We derive the number of managers needed to ensure that the organization grows to a conflict-free equilibrium scale of production as a function of design choices that affect the incidence of conflicts within and between teams. For simplicity, we do not explicitly consider how the organization's designer makes these design choices. In *Appendix §1: Elaboration of Designer's objective function*, we give a more complete account of how these design choices may be viewed as the result of optimizing an objective function that assumes that scaling is profitable, subject to the constraint that conflicts unresolved by managers are kept to zero.

Technological and cultural changes that affect conflicts may be difficult to anticipate in dynamic environments. For instance, a new technology for collaboration may arise or cultural and socioeconomic changes may lead to a growing demand for working from home, raising the possibility of greater conflicts. We therefore also consider an adaptation stage in which initial design choices can be revisited and changed (in ways which could not be anticipated at the beginning of the growth process), but with costs.

In the baseline analysis, we make two simplifying assumptions that we relax once the core intuition for our results has been established. First, we follow classical analyses of hierarchies and model a "separated" hierarchy, in which managers and workers play distinct roles (Williamson, 1967). We assume that conflicts arise only among production workers, and managers at any layer do not generate additional conflicts—they only resolve conflicts arising between production workers over whom they have authority.[3] In nonseparated hierarchies, managers are involved also in production function of the organizations (Puranam, 2018). This increases the pressure on managerial capacity on conflict resolution, but it does not alter our insights in the absence of incentive misalignment. Second, we assume that the goal for middle managers is to resolve conflicts among their direct subordinates, and pass on, unfiltered, any conflicts that fall outside their jurisdiction (i.e., outside their own teams of direct and indirect reports). Put differently, if the workers in different teams have a conflict, these are channeled upwards until the first common boss is reached (see Figure 1). This is formally equivalent to

[3]One can also imagine the other extreme when production involves the sequential flow of work through increasingly powerful actors (e.g., in a consulting firm, a research team, or in a craftsman's shop); this is a nonseparated hierarchy. Knowledge hierarchies (Garicano, 2000) and hierarchies that enable parallel information processing (Radner, 1993) are task hierarchies but not necessarily authority hierarchies. The separated hierarchy model is sufficiently general to capture such higher-level conflicts as well.

the assumption that all unresolved conflict among peers can only be resolved by the first manager who has authority over both (March & Simon, 1958; Mintzberg, 1983). Depending on the shape of the hierarchy, conflicts may have to be escalated across levels before the first common boss can be found.

4.1 | Conflict-free equilibrium conditions for a three-layered hierarchy

We first consider the case of a three-layered hierarchy which has a "layer 1" of production workers grouped in teams, a "layer 2" of middle managers (one for each team), and a "layer 3" CEO. The three-layered structure is the smallest one in which we can illustrate our arguments clearly. Later we extend the analytic model beyond three layers. See Table 1 for a full list of model parameters.

In a three-layered hierarchy, team size at the layer 1 corresponds to the span of control of each middle manager denoted by ω_1, and the number of middle managers corresponds to the span of control of the CEO denoted by ω_2. Under the assumptions that no unresolved conflict exists, and all managers are fully utilized, the span of control ω_i for a manager (i.e., the number of their direct subordinates) in either layer, $i=1,2$, are such that their respective conflict-

TABLE 1 Model parameters.

Variables/ parameters	Name	Description
Variables		
ω_i	Span of control at layer i	The total number of direct subordinates per manager (e.g., workers at layer 0, first middle manager at layer 1, etc.)
N	Total number of production workers.	
Z_i	Scope of supervision at layer i	Total number of production workers under a manager's supervision at layer i ($Z_i = \prod_1^i \omega_j$ where ω_i is span at layer i).
Design parameters		
θ_w	Within-team conflict mitigation, captures the extent of self-management within teams.	Probability that an interaction within a team among workers will not turn into a conflict in need of managerial resolution. $\theta_w \in (0,1)$
θ_b	Between-team conflict mitigation, captures the extent of containment of conflict within teams.	Probability that an interaction between workers of two different teams will not turn into a conflict in need of managerial resolution. $\theta_b \in (0,1)$
C_m	Managerial capacity	The capacity of a manager to deal with unresolved conflicts among subordinates + direct supervision of subordinates.
k_i	Capacity multiplication factor at layer i.	The capacity of manager at layer i as multiple of C_m.(k_i>1)

resolution capacity is equal to the supervisory load imposed on them. We denote layer 1 manager capacity by $C_m>0$ and layer 2 CEO capacity by a "k_2" multiple of C_m. Accordingly, the following relations hold at the conflict-free equilibrium:

$$C_m=(1-\theta_w)\times\omega_1^2\times\frac{1}{2}, \tag{1}$$

$$k_2\times C_m=(1-\theta_b)\times\left(\omega_1^2\omega_2^2-\omega_1^2\omega_2\right)\times\frac{1}{2}. \tag{2}$$

In Equation (1), $\omega_1^2/2$ indicates total number of possible interactions among ω_1 workers in a team that requires managerial direction/supervision. For each worker, there are ω_1-1 peer-to-peer interactions (Graicunas, 1937; Shah et al., 2021) as well as interactions with the manager because of direct supervision. We assume that the interactions with the manager are half as prone to conflict as interactions among peers since the boss is the hierarchical superior.[4] Accordingly, there are $\omega_1^2/2$ interactions that can potentially generate conflicts that the manager will have to resolve.

Appearing in the same equation, the parameter θ_w bounded between (0,1) captures the probability with which interactions within a team can be managed laterally without turning into conflicts that must be escalated to the first common supervisor. Thus, θ_w tunes the extent to which the potential conflicts within teams can be reduced to yield lower supervisory burden on team managers; it is a measure of how *self-managed* the teams are. Technological factors that could lead to a high θ_w design could include a modular task decomposition within the team of subordinates who report to a common boss (as in a call center or accounting department, where processes are highly standardized and repeatable), or creating high levels of shared knowledge using electronic repositories (as used in software development). Cultural and organizational factors that could lead to a high θ_w (for a given task interdependence) include collocation, homogeneity in terms of knowledge and values achieved through selection and socialization of employees, formal conflict mitigation processes, and informal norms to aid peer-to-peer dispute resolution within teams (Behfar et al., 2008; Bunderson & Boumgarden, 2010; Langfred, 2004, 2007).[5]

In Equation (2), the scope of the first-layer manager is the number of all possible interactions among workers under indirect supervision less the scope of the middle managers. Here $(\omega_2\omega_1)^2/2$ indicates the number of all possible dyadic conflicts among workers under the focal layer 2 manager, the CEO, while $\omega_2\omega_1^2/2$ is the sum of all possible conflicts within the production teams, which are dealt with by the layer 1 managers.

The parameter θ_b bounded between (0,1) tunes the probability that these between-team interactions are manageable laterally, without turning into conflicts that need escalation to a common higher manager (in this three-layered hierarchy, the CEO). It is therefore indicative of *self-containment* of teams. Technological factors that could lead to a high θ_b design include a modular decomposition of tasks *between* teams such that no interdependencies between them

[4]Our results are robust to varying this ½ factor. Results available upon request.

[5]One can also interpret a high θ_w as indicating conditions that allow for high levels of optimal delegation. The optimal level of delegation of decision rights balances autonomy (i.e., freedom from supervision) against loss of control for the superior (Dobrajska et al., 2015). Therefore a high θ_w implies that subordinates within the team can work effectively together without the need for hierarchical intervention, allowing the optimal level of delegation to be greater.

are recognized, or highly standardized processes that connect the work of different teams or automate the coordination between teams (as in version control in software development). Organizational and cultural factors that can produce a high θ_b (again, for a given level of task interdependence) include norms or processes of peer-to-peer dispute resolution *between* teams (for instance, holacracies have elaborated procedures for "processing tensions" among peers across teams, see Robertson (2015)), collocation, and homogeneity of broader organizational culture. In the baseline analysis, we treat θ_w and θ_b as independent.

This model focuses on the conflict resolution function of authority, but the approach can be generalized. For instance, if we believe that other managerial functions such as information aggregation, supervision or mentoring give rise to a linear burden on supervisory capacity, then they are subsumed within Equation (1)—the quadratic function is the result of a sum of a quadratic $\omega_i(\omega_i - 1)/2$ and a linear function $\omega_i/2$. On the other hand, if these functions also gave rise to nonlinear effects of indirect subordinates, then those are already implicitly included in the baseline model, because these additional burdens on managers would lower values of θ_w and θ_b and our results will generalize for all possible values of θ_w and θ_b which lie between 0 and 1. It is also possible, that information aggregation, supervision and mentoring could change the feasible space of the parameters themselves, which implies that we would have to consider our results only for those feasible spaces. In sum, as long as conflict resolution is an important aspect of what managers do in the authority hierarchy (the boundary condition for our analysis), our results will be relevant. The fact that they may also perform other functions is either implicitly accounted for (if they also result in nonlinear effects of indirect subordinates), subsumed (because they will be weaker than the effects of conflict in terms of consuming managerial capacity) or indicates a subset of the parameter space where our results are most relevant.

4.2 | Comparison to prior models

An early formalization of the shape of an authority hierarchy comes from Williamson (1967), who showed how to compute the layers of an authority hierarchy assuming a constant span of control for an organization of any size (also see recent refinements by Csaszar, 2021). Subsequent work has elaborated on the trade-off arising from limits to managerial capacity, which restrict managerial spans to reduce bottlenecks but imply more layers of hierarchy, creating control and information loss as well as delays (i.e., increasing the cost of layers) (Colombo & Delmastro, 2008). Models that study the implications of this tradeoff include Bresnahan et al. (2002), Garicano (2000), and Bloom et al. (2014), which focus on improvements in managerial capacity, and Rajan and Wulf (2006), Guadalupe and Wulf (2010), Bloom et al. (2010), and Kuwahata (2015), which focus on changes to the organization's environment.

Our model builds on the basic approach of deriving the optimal span of control for a manager in an authority hierarchy as a match between their capacity and the load on that capacity imposed by their subordinates. However, we depart from prior models in two ways. First, we assume that the burden of supervision on managers arises from resolving conflicts among subordinates (including indirect subordinates). This imposes a nonlinearly increasing demand on managerial capacity as a function of scale, so that managerial spans cannot be assumed constant across layers, as many prior models have done (Beckmann, 1960; Simon, 1976; Williamson, 1967). Second, we focus on the impact of design choices that shape where the unresolved conflicts are most likely to occur—within or between teams—that become exogenous parameters during the actual growth process of the hierarchy.

4.3 | Results

Using the conflict-free equilibrium conditions set out in Equations (1) and (2), we compute the shape and scale of the resulting organization at the end of its growth process, given the design parameters θ_w and θ_b and the managerial capacity parameters C_m and k_2.

4.3.1 | The shape of hierarchy

In this three-layered hierarchy, we first examine the managerial spans (i.e., team size) and the number of managers in the hierarchy. We can calculate the managerial span at each layer of the hierarchy from Equations (1) and (2) as below[6]:

$$\omega_1 = \sqrt{\frac{2C_m}{1-\theta_w}}, \tag{3}$$

$$\omega_2 = \frac{1}{2} + \sqrt{k_2\left(\frac{1-\theta_w}{1-\theta_b}\right) + \frac{1}{4}}. \tag{4}$$

While much debate in the practice literature has been concerned with the exact values of optimal managerial span,[7] Equations (3) and (4) set out the general contingencies on which they depend. The first-layer span (i.e., team size) in (3) is increasing in managerial capacity, C_m, and within-team conflict mitigation, θ_w. It approaches infinity when within-team conflict mitigation approaches 1, which reflects the intuition that managers are unnecessary if team members can self-manage, resolving all conflicts arising from their interactions in a peer-to-peer manner.

Equation (4) shows that the span of the CEO (i.e., the number of middle managers) is shaped by the ratio of within-team to between-team conflict mitigation measures. The number of middle managers ω_2, increases unboundedly when between-team conflict mitigation approaches one (for instance, when teams are effectively self-contained) and approaches its minimum value when within-team conflict mitigation approaches one (when teams are effectively self-managing). Finally, since the total size of the organization is $\omega_1.\omega_2$, managerial intensity (ω_2/N) is simply $1/\omega_1$: it decreases in both managerial capacity as well as the degree of self-management within teams.

In Figure 2, we illustrate two possible designs for a conflict-free organization with a production scale $N = 40$ and managerial capacities of $k_2 = 2$, and $C_m = 10$. At the top of Figure 2, teams are designed to prioritize self-management (higher θ_w), consist of 20 members each and require conflict resolution from the corresponding 2 middle managers. At the bottom of Figure 2, teams of size 8 are designed to prioritize self-containment (higher θ_b) and there are 5 middle managers.

[6]We assume that spans are positive real numbers for tractability. Since our analysis hinges on the conflict load created by the spans, this is a reasonable assumption.

[7]See for instance https://www.mckinsey.com/business-functions/organization/our-insights/how-to-identify-the-right-spans-of-control-for-your-organization#; and https://www2.deloitte.com/content/dam/Deloitte/us/Documents/human-capital/us-spans-and-layers-for-the-modern-organization-2020.pdf.

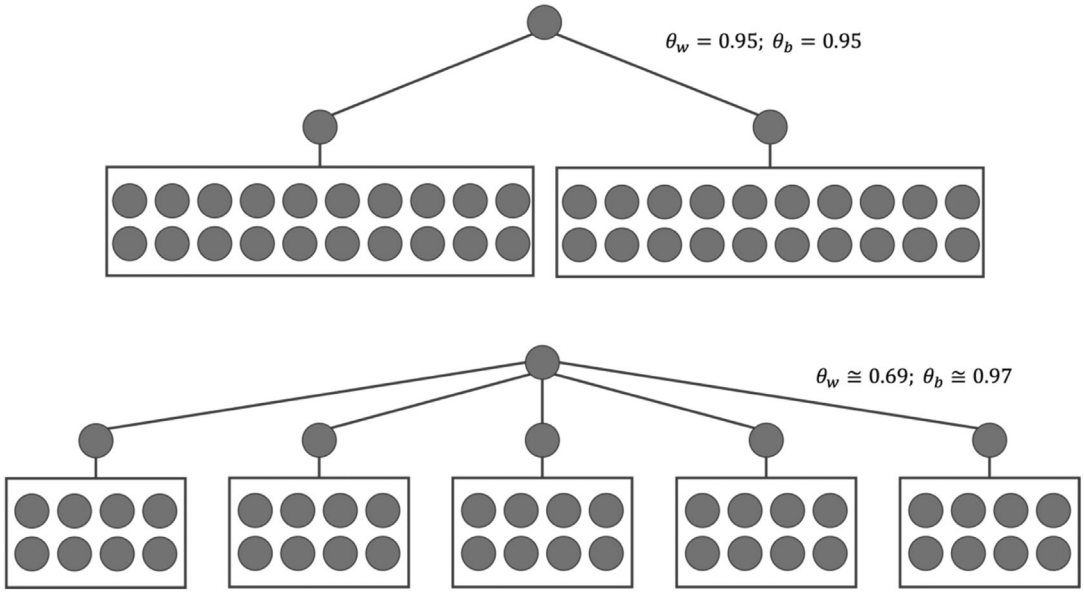


FIGURE 2 Equivalent ways of organizing a three-layered hierarchy with scale 40. Two ways of designing an organization of production scale $N = 40$ with same managerial capacity of $k_2 = 2$, $C_m = 10$: (Top) Flat design with team size 20 and 2 middle managers, (Bottom) Hierarchical design with team size 8 and 5 middle managers.

4.3.2 | The scale of production

We next examine how the scale of production depends on the conflict mitigation parameters and managerial capacity. In all further analysis, for tractability we approximate Equation (4) such that

$$\omega_2 = \frac{1}{2} + \sqrt{\frac{2k_2C_m}{1-\theta_b} \times \frac{1}{\omega_1^2} + \frac{1}{4}} \sim 1 + \sqrt{\frac{2k_2C_m}{1-\theta_b}} \times \frac{1}{\omega_1}. \tag{4'}$$

Appendix §2 shows that the error introduced in ω_2 by this approximation is less than 1/2 for any value of the other parameters.[8] With this approximation in place, we can compute the production scale

$$N = \omega_1\omega_2 \sim \sqrt{\frac{2C_m}{1-\theta_w}} + \sqrt{\frac{2k_2C_m}{1-\theta_b}}. \tag{5}$$

Equation (5) shows that both the conflict mitigation parameters θ_w and θ_b are positively related to production scale. Given our assumption that the marginal benefit of scaling is constant and positive, we can infer that the designer of the organization would always have set

[8]The results of numerical analysis show that the behavior of the simplified model is congruent with the ones of the fully specified ones. Albeit limited to a parameter space, we could reproduce the major outcomes without the simplifying assumption. The results can be shared upon request.

θ_w and θ_b to be as large as possible subject to the (firm-specific) costs of increasing these parameters (Appendix §1). However, different organizations could still select different values of θ_w and θ_b for idiosyncratic reasons. For instance, how easy it is to modularize interactions or build effective norms for peer-to-peer conflict management is likely to be different across organizations due to distinct path-dependent histories, even in the same industry. Therefore, organizations can vary in their equilibrium conflict-free scale depending on the emphasis they place on self-containment (high θ_b) vs. self-management (high θ_w) designs.

While θ_b (self-containment) plays no role in shaping managerial intensity in this three-layered hierarchy (since that is $1/\omega_1$), we can see from (4′) and (5) that both the number of middle managers and scale increase in θ_b, with the latter increasing more rapidly with this parameter. This suggests that self-containment might play a role in lowering managerial intensity in larger multilayered systems, a conjecture we verify in the next section.

Equation (5) shows that N also increases in the supervisory capacity at both layers (i.e., C_m and k_2C_m). Even though located distant from the production layers, the CEO's capacity multiplier relative to the middle manager k_2 has a direct impact on scale with decreasing marginal impact (i.e., $\partial N/\partial k_2>0$ and $\partial^2 N/\partial k_2^2<0$). Managerial capacity can be affected by costly investments in selection, training and technology (e.g., improved capacity for managerial decision making and supervision through algorithms). As with the conflict mitigation parameters θ_w and θ_b, if managerial capacity $(k_2)C_m$ is endogenous to design, then the Designer would also want capacity to be as large as possible.

Finally, Equation (5) also shows that the two conflict mitigation parameters do not have symmetric effects on optimal scale; self-containment is more consequential than self-management (for $k_2 > 1$). Figure 3 graphically illustrates how the equilibrium scale of the production (N) changes over the parameter space based on the combination of the conflict mitigation parameters, $(\theta_w,\theta_b) \in (0,1)\times(0,1)$ holding other parameters constant at $C_m=10$ and $k_2=2$. The horizontal axis represents θ_b and vertical axis indicates θ_w. The graph shows that the organizational scale increases as one moves from SW to NE of the plane—as Equation (5) shows, scale grows without limit as θ_w and θ_b approach 1. The effects are not symmetric, however, because of the capacity multiplier $k_2>1$.

Figure 3 shows that the equilibrium scale is divided into two regimes by a shifted diagonal from SW to NE (see $\overline{AB}$). This diagonal indicates the line along which the marginal effects of the two parameters on scale (N) are identical, having the functional form:

$$\theta_w = k_2^{-1/3}(\theta_b - 1) + 1. \tag{6}$$

We obtain Equation (6) by solving $\frac{\partial N}{\partial \theta_w} / \frac{\partial N}{\partial \theta_b} = k_2^{1/2} \times \left(\frac{1-\theta_w}{1-\theta_b}\right)^{3/2} = 1$ where the two marginal effects are balanced. Above this line, the marginal contribution of θ_w to N is greater than that of θ_b, and below vice versa. For illustration, Figure 4 focuses on the white dashed line where the relation $\theta_w+\theta_b=1$ holds. We observe that below a threshold value of θ_b^*, reduction of θ_b (resulting in the increase of θ_w) contributes to larger scale, whereas above this threshold its increase does so. Because the threshold is on the shifted diagonal where marginal effects are equal, change in parameters in both directions has the same marginal contribution. Further, Equation (6) shows that the combination of managerial capacity (k_2) and self-containment act in a functionally equivalent manner to self-management of teams. This functional equivalency is visible in Figure 3 through the contour lines which denote constant production scale for different combinations of conflict mitigation parameters.

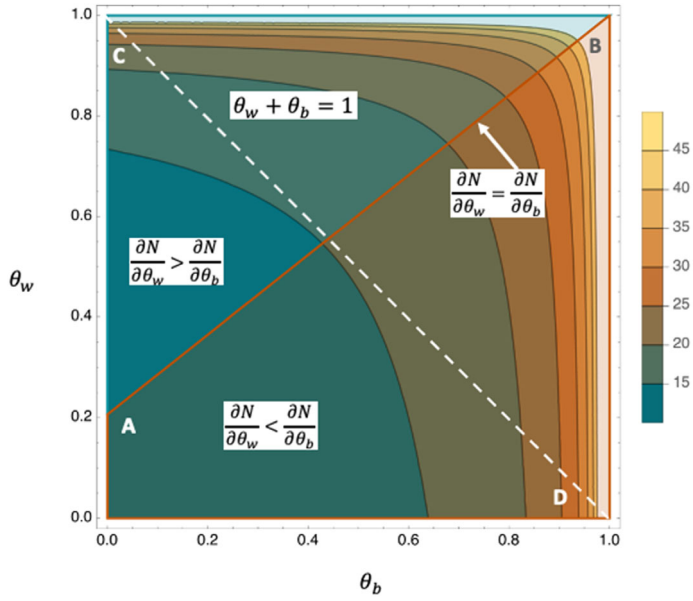


FIGURE 3 Production scale as a function of conflict mitigation parameters. We generalize Figure 2 to all values of conflict mitigation parameters and production scale.

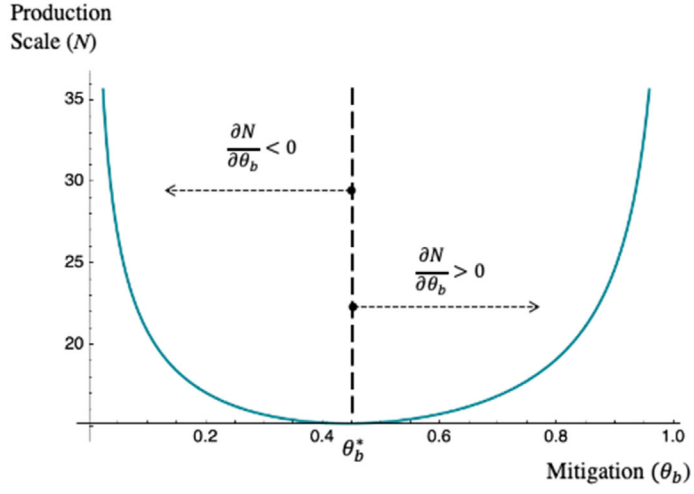


FIGURE 4 Marginal contribution of conflict mitigation parameters to the production scale. The marginal contribution of the conflict mitigation parameters depends on which region the organization already is in. Given a budget constraint, the parameter with highest marginal contribution per marginal cost will be preferred. For $\theta_w + \theta_b = 1$, organizations already above the threshold value of θ_b^* will prefer reinforcing the between team conflict mitigation mechanisms, and vice versa for those below.

4.4 | Adaptability analysis: The long-term impact of initial design choices

Next, we consider how the organization adapts to unanticipated opportunities to change the conflict mitigation parameters (i.e., ones not foreseeable during design prior to the growth

stage), subject to some constraints. Such opportunities might arise from technological or organizational innovation, for instance, improved digital collaboration tools (Hinds et al., 2002), or improved practices for building collaborative social norms through data-driven sorting of employees on entry and exit (Harrison & Carroll, 2006).

Reorganizations typically cannot alter the design of organizations ab initio but are constrained by existing organizational conditions (Gulati & Puranam, 2009; Raveendran, 2020). While reporting structures at higher levels in the hierarchy can be changed by administrative fiat, the basic patterns of division of labor, specialization, interdependence and cultural norms of collaboration and conflict resolution are harder to alter (Nickerson & Zenger, 2002; Raveendran, 2020). We therefore consider only local changes to the conflict mitigation parameters in this adaptability analysis and ask if *the Designer could nudge the conflict mitigation parameters, subject to some constraints, how should she do so?*

We know from Equation (5) that whatever the current set of parameters θ_w and θ_b, if exogenous changes allow for resetting of these parameters, it will always be optimal to increase both until their marginal returns equal their marginal costs. However, even if the marginal costs of adjustment of each parameter are identical, their marginal returns will not be, inducing path dependence in reorganization. As shown in Figure 3, within the regime where the combination of parameters is located above the critical points (i.e., above the line $\overline{AB}$, where $\theta_w \gg \theta_b$), increasing θ_w yields higher marginal benefits in terms of scale. Conversely, when the organization is located below the line $\overline{AB}$ the marginal benefit for scale of improving θ_b is larger. Thus, if the Designer can make marginal adjustments to the two parameters with equivalent costs, then the direction in which such change can be most usefully made will depend on the current levels of the parameters. It may even involve improving the parameter that is already closer to 1 because the returns will be higher from doing so. We also explore more generally the case when the two conflict mitigation parameters may be interdependent beyond the condition of $\theta_w + \theta_b = 1$ (see *Appendix §3: Trade-off between the two conflict mitigation parameters*).

The results from this adaptability analysis thus suggest that one should avoid the impulse to do "fire-fighting." Depending on the current location relative to the threshold, it may instead be preferable to "improve the better," to focus on improvements in the conflict mitigation parameter that is already higher. This would be true even if the marginal costs of changing either parameter were the same. A further implication is that over time organizations may rationally continue to focus on the kind of conflict mitigation they had an initial advantage at: within or between teams. Initial choices prior to the growth stage can be reinforced by choices made for adaptability when unforeseeable opportunities for redesign arise. As a consequence, even small initial differences may produce large differences in designs over time if reorganization takes place repeatedly (De Santola & Gulati, 2017; Simsek et al., 2015; Stinchcombe, 1965).

We illustrate this by considering two organizations with $N = 15$ production workers, where Organization 1 lies above the red threshold line in Figure 3 with $(\theta_w, \theta_b) = (0.55, 0.424)$ and Organization 2 below the red threshold line with $(\theta_w, \theta_b) = (0.52, 0.45)$, each parameter pair fulfilling Equation (5) with $C_m = 10$ and $k_2 = 2$. These small differences could arise from firm-specific differences in the cost of setting the conflict mitigation parameters before the growth stage unfolds. Given these starting points, in the second (adaptation) stage of reorganization going from $N = 15$ to $N' = 16$, Organization 1 above the threshold line would need to adjust $\Delta\theta_w = 0.11$ units keeping θ_b constant or $\Delta\theta_b = 0.12$ units keeping θ_w constant; for equal marginal adjustment costs, Organization 1 will reinforce its *within*-team conflict mitigation capacity. The Organization 2 below the threshold line would need to adjust $\Delta\theta_w = 0.12$ units keeping θ_b constant or $\Delta\theta_b = 0.11$ units keeping θ_w constant; again, for equal marginal adjustment costs,

Organization 2 will reinforce its *between*-team conflict mitigation capacity. If the trajectories of these organizations involve a series of iterative cycles of reorganization, then they will diverge significantly over time, despite being initially nearly identical.

4.4.1 | Summary

The analysis of the three-layered hierarchy shows the intuitions behind how the shape of hierarchy as well as the scale of the organization at the end of the growth process depend on designs for self-managed and self-contained teams, as well as managerial capacity. First, managerial intensity declines with managerial capacity and self-management within teams, and there are indications that self-containment will also play a role in curtailing managerial intensity in larger multilayered systems. Second, the optimal scale of the organization increases with both self-management and self-containment of teams, but the latter has a stronger effect. Third, designs display path dependence. Choices made prior to the growth stage can be reinforced by choices made for adaptability when unforeseeable opportunities for redesign arise.

4.4.2 | Generalizing beyond three-layered hierarchies

In Appendix §4 we generalize the model beyond the three-layered hierarchy. While the analysis is technically more complicated, the results are qualitatively the same as in the three-layered hierarchy, with some additional insights. First, for an arbitrary number of layers, we replicate our analysis about the distinct effects of θ_w and θ_b on scale and shape of hierarchy during the growth stage, as well as the adaptability stage. We find that managerial intensity declines in both self-containment and self-management parameters as well as managerial capacity. Second, we also find that the asymmetry—where self-containment affects optimal scale more than self-management—becomes stronger in multilayered structures. Third, the adaptability analysis shows that multilayered organizations will be likelier to invest in improving self-containment than self-management when opportunities for changing these parameters arises. This suggests also that the design interventions and skills needed in multilayered structures will be systematically different from those in fewer layered structures, and that this difference may be an additional source of difficulty when scaling up. Additionally, we find that in multilayered hierarchies, it is extremely unlikely that managerial spans can stay constant across layers mainly because the managerial capacity which is required to meet the equilibrium zero-conflict conditions increases exponentially as one goes up the ladder.

5 | DISCUSSION AND CONCLUSION

To understand the conditions under which organizations might scale without increasing the extent of their authority hierarchy (i.e., the number of managers relative to the number of workers), we formulated a model of hierarchical growth. The central role of managers in this model is to resolve conflicts and disputes among their subordinates. Conflicts are not a purely technologically determined property. Two organizations with the same task interdependence structure can nonetheless experience different degrees of within- and between-team conflict. This is because their norms and processes for avoiding conflict—which in turn depend on the

organization's processes such as how it selects employees, socializes them, and places them in the system—will also matter. Intuitively, in such a model, designs that prevent conflicts from being realized in the first place (Fjeldstad et al., 2012) or endow managers with greater capacity to resolve conflicts imply a lower need for an authority hierarchy. However, our analysis also points to two further conclusions.

First, efforts to mitigate conflicts that occur within and between teams have different implications for the optimal conflict-free scale of the hierarchy: in general, optimal scale is more sensitive to between-team than within-team conflicts, and this is even more the case in larger multilayered hierarchies. Put simply, self-containment dominates self-management as a design for scaling flatter. Second, our results highlight that when reorganization opportunities arise, which parameter it is better to improve will depend on their current values. Further, optimal scale may be better achieved through improving the conflict mitigation parameter that is already higher, not the one that is lower (which might seem more intuitive). This creates a self-reinforcing path that can produce large differences in designs starting from small initial differences.

5.1 | Implications for research

5.1.1 | Three levers for scaling nonhierarchically

Our results help to integrate the insights from several formerly disconnected literatures: on modularization and its relation to hierarchy (Ethiraj & Levinthal, 2004; Zhou, 2013), on self-managed teams and the role they play in nonhierarchical organizations (Bunderson & Boumgarden, 2010; Lee & Edmondson, 2017; Meyer et al., 2017), on the relationship between culture and structure (Bloom et al., 2010), and on managerial capacity and its impact on organization design (Bloom et al., 2014; Garicano, 2000).

We find that designing to scale nonhierarchically will require increasing the two conflict-mitigation parameters (for any given level of managerial capacity). "Self-managed teams" with high θ_w and "self-contained" teams with high θ_b are thus two possible paths to scaling nonhierarchically, though the relevant literatures have each focused so far on only one or the other. There is also the third well-known path of increasing managerial capacity as we climb layers (Bloom et al., 2014; Garicano, 2000). Our results point to functional equivalence relationships between these parameters. Absent efforts to increase them, mechanically flattening hierarchical structures can produce significant unresolved conflict within the organization (Meyer et al., 2017).

This framework for thinking about managerial capacity and conflict within and between teams may help us interpret different empirical studies within a common framework. For instance, Lawrence and Poliquin (2022) studied the elaboration of hierarchy in Brazilian firms and report that founding teams are likelier to adopt a hierarchical structure when they have greater barriers to communication because of a lack of shared experience (which should lead to low θ_w) and a higher number of specialized workers needing extensive coordination (which should also lead to low θ_w and low θ_b). Neither a focus exclusively on modularity (self-contained teams) nor on self-management within teams would explain these associations between different forms of diversity and hierarchy; but the perspective on the joint effects of within- and between-team conflicts we have developed can do so.

In a related spirit, Lee (2022), in a study of more than 6000 video gaming start-ups, notes that hierarchical levels are more strongly associated with commercial success (measured in

terms of units sold globally) when task complexity increases so that cross-functional teams become necessary (i.e., θ_b decreases). Further, the positive relationships between hierarchical levels and commercial success are strongest when employees lack social capital in terms of shared experiences and broad cross-functional experience, leading to "severe relationship conflict" between functions (i.e., when θ_b and θ_w are low). Lee's results are important because the received view has been one of technological changes leading to delayering because of improvements in the managerial capacity (C_m) for monitoring (Bloom et al., 2014; Bresnahan et al., 2002; Garicano, 2000). But technological change can also increase potential conflicts, which may lead to an increase in hierarchical levels, as appears to have been the case in this context. Further, Lee's data shows that apparently different factors—such as technological properties and social capital—can nonetheless have equivalent effects, just as our model predicts, if both ultimately affect the conflict mitigation parameters in the same way.

However, we also found that the two paths based on conflict mitigation are not symmetric. Self-contained team designs are superior to self-managed ones for optimal scaling, and this advantage magnifies with scale. Our results also enjoy some face validity in case accounts of nonhierarchical firms like Buurtzorg, Spotify, Valve, FAVI, Morningstar, and W. L. Gore (Laloux, 2014). Some of these firms that are of moderate and large size (e.g., the gaming software maker Valve and the white-goods manufacturer Haier) operate with fairly autonomous and self-contained teams (a high θ_b design). Others of smaller size (e.g., the tomato paste processing company Morningstar) feature much more interdependent workgroups (suggesting a low θ_b design). They rely instead on norms that minimize conflicts within workgroups, such as their "Colleague's Letter of Understanding," an informal contracting device among teammates (a high θ_w design) that produces empowered teams. Differences in the extent of task interdependence (possibly higher in Morningstar) and profitable scaling opportunities (possibly lower in Morningstar) between the environments could help explain these variations, as per our theory.

Further, the asymmetry in these two paths to scaling nonhierarchically through conflict mitigation increases with the size of the organization. As the overall organizational size increases, the potential for conflicts is much greater between teams than within teams. This is because the number of between-team conflicts will increase as a super-linear function of size, whereas it will increase as a linear function of number of teams. As a consequence, between-team conflict mitigation needs to be nearly perfect to bring conflicts down to levels that can be dealt with by plausible levels of managerial capacity.

5.1.2 | The long-term impact of initial design choices

Researchers have noted that factors pertaining to early organization design choices appear to constrain or enable entrepreneurial growth (Cao et al., 2015; Marquis & Tilcsik, 2013; Stinchcombe, 1965). As a consequence, scaling up can be challenging for start-ups even when their business model is effective, and they face no constraint in demand, production, capital, or talent (De Santola & Gulati, 2017). Our model offers a specific mechanism through which early choices about an organization's design—specifically choices that affect the potential emergence of conflicts between and within teams—impact the eventual scalability of the organization in terms of its reliance on authority hierarchy.

When reorganization opportunities arise, the parameter to prioritize depends on the current location of the organization in the parameter space, relative to a threshold that depends on managerial capacity (as well as the number of layers in the hierarchy). This is an instance of

how initial design choices can cast long shadows on the organizational structure, in this case on the shape of the authority hierarchy as well as the direction of its change under efforts to reorganize when possible. The results particularly suggest that, depending on where the organization finds itself in the space of conflict mitigation parameters when reorganization opportunities arise, it may be wiser to "improve the better"—to focus on improvements in the conflict mitigation parameter that is already higher.

5.2 | Limitations

In the interests of tractability, we have made some simplifying assumptions that future work might elaborate on. For instance, instead of assuming that the task or knowledge hierarchy is orthogonal to the authority hierarchy as we have done (in our model, managers do not generate conflicts), it is possible to extend our model to an integrated hierarchy, where higher-level managers also engage in production. Intuitively, this would add to the conflicts at every layer, exerting even stronger pressures on managerial capacity and therefore leading to taller hierarchies.

Further, it may be unrealistic to assume a fixed number of layers and zero unresolved conflict and equilibrium between conflicts generated and managerial capacity at every layer in the hierarchy. Unresolved conflicts are endemic in organizations (Cyert & March, 1963), and presumably account at least in part for the typical pathologies of organization design involving various forms of integration failure (e.g., silos, parochialism, bottlenecks) (Nadler et al., 1997). Moreover, as Edith Penrose famously argued, it is more natural to assume that as organizations grow, managers will sometimes have underutilized capacity—since they represent "lumps" of capacity—as well as sometimes suffer from excess demands on their capacity beyond what they are capable of meeting, since new managers cannot be hired and socialized exactly when they are needed (Penrose, 1959). In additional computational analysis, we generalized the model to capture a more organic process of hierarchical growth, in which both workers and managers are added over time without imposing these equilibrium assumptions on managerial capacity and realized conflicts. In this process, as the organization scales by increasing the number of workers, there is an increase in conflicts, which managers are hired to manage (at a constrained rate). This process can result in periods in which managerial capacities are underutilized as well as periods in which they are exceeded (with unresolved conflicts). While the qualitative picture to emerge from this dynamic growth simulation is consistent with that reported from equilibrium analysis in the paper, it also offers opportunities for further research.

We have also assumed that while the conflict mitigation parameters may change over time (reorganization), they are not affected in reverse by the hierarchy's shape. For instance, an extensive hierarchy may enhance motivation by providing a career ladder, which could endogenously increase conflict mitigation parameters. Clearly, such dynamics are not unbounded; if so, all hierarchies would flatten eventually. Conversely, there is evidence that within teams, tall hierarchies may stimulate more conflict by creating competition to reach the top (Hays & Bendersky, 2015). It remains to be seen how these forces affect the overall shape of the hierarchy and is an interesting extension for future work.

Lastly, we do not distinguish between pairs of interactions. All are treated as subject to the same conflict mitigation parameters. In reality, the impact of unresolved conflicts arising between, say, sales and production may be more significant than that of those between, say, marketing and production. We disregard this variation, so that in effect our conflict mitigation parameters may be treated as an "on average" property that summarizes across all types of

inter-unit interactions. When applying the model to empirical contexts where such differences matter, the model will have to be adapted accordingly.

6 | CONCLUSION

Increasing our understanding of authority hierarchies is a significant and timely undertaking. Recent advances in decision and collaboration technologies and algorithmic management have the potential to alter not only managerial capacity for conflict resolution but also the potential for conflict mitigation within and between organizational units (Malone, 2018). Our theory may be helpful in guiding careful empirical exploration of how such changes may affect authority hierarchies.

DATA AVAILABILITY STATEMENT

Further results available on request from the authors.

ORCID

Ekin Ilseven https://orcid.org/0000-0001-8216-3150
Phanish Puranam https://orcid.org/0000-0002-0032-8538

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How to cite this article: Lee, E., Ilseven, E., & Puranam, P. (2023). Scaling nonhierarchically: A theory of conflict-free organizational growth with limited hierarchical growth. *Strategic Management Journal*, *44*(12), 3042–3064. https://doi.org/10.1002/smj.3541