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Organizing beyond Boundaries: Capabilities and Design

DISSERTATION

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by

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DEDICATION

To my Parents and all the Steinbergers.

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ABSTRACT OF THE DISSERTATION

Organizing beyond Boundaries: Capabilities, and Design

By

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Doctor of Philosophy in Management

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Professor Margarethe Wiersema, Chair

This dissertation examines the question of how firms design formal mechanisms to support the development of capabilities for organizing beyond the traditional boundaries of factory and office. This question is of growing interest in strategy as a result of several ongoing developments: increased modularization of products and processes that enable coordination outside of the firm; continued advances in digital and communications technologies that enable rich communication; and the further growth of franchising systems, platforms and ecosystems that operate based on coordinating agents who are often not internal employees. Firms can stand to benefit from greater scale and scope when organizing beyond boundaries, but must face the challenges of executing reliably with less direct control over operations.

To better understand these potential benefits and challenges, I use conceptual and design methods to develop frameworks regarding the relationship between firm strategy and organizing beyond boundaries. In Chapter 1, I introduce a framework for understanding organizational capabilities in terms of information processing. The framework enables conceptualizing capabilities in terms of their ability to scale, which is a

critical issue in organizing beyond boundaries but has been less examined in prior literature. In Chapter 2, I examine how firms may structure the physical and representational spaces in which routines are performed, considered as an increasingly important source of control given less ability when organizing beyond boundaries to specify processes directly. In Chapter 3, I then examine design strategies when organizing beyond boundaries, which I link to a greater focus on developing broad systems over the long-run. Overall, the dissertation thus contributes to our understanding of firm strategy in organizing beyond boundaries by developing insights into the dynamics and spaces of micro-level organizational action and routines, as well as the macro-level implications for design strategy.

INTRODUCTION

Organizational capabilities have been described as intelligent, collective search processes that enable adapting to the uncertainty of action in complex worlds (Levinthal, 2000). Drawing on March and Simon (1958), earlier scholars viewed search processes as embedded fundamentally in an organization's routines. Much recent work, meanwhile, has argued for a view of capabilities as shaped fundamentally by individual action. This work, however, has yet to link individual action explicitly to search processes, such that the distinct implications for our understanding of capabilities remain unclear. In this dissertation, I seek to address this gap by revisiting early perspectives on information processing central to the development of concepts of search, and which can be related either to routines or to individual action. In so doing, I am able to identify capabilities in terms of distinct dimensions of effectiveness, efficiency and flexibility. The most basic claim is that accounting for individual action — specifically, in terms of the processing of information, and in terms of the physical and representational spaces in which individuals' routines are embedded — implies a far deeper role for organizational design than has been considered in recent decades.

This dissertation thus more normatively seeks to examine the question of how firms actually might design formal mechanisms to support the development of capabilities for organizing beyond the traditional boundaries of factory and office. This question is of growing interest in strategy as a result of several ongoing developments: increased modularization of products and processes that enable coordination outside of the firm; continued advances in digital and communications technologies that enable rich

communication; and the further growth of franchising systems, platforms and ecosystems that operate based on coordinating agents who are often not internal employees. Firms can stand to benefit from greater scale and scope when organizing beyond boundaries, but must face the challenges of executing reliably with less direct control over operations.

To better understand these potential benefits and challenges, I use conceptual and design methods to develop frameworks regarding the relationship between firm strategy and organizing beyond boundaries.

In Chapter 1, I introduce a framework for understanding organizational capabilities in terms of information processing. The framework enables conceptualizing capabilities in terms of their ability to scale, which is a critical issue in organizing beyond boundaries but has been less examined in prior literature. Despite the importance of capabilities to firm performance, some scholars continue to find lack of clarity in the concept. As a result, models can be vague in terms of how they relate capabilities to a firm's possible behavior and to its ability to extend this behavior. In this paper, I propose that one plausible path to addressing such issues is to model capabilities in terms of information processing. Revisiting foundational, yet now little discussed, debates about the nature of information processing during the emergence of the Carnegie School, I identify two approaches — one based on step-by-step decisions, or 'algorithms', and one based on facts about 'situations'. I identify the nature and limits of capabilities under each approach in terms of information processing, where each approach's limits serve as contingencies in an organizational design choice. While an information processing approach cannot account for the particular content of a firm's capabilities, I show how it may offer insight into some basic structural properties and their dynamics.

In Chapter 2, I examine how firms may structure the physical and representational spaces in which routines are performed, considered as an increasingly important source of control given less ability when organizing beyond boundaries to specify processes directly. A growing number of organizations perform routines not in a distant factory or office but in spaces proximate to consumption, where production thus might be said to be 'local'. 'Local production' poses distinct challenges of developing capabilities for performing routines in limited time and space. Here, I develop a framework for understanding these capabilities by comparing data on how two organizations designed the physical and representational spaces underlying their routines. It identifies both abstract ('sense'-less) and perceptual ('mind'-less) sources of action, afforded by the logic of the organization's production space.

In Chapter 3, I then examine design strategies of modularity when organizing beyond boundaries, which I link to a greater focus on developing broad systems over the long-run. Modularity has been a core concept in relating organizational design to firm strategy. Recent work finds that, amid advances in digital and communications technologies, firms increasingly modularize products and processes to support strategies of rapid adaptation. The same advances may also, however, enable developing broad systems, requiring long-run adaptation strategies. Here, I analyze field data on the design and development of a knowledge base intended to be relevant a cuisine, taking cuisines as metaphors of systems. Linking my findings to work on systems design in the AI literature, I show how modularization enables long-run adaptation when related to the production space over products or processes. I discuss implications for firm strategy and industry evolution.

Overall, the dissertation thus contributes to our understanding of firm strategy in organizing beyond boundaries by developing insights into the dynamics and spaces of micro-level organizational action and routines, as well as the macro-level implications for design strategy.

CHAPTER 1: MODELING ORGANIZATIONAL CAPABILITIES: AN INFORMATION PROCESSING APPROACH

Strategy scholars broadly agree that capabilities are an important source of variation in firm performance (Helfat *et al.*, 2009). Yet despite much discussion, there remains less agreement on how precisely to conceptualize and model them.

Knowledge-based views (e.g., Zollo and Winter, 2002) have understood capabilities to refer to processes of exploring and exploiting sources of value creation embedded in organizational routines. Other scholars (e.g., Abell, Felin and Foss, 2008), however, suggest that modeling capabilities in terms of the aggregate construct of routines may be problematic. For example, Foss and Klein (2005) argue that a basis in routines, as opposed to lower-level action (i.e., of individuals), leads knowledge-based views to be 'not clear [regarding] how capabilities are conceptualized, dimensionalized, and measured.' Felin *et al.* (2012; 2014) find that a key consequence of a lack of clarity is that models of capabilities for exploration (i.e., for learning, innovation or new product development) tend to be restricted to a mostly given set of routines performed by homogenous individuals. They suggest that firms often engage in more open-ended processes of exploration based on heterogenous individuals, and that capturing such processes requires precise assumptions about lower-level action.

Scholars have also raised issues with research on capabilities in regards to processes of exploitation. Levinthal and Wu (2010) find that, while much work in strategy follows Penrose (1959) in assuming that firms face challenges to extending their resources, the same work tends to imply that capabilities are relatively scale-free. Along these lines,

Knudsen, Levinthal and Winter (2014), citing the extensive literature on the challenges of replicating routines (e.g., Rivkin, 2001), find that a firm's efforts to extend its capabilities by scaling up may in fact impede on operations and alter the nature of the capabilities themselves. Here, assumptions about lower level action may also be helpful in capturing scale-dependent aspects of a firm's capabilities.

These issues in modeling capabilities for exploration and exploitation may be of increasing empirical relevance. Whereas knowledge-based views have often linked firm-specific capabilities to internal employees and culture (e.g., Kogut and Zander, 1992), scholars note that a growing number of firms execute strategies beyond their traditional boundaries thanks to expanding digital connectivity, the falling costs of storing and processing digital information, and increased modularization of products and processes (Benner & Tushman, 2015; Davis, 2016; Jacobides & Billinger, 2006; Gawer, 2014). This shift beyond boundaries suggests firms may be engaging in more open-ended processes of exploration (i.e., crowdsourcing and opensourcing), and may face a distinct set of challenges in managing coordination costs while scaling (i.e., developing large-scale communications or distribution systems). Overall, then, we may benefit from developing models of capabilities based not just on routines, but also on lower-level action underlying them.

In this paper, I propose that one plausible path for doing so is to model lower-level action in terms of information processing (e.g., Thompson, 1967). While information processing has been most explictly drawn on in the Carnegie School as a way to model firm-level coordination of tasks or individuals (Galbraith, 1974; Puranam, Raveendram and Knudsen, 2012), it is a core assumption about behavior in all process perspectives that

assume bounded rationality. Yet though much prior literature on capabilities considers the firm as a means of coordination by serving as an efficient mechanism for processing information (e.g., Nelson and Winter, 1982; Grant, 1996), information processing itself tends to be invoked as a background assumption rather than modeled explicitly (Foss, 2003).

Perhaps one reason information processing has been given relatively less attention in research on capabilities is that the precise assumptions underlying its initial use in the Carnegie School developed not in the organizational literature, but in Herbert Simon's seminal work with Allen Newell in building software programs (Newell and Simon, 1956). Similar to how March and Simon (1958) offer a view of organizations in terms of 'organizational programs' composed of decision-making structures (Gavetti, Levingthal and Ocasio, 2007), Simon's software programs are based on *algorithms*, in which decision-making structures are formalized in terms of a step-by-step logic of procedures for processing digital information (Simon, 1962; Day, 2008). For example, Marriott provides accommodation based on a collection of formal procedures and rules regarding customer service, cleaning, and other services. Simon soon after related algorithms to the formal structures underlying the execution of processes in any artificial system — whether software, industrial products, or organizations (Simon, 1969). His logic implies that lower-level action in firms might be considered as units of information processing, where capabilities for exploration and exploitation may be modeled in terms of the dynamics of algorithms.

Interestingly, examining the historical context of Simon's software programs reveals that his focus on algorithms relates to one of two paradigmatic models of information

processing. In contrast to Simon's step-by-step *procedural* view of the structure of information processing in terms of *algorithms*, the mathematician John McCarthy (1959) argued for a *predicate* view – in which information processing could be expressed in terms of a set of relevant facts regarding the *situations* in which activities take place (Kay, 2008). For example, Airbnb also provides accommodation but based more on a set of multimedia that contains information relevant to interactions between hosts and hostees. McCarthy believed that his 'situated' approach to modeling the execution of processes would be less restrictive on individuals' (i.e., users of software) behavior and more robust to scaling by simply modeling relevant information, rather than necessarily any particular step-by-step procedures to follow (McCarthy, 2007). Though McCarthy's approach has not been much discussed in prior work in strategy, since the mid-1990s, it has been drawn on by a growing number of firms (Graham, 2001).

In this paper, I thus develop models of capabilities by drawing on assumptions about lower-level action within both Simon's and McCarthy's approaches to modeling formal structure in terms of information processing. While identifying formal structures for processing information cannot specify the content of a firm's actions, I shall show how doing so can give insight into some basic properties and their dynamics.

Modeling Capabilities in terms of Information Processing

To analyze capabilities for both exploring and exploiting in terms of information processing, I first translate the basic logic of the 'algorithmic' and 'situated' approaches' as developed in software programs into the context of firms.

Algorithmic approach. An algorithm can be defined as any finite sequence of decision-making steps towards a goal. In the context of firms, algorithms can be thought of as more abstract versions of boundedly rational process constructs such as programs, decision-making structures or routines (March and Simon, 1958; Gavetti *et al.*, 2007; Nelson and Winter, 1982). Executing an algorithm requires *sequential* decision-making based on processing information. Simon found that both flexibility (i.e., open-endedness) of exploration and efficiency in exploitation (i.e., ability to scale) was driven by the extent of interdependence among both decisions and units of information, where interdependence could be best reduced by arranging information hierarchically (Simon, 1969). Thus, a view of executing processes based on algorithms leads to a model of information processing in terms of sequential decisions and hierarchically structured information.

Situated approach. In McCarthy's software programs, a 'situation' may be considered as a set of facts relevant to processes of moment-to-moment reasoning or reacting in regards to a goal. In the context of firms, such a set of facts can be thought of as a more abstract term for process constructs in regards to situated action, such as maps, references, or affordances (Suchman, 1987; Brown and Duguid, 1991; Orlikowski, 2002). McCarthy found that both flexibility and efficiency of execution was driven by the extent to which interdependence could be best *eliminated* by providing the most parsimonious set of facts and not tied to particular procedures (McCarthy, 2007). Thus, a view of executing processes based on 'situations' leads to a model of information processing in terms of moment-to-moment reasoning and reacting where information is structured into a set of facts.

I summarize the approaches' differences in Table 1.1. below.

I suggest that the two approaches' models of information processing both can serve as precise assumptions about lower-level action, that can in turn be used to model capabilities for information processing in firms. First, capabilities for exploration can be considered as the ways in which a firm may process information flexibly by interchanging, recombining or improvising sequential aspects of algorithms, or by creating relevant facts about the situations in which indidviduals are embedded. Second, capabilities for exploitation can be considered as the extent to which a firm can process information using a *procedural logic* based on sequence and hierarchy in an algorithmic approach, or using a *predicate logic* based on sets of relevant facts in a situated approach. Next, I analyze processes of exploration and exploitation under both approaches, before analyzing how the two approaches present an organizational design choice based on a firm's assumptions about the nature of its capabilities

TABLE 1.1
Algorithmic and Situated Approaches to Modeling Information Processing

	Algorithmic Approach	**Situated Approach**
Organizational Analogs	Organizational programs; Decision-making structures; Organizational routines	Maps; References; Affordances
Basis of Action	Procedural Logic	Predicate Logic
Structure of Action	Sequences of decisions	Moment-to-moment reasoning and reacting
Source of Efficiency and Flexibility	Arranging information hierarchically	Arranging information parsimoniously

Capabilities for Exploration

First, I consider a firm's capabilities for exploration under both approaches.

Algorithmic approach. Executing based on algorithms assumes a pre-existing structure of sequential decisions and hierarchically structured information, such that processes of exploration face a constraint of having to respond to this structure.

Open-endedness in exploration can be afforded by grouping similar decisions or units of information to reduce interdependence. Given well-defined interdependencies, processes of exploration may in turn span all the ways in which decisions and information can be rearranged (Baldwin, 2008). For example, enterprise resource planning (ERP) systems enable various features of processes to be mixed and matched by an individual firm. This flexibility, however, requires the features themselves to be standardized, where customization is thus constrained by the need to fit within the broad hierarchical structure of an ERP system (Kallinikos, 2004).

In this sense, an algorithmic approach enables processes of exploration that correspond to recombining existing sequences of decisions and information (Foss and Klein, 2005; Kogut and Zander, 1992).

Situated approach. Since executing based on a set of facts does not assume a pre-existing structure of sequence and hierarchy, processes of exploration may be relatively open-ended, while facing a fundamental constraint from the particular set of facts based on which individuals reason or react to situations.

Open-endedness in exploration can be enhanced by identifying a more general and parsimonious set of facts that has relevance across a broader range of situations. Given that facts are mostly independent, processes of exploration may span all the goals and

situations in which they are relevant. Consider, for example, Uber's goal of providing on-demand rides across localities that vary in terms of density of riders and drivers, types of vehicles and roads, and availability of high speed internet. By developing an app and information system generalizable to all such localities, Uber may explore other behaviors such as food delivery, freight distribution, and self-driving vehicles technologies without a fundamental change in its structure for processing information.

In this sense, a situated approach enables processes of exploration that correspond to creating more sets of information generalizable across a greater diversity of situations.

Capabilities for Exploitation

I next consider a firm's capabilities for exploitation under both approaches.

Algorithmic approach. Following Simon's view that efficiency in a system depends on the extent of interdependence among decisions or information (Simon, 1962), I analyze a firm's capabilities for exploitation in terms of how an additional interdependency may affect a firm's information processing requirements.

Simon argued that a linear reduction in interdependencies can lower information processing requirements exponentially (Simon, 1962: p. 1). This assumes, however, that the decisions and information that a firm must manage remain fixed. As Knudsen *et al*. (2014) point out, when a firm scales, interdependencies may in some cases also grow; such a dynamic would induce an exponential *increase* in information processing requirements. This increase may be mitigated if some interdependencies are 'epistemic', meaning they exist analytically but need not be accounted for in the actual execution of processes

(Puranam *et al*., 2012). For example, a firm's goal may require the action of two individuals, but these individuals do not necessarily need to coordinate explicitly and thus their interdependency would not raise information processing requirements. Nonetheless, a tendency towards 'bloat' in the number of interdependencies has been found across diverse contexts such as hardware design (Brooks, 1975), enterprise resource planning (ERP) (Kallinikos, 2004), and operations (Levinthal and Wu, 2010).

I thus suggest that an algorithmic approach leads to processes of exploitation in which information processing requirements are relatively scale-dependent.

Situated approach. In line with McCarthy's view that efficiency in a system depends on generating a set of relevant facts about situations (McCarthy, 1959), I analyze a firm's capabilities for exploitation in terms of how an additional fact may affect a firm's information processing requirements.

McCarthy argued that additional facts may *lower* information processing requirements by enabling individuals to reason about situations while eliminating the need to consider previous facts (McCarthy, 1959). In the context of firms, for instance, Airbnb has been able to develop a parsimonious system for managing interactions between hosts and hostees based on data from a great diversity of situations. In this sense, when a firm scales its processes across a greater range of situations, the set of relevant facts may expand, yet this may not lead to a disproportionate increase in information processing requirements.

I thus suggest that a situated approach leads to processes of exploitation in which information processing requirements are relatively scale-independent.

Information Processing Approach as Organizational Design Strategy

The prior section shows how capabilities for exploration and exploitation can be identified in terms of information processing. In particular, I identify an algorithmic approach, in which capabilities relate to exploring by recombining existing goals and information, and to exploiting by reducing growth in interdependencies. I also identify a situated approach, in which capabilities relate to exploring by creating new goals and information, and by expanding the situations from which information is generated. I summarize the two approaches below in Table 1.2.

TABLE 1.2
Processes of Exploration and Exploitation in Algorithmic and Situated Approaches

	Algorithmic Approach	**Situated Approach**
Processes of Exploration	Recombining decisions and information	Creating generalizable information
Affordances	Reduced interdependence	Parsimony
Constraints	Firm's pre-existing sequential and hierarchical structures for processing information	Firm's particular set of facts
Processes of Exploitation	Increasing interdependence	Increasing number of facts
Scale-Dependence	High	Low

Given that the two approaches to modeling capabilities suggest distinct processes of exploration and exploitation, I suggest that choice of approach can be considered as a

strategic organizational design choice. I next identify two factors — the particular nature of a firm's capabilities, as captured by its value proposition, and its existing information processing resources and capabilities. I use these factors to analyze a firm's strategic choice of approach. I do so by analyzing what may drive a firm's choice under initial and subsequent initiatives.

Though the prior section suggests that a situated approach may enable more open-ended exploration and relatively scale-independent exploitation, an algorithmic approach may still often be preferred. One reason is that a fairly well-defined product with relatively higher information processing requirements can also serve as a bottleneck for appropriating value (Simon, 1947). For example, Microsoft has developed and maintained millions of lines of code for its MS Word program internally, which helps it to keep full rights over lucrative licensing revenues.

Value proposition drives initial choice. I suggest that a firm's initial choice instead seeks to align its value proposition aligns with the type of exploration. Namely, value propositions based on precise metrics may require restricting open-endedness in exploration, and favor an algorithmic approach. In contrast, value propositions based on basic metrics may be more adaptable to new information and favor a situated approach.

Compare, for instance, the value propositions of Amazon (e-commerce) and DropBox (online file storage and sharing), both of which relate to helping users execute behavior over the internet. Amazon's value proposition of convenience and delivery is managed by the use of precise metrics for its logistics, such as its order fill rates, percent of on-time deliveries, and order accuracy rates. It thus makes sense for Amazon to make large investments in information processing resources based on standardized procedures (i.e.,

systems for managing its logistics), as it may capture value by executing processes according to these precise metrics even marginally better than its competitors.

In contrast, DropBox, in its cloud service for managing files, competes based on a value proposition linked to basic metrics regarding behavior outcomes — whether its interface sufficiently simplifies how users manage their files. It thus makes sense for DropBox to invest not so much in information processing capabilities regarding its processes, as in its usability. DropBox's ability to compete with enterprise software companies has in turn been based on feedback from individual customers across diverse situations, rather than building and maintaining dedicated systems for each client.

I thus suggest initial choice of approach is driven by whether a firm's value proposition relates to precise or basic metrics.

Information processing resources drive subsequent choice. A firm's choice of approach for its initial behavior need not be consistent with subsequent initiatives that it undertakes. Further, initial choice may affect subsequent choice by involving investments in information processing resources (i.e., personnel, proprietary databases, server farms) that shape a firm's sensitivity to information processing requirements. A second issue thus concerns how a firm's initial choice of approach influences its subsequent choice.

A firm that makes an initial choice of a situated approach may end up also making complementary investments in information processing resources. In such cases, the firm may have incentive to extend its resources to another initiative using an algorithmic approach. At Alphabet, for instance, while I find its search engine business (Google) is consistent with a situated approach (in being flexible to new types of information created online), it monetized search by investing in information processing resources. One example

of these investments is Google Maps, in which it developed capabilities for generating directions based on a large database of standard information about geographical features such as street names and businesses.

I thus suggest subsequent choice of approach is driven by whether a firm can capture value by extending its value proposition through investments in information processing resources.

Discussion

Strategy researchers have long emphasized the importance of capabilities, but have yet to agree on assumptions about lower-level action from which to relate capabilities to performance. As a result, prior work has tended to model capabilites within a fairly restrictive view of processes of exploration and an implicit assumption that processes of exploitation are scale-free. In this paper, I seek to address this gap.

Information Processing as an Approach to Modeling Capabilities

My main contribution is to develop a way of modeling capabilities based on clear assumptions about lower-level action in terms of information processing. Prior work has tended to invoke assumptions about limits to information processing but, in modeling capabilities based on the more aggregate construct of routines, has given greater attention instead to issues of decision-making under uncertainty than to issues of execution (Simon, 1962: p. 1; Foss, 2003).

In particular, by tracing assumptions about information processing in the organizational literature (e.g., Thompson, 1967) to their roots in the early development of software programs, I identify a way of talking about capabilities in terms of the structure and dynamics of information processing. While recent research has fruitfully modeled lower-level action in terms of the heterogenous attributes of individuals in firms (Abell *et al.*, 2008), such attributes correspond to variation in content rather than processes, and thus do not directly measure capabilities. Although using information processing does not speak directly to the content of capabilities — i.e., from the attributes of individuals (Felin *et al.*, 2012, their shared dispositions and meanings (Orlikowski, 2002), or from particular plant and equipment (Helfat and Winter, 2011) — it enables specifying some basic boundary conditions on executing processes of exploration and exploitation.

Further, by drawing on insights from the early development of software programs, I also reveal two distinct approaches to information processing, one in which the basic unit of formal structure is the step-by-step decisions of an 'algorithm', and another a set of relevant facts regarding a 'situation'. By showing how each approach affords distinct organizational processes, I reveal a distinct organizational design choice. Specifically, while prior literature on design has tended to focus on contingencies regarding the complexity or uncertainty of a firm's strategy (e.g., Galbraith, 1974), the choice discussed here relates to distinct understandings of capabilities. Further, I show how design choice reflects a firm's distinct understanding of the nature of its capabilities, and that this in turn interacts with its amount of information processing resources. In the earlier Amazon example, for instance, though I find that its e-commerce business strategy is consistent with an algorithmic approach, I find that its Mechanical Turk service (an online app for users to

coordinate work tasks) is consistent with a situated approach. Namely, in developing a user interface (the features of which I consider to be a general set of facts relevant to users' situations), it is based on enabling workers to create new types of information for their particular jobs.

Exploration as Recombinative or Open-Ended Information Processing

This paper also contributes by offering insight on the constraints and affordances on firms' processes of exploration. Prior perspectives on capabilities have tended to find that firms' constraints on exploration primarily relate to risk. Given uncertainty regarding future technological and competitive conditions, and given that exploration is costly and path-dependent, the basic constraint on exploration is that a firm will make the wrong choice about what to explore (Levinthal, 1997). As such, scholars describe various firm-specific mechanisms, such as simple rules (Davis, Eisenhardt and Bingham, 2009) or absorptive capacity (Zahra and George, 2002) that may improve the effectiveness of exploration.

In contrast, this paper suggests that a firm's processes of exploration also face fundamental constraints from its formal structures for processing information. Under an algorithmic approach, these constraints relate to an emphasis on recombining existing information. In some cases, a firm's formal structure for processing information may be interdependent or so embedded in its specific knowledge and processes that its ability to create novel recombinations (i.e., for new product development) may be limited (Henderson and Clark, 1990). This paper, however, suggests that a firm that processes information primarily consistent with the procedural logic of algorithms faces a more

fundamental constraint of requiring any exploration to respond to these algorithms. For example, whereas Linux enables individuals freely to contribute code to its open-source software repository, all such contributions must be compatible with the step-by-step procedures of the 'kernel' — or the core structure of the Linux operating system.

Further, this paper shows how under a situated approach, exploration processes can also involve new information, without regard to any core algorithms. Here, a firm's formal structure for processing information in some ways resembles recent discussions of entrepreneurial action (Teece, 2012), in which individuals engage in open-ended processes of discovering, creating or imagining new opportunities by exploring diverse situations (Alvarez and Barney, 2007; Klein, 2008). This paper concurs with these perspectives, but also suggests that the situated approach offers a way to consider fundamental constraints on this open-endedness. Namely, the claim is that processes of exploration relate to information processing based on some set of relevant facts that must remain parsimonious to be manageable.

Scale-Dependence of Capabilities

Another contribution of this paper is to show how information processing can be used to model some fundamental constraints on processes of exploitation in terms of scaling. Amid expanding connectivity and the falling costs of digital information, scholars have been observing a shift in towards executing beyond firm boundaries (e.g., Tushman et al., 2012), as firms seek to scale large-scale systems. Aspects of this phenomenon, such as the disaggregation of industries, reliance on shared resources such as cloud storage, and greater use of freelancers, have been explored within a diverse literature. Scholars describe

a shift in the locus of organizing from individual firms towards collaborative forms: autonomous groups of firms, individuals or institutions with a shared value proposition ('ecosystems') or other systemwide goal (i.e., 'communities' or 'meta-organizations'), based on a core technical or transactive structure ('platforms') (Gawer, 2011; Gulati, Puranam, & Tushman, 2012; O'Mahony & Lakhani. 2011).

Nonetheless, this literature has focused mostly on issues of innovation, demand creation, and competitive dynamics, and has given less attention to the potential challenges of scaling capabilities. In fact, issues of scaling were among the central issues in early work examining the role of information processing in organizations, which emerged broadly within the same intellectual conversations as those in which Simon and McCarthy developed their software programs (Pickering, 2010). Here, the concern was that organizations would grow too large and complex to manage based on administrative structures consistent with an algorithmic approach. Indeed, as firms have shifted beyond their traditional boundaries in the past few decades, their ways of processing information appear to have also increasingly shifted towards structures consistent with the situated approach described here (Graham, 2001). By showing how this situated approach may lead to relative scale-independence, this paper offers a way of explaining the logic behind this shift.

Conclusion

In this paper, I have examined models of capabilities in terms of information processing along with implications for organizational design. In addition to an approach where algorithms are the basic unit of formal structure for processing information, I also identify

an approach where structure relates to sets of facts relevant to particular situations. My analysis of these approaches shows basic affordances and constraints on capabilities. Further, I find that a firm's choice of approach depends on its understanding of the nature of its capabilities, along with its existing information processing resources. Besides offering a formal way of modeling capabilities, I contribute insight into issues of open-endedness in exploration and scale-dependence in exploitation of increasing importance to strategy as a growing number of firms seek to develop large-scale systems beyond their traditional boundaries.

CHAPTER 2: PERFORMING ROUTINES FOR LOCAL PRODUCTION: 'SENSE'-LESS AND 'MIND'-LESS CAPABILITIES

A growing number of organizations appear to be moving away from the coordination of internal employees in favor of the coordination of workers distributed externally across platforms, ecosystems or communities (Benner & Tushman, 2015). This shift is found to hold deep implications for theories of organizing spanning diverse literatures, from organizational design (Gulati, Puranam, & Tushman, 2012), to organizational communication (Orlikowski & Scott, 2015), business model innovation (Teece, 2010) and economic sociology (Davis, 2015).

Thus far, however, surprisingly little has been said regarding the implications of a shift towards external coordination for our understanding of organizational routines. Attention to these implications may be worthwhile, as prior theories have often stressed the importance of internal employees in developing organizational knowledge and a shared language as 'sources of action' (Cohen et al., 1996; Rerup & Feldman, 2011) for performing routines (Kogut & Zander, 1996; Dosi, Faillo & Marengo, 2008; Pentland & Rueter, 1994; Dittrich & Seidl, 2017).

Clearly, a shift away from internal employees may decentralize or otherwise reconfigure organizations' processes for developing knowledge and a shared language. Recent examples, however, suggest that such a shift may also induce organizations to develop sources of action specific to performing routines in the spaces in which external workers are situated.

For instance, organizations developing technologies such as adaptive robots (i.e., Rethink Rebotics), sensor networks (i.e., IBM Watson) and 3D printers (i.e., FabLabs)

enable workers to configure particular *physical spaces* to perform routines for manufacturing or prototyping processes. Amazon's Mechanical Turk, UpWork, and DropBox offer tools to manipulate and share digital information in task- or project-specific *representational spaces* (i.e., online software interfaces) for performing routines for administrative or knowledge work. Finally, Airbnb and Uber have designed systems for generating rich, real-time information regarding the particular *geographic spaces* in which workers perform routines for hosting guests or offering ride services.

In these examples, organizations' capabilities relate to supporting workers who perform routines within their particular spaces, in contrast to the more familiar case where capabilities relate to how workers perform routines within their particular domains of knowledge or skills (Dosi, Nelson & Winter, 2000). The examples suggest a need to consider routines as performed not just in a distant factory or office, but also in what we might call spaces of 'local production'. While 'local' has been used in prior literature metaphorically to refer to the 'neighborhood' or 'areas' of an organization's knowledge base (p. 31: Nelson & Winter, 1982; p. 700: Kusunoki, Nonaka, & Nagata, 1998), here I refer to routines simply where production is roughly proximate in space and time to consumption (Bradach, 1998; Winter & Szulanski, 2001). Understood this way, local production describes important, yet still little examined (Bradach, 1998: p. 18), aspects of routines both in manufacturing, collaborative software, and the sharing economy, but also in many organizations we familiarly encounter, from hospitals, to schools, to restaurants.

Whether regarding physical, representational or geographic space, local production draws attention to the challenges of performing routines consistently, yet where no two situations are quite the same (Zbaracki & Bergen, 2010; Bechky & Okhuysen, 2011; Turner

& Rindova, 2012; Deken, Carlile, Berends, & Lauche, 2016). When a cook makes a meal, she must perform by adjusting to ingredients that are familiar, yet vary initially in shape, water content, flavor, and position in the kitchen, and which then evolve on a moment-to-moment basis as they are handled (Winter, 1968; Kirsh, 1995). When two workers collaborate on a project online, they must communicate information displayed through dynamic multimedia across the space of a screen, which then continually evolves during their interaction (D'Adderio, 2011; Dourish & Mazmanian, 2011).

As a growing number of organizations move towards coordinating external workers in spaces of local production, it becomes important for organizational scholars to understand capabilities for performing routines in these spaces. These capabilities must be understood not only in terms of existing theories of organizational knowledge and shared language that assume internal employees, but also in terms of sources of action distinct to external coordination. In this paper, I thus focus on understanding these capabilities — What sources of action enable workers performing routines in spaces of local production to respond on a moment-to-moment basis to broadly familiar yet always evolving situations?

To explore this question, I identified two organizations with nominally the same goals, yet distinct spaces for local production: a chain restaurant in Seoul, and a restaurant in the Korean countryside that both prepared and served everyday Korean meals. I identified two broad sources of action for performing routines distinct to local production, which I characterize as 'sense'-less capabilities (based on abstract sources of action) and 'mind'-less capabilities (based on perceptual sources of action). I illustrate how these capabilities were afforded by the logics of the restaurants' production spaces (the 'kitchen'), their task characteristics (the 'cooking'), and their use of representations (the 'recipes').

The paper contributes a framework for exploring how organizations perform routines for local production. Much research on routines has involved discussions over the relative roles of agency and structure and, in turn, over whether routines serve as a source of change or stability in organizational action (Parmigiani & Howard-Grenville, 2011). Although these discussions have offered important insights, they have also tended to focus on sequential aspects of routines, such as individuals' 'skills' (Nelson & Winter, 1982) or socially enacted 'grammars for action' (Pentland & Rueter, 1994). As such, they have relatively neglected analysis of the physical, representational and geographic spaces in which routines are performed. Given that organizations increasingly coordinate based on workers embedded in particular, external situations, it becomes important to consider the implications of these spatial aspects regarding the role of both agency and structure in performing routines.

Further, prior research on sources of action in routines has also tended to emphasize abstract sources of action, such as tacit knowledge (Winter & Szulanski, 2001) or a shared language (Feldman et al., 2016), that do not directly relate to the moment-to-moment performing of routines. Recent work has addressed this gap by drawing attention to the importance in routines of processes of improvisation (e.g., LeBaron, et al.; Bechky & Okhuysen), but has tended to be at the group- or organizational-level. In this paper, I suggest that this recent work can be complemented by giving attention to how an organization's production space and representations can afford perceptual sources of action in the moment-to-moment performing of routines.

Performing Local Production Routines

Local production can be distinguished from production at a distant factory or office by the distinct challenges of performing routines in real-time and limited space that result from being proximate to consumption. Whereas the production of even diverse goods at a factory assumes stable expectations regarding the space, equipment, tools, materials and employees for each production run, local production involves assuming that particular situations can shape the arrangement of all of these factors on a moment-to-moment basis (Howard-Grenville, 2005; Deken et al., 2016; Agre & Horswill, 1997).

Existing work has explored capabilities specific to local production primarily in the context of business format chains. This work finds that the need for consistency across local outlets requires capabilities for replication, based on processes for transferring centrally developed knowledge underlying routines (Bradach, 1998; Winter & Szulanski, 2001). Capabilities for replicating routines may be valuable, as even routines that can be extensively codified and thus seemingly easy to imitate may have tacit aspects that require firm-specific articulation and transfer processes (Rivkin, 2001; Jensen & Szulanski, 2007).

This paper's purpose of understanding not the transfer, but the performing of local production routines, however, requires attention not just to challenges of codifying and articulating knowledge, but to challenges arising from proximity to consumption.

Performing Routines in Real-Time

Firstly, proximity to consumption creates distinct challenges of performing routines in real-time. In certain cases, such as an emergency medical team treating a trauma patient, organizations must respond under extreme time pressures and with major consequences.

In other cases, such as operating and using a vending machine, the goal of dispensing snacks may be predictable and trivial enough to manage mostly from a distance. More typically, local production involves responding consistently, on a moment-to-moment basis, to situations that are highly varied and evolving in their details, yet always broadly familiar (Turner & Rindova, 2012).

Performing Routines in Limited Space

Proximity to consumption also creates distinct challenges of performing routines in limited space. Whereas a new task in a factory and office might be performed simply by adding another machine, purchasing additional cubicle space, or outsourcing it altogether, local production refers to a need to perform all tasks in a limited space. Differences in spatial aspects, such as the flexibility and positioning of equipment, tools, materials, or representations may have major effects on an organization's capabilities for responding flexibly to particular situations. Chefs, for instance, depend on their abilities not just to perform cooking techniques, but also to maintain a proper 'mise-en-place' — their arranging of the space in which they perform these techniques (Kirsh, 1995). Organizations' capabilities of handling challenges of limited space may not always be easy to describe in terms of sequential aspects such as knowledge about rules and procedures (e.g., Nelson & Winter, 1982; Cowan, David & Foray, 2000; Dosi et al., 2002). For instance, doctors and nurses with deep expertise, a long history of working together, and medical records that capture rich data about its patients, may nonetheless find it challenging to perform even basic routines reliably in the limited space of a hospital room.

Thus, this paper examines local production in the two organizations on which I did

fieldwork by focusing on the distinct challenges in performing routines in real-time and limited space.

Methods and Research Setting

To develop a framework for understanding capabilities for performing local production routines, I observed the physical and representational spaces of two restaurants in Korea — a chain restaurant in Seoul and a restaurant in the countryside. These restaurants both had goals of making everyday Korean food proximate to its consumption, and thus both had routines characterized by local production.

In the two restaurants, the significance of local production arose in the need to perform tasks regarding cooking, cleaning, and customer service that responded to continually evolving situations in real-time. Although both restaurants' menus were mostly fixed in advance, neither could fully anticipate the way in which tasks would be scheduled, how materials would be used, or exactly how many customers would come and what their preferences would be until the moments in which routines were performed. The need to deal immediately with materials as they cooked, or with multiple customer orders, presented challenges of both time and space in performing routines consistently. As such, these were excellent organizations for observing the effects of proximity of consumption on performing routines.

Below, I describe how I collected data on these two organizations' local production routines, and outline some of their key differences and similarities.

Data Collection

I collected the data for this study through observational fieldwork at a chain restaurant (and its parent company headquarters), and at a restaurant in the Korean countryside. In both spaces, I focused on building an understanding of their spatial sources of action for performing local production routines, and how they developed these sources of action. Since my primary aim was to understand these sources of action as they relate to capabilities for local production, I emphasized observing structural aspects of the restaurants (facilities, tasks, and representations).

Chain restaurant. My data drew from a chain restaurant in central Seoul. The primary source of data were observational field notes — I conducted 54 hours of observation, primarily of the kitchen, as the staff and managers prepared for and executed operations during the lunch and dinner shifts. During these sessions, I observed how the layout of the overall facility, equipment, tools and materials were brought to bear in performing the routines of the restaurant, from set-up during mid-morning, until the end of the lunch hour, and again during the evening dinner rush.

Countryside restaurant. My data also drew from a restaurant in the Korean countryside, about 300 hundred kilometers outside of Seoul, which was run by a sole owner and several assistants. I spent two full days observing and conducting semi-structured interviews, and then spent a total of four days as a participant-observer, helping with cooking tasks. Excepting the participant-observation, I conducted the visits largely as in the chain restaurant, with a focus on observing structural aspects of the facility, its tasks and representations. Also as in the chain restaurant, I kept field notes and took photos and video of the setting and the cooking tasks in action.

Research Setting

Performing routines in both the chain and countryside restaurants required capabilities that afforded sources of action to respond to broadly familiar yet always evolving situations. By focusing on sources of action that relate to capabilities, I wish to refer to an understanding of action that is a bit broader than prior focuses on human agency as a source of change in routines (Rerup & Feldman, 2011). That is, I wish to focus on structural aspects of the restaurants' facilities, equipment, tools and materials, and representations (D'Adderio, 2008; Pickering, 2010)) integral to performing routines. To set the stage for understanding how these structural aspects shaped the restaurants' routines, I briefly analyze their commonalities and differences. I summarize the comparisons in Table 2.1 below.

Two broad commonalities distinguished the restaurants. First, both the chain and countryside restaurant performed routines close to the space and time of consumption. This spatial and temporal proximity arose from dealing with dynamic food ingredients and cooking processes, and the need to respond to customer demands in real time. Second, the goals were nominally similar: at the chain and countryside restaurants, routines all concerned the production of everyday Korean meals, produced at a moderate price level (under $10 for a meal). Everyday Korean meals, while encompassing a great variety of ingredients, have a signature structure of rice, soup, and primarily vegetable side dishes, anchored by fermented flavor bases (soy sauce, soybean paste, chili-soybean paste, and preserved fish or shrimp sauce) (Kim, et al., 2016).

Nonetheless, three differences that I observed help reveal how the restaurants developed distinct capabilities for local production: different *task structures* arose from

differences in task descriptions, customer flow and their location's physical environment. These differences induced different understandings of the nominally similar goals, and motivations among workers.

First, the chain restaurant, in having to respond to detailed manuals and procedures from its parent company, performed routines based on descriptions of discrete tasks, which raised challenges in performing routines of managing *interdependencies* between these descriptions of tasks. Fulfilling a customer's order for a meal required multiple ingredients, tools and personnel as described in the manuals to be on hand, and for these to be combined under detailed, pre-specified steps. Yet since customer flows and orders could not be fully known in advance, events such as a lunch rush or special requests led to descriptions of tasks always being interdependent in slightly different ways. The countryside restaurant, in contrast, was not bound to any parent company, and did not perform routines based on descriptions of discrete tasks. Fulfilling a customer's order thus involved little reference to descriptions of tasks, and this lack of description led to less concern with issues of interdependencies between tasks. For example, the owner used one verb roughly translated as '*getting the food out*' to refer to cooking tasks directly related to fulfilling customer orders, and another verb roughly translated as 'cooking' for the tasks she considered most fundamental.

In addition, while the chain and countryside restaurants both performed routines related to a goal of producing everyday Korean meals, workers from each restaurant displayed different understandings of this nominally shared goal. The chain restaurant emphasized consistently meeting the standards and brand concept specified by its parent company; everyday Korean meals were construed as 'healthy', 'fresh', and served in 'clean

surroundings'. In contrast, goals at the countryside restaurant emphasized maintaining principles regarding Korean cuisine. Here, the owner and assistants characterized everyday Korean meals in terms of achieving 'deep taste' by consistently performing the work with care.

TABLE 2.1
Similarities and Differences in the Chain and Countryside Restaurants

Aspect	Chain Restaurant	Countryside Restaurant
Similarities		
Routines characterized by local production	Food cooked and served proximate to consumption	Similar
Nominal behavior	Structure of meals of rice, soup and side dishes (*kimchi*, etc.), with fermented flavor bases (soy sauce, soybean paste, chili-soybean paste, fish/shrimp sauce)	Similar
	Producing everyday Korean meals	Similar
Differences		
Task Structures	Same-day, sequential task interdependencies Need to respond to sequence of tasks in detailed template Need to respond to varying customer flows	Various rhythms of concurrent, spatially arranged tasks Need to perform basic tasks over days and months Same day, sequential tasks as merely 'getting out the food'
Understanding of Goals	Specific standards and brand concept, i.e., 'quality, service cleanliness'	'Deep taste'; 'care'
Motivations	Running and organizing a business	Nature of the work itself.

Differences in each restaurant's goals also related to workers' distinct motivations.

In the chain restaurant, employees described motivations for work as being part of an innovative organization, building a global brand for Korea, or simply building a successful business. Thus, motivations in the chain restaurant tended to focus on processes of organizing and developing a business. In the countryside restaurant, workers described motivations as, for instance, intrinsic enjoyment, keeping physically and mentally healthy, and being part of extending a tradition. Thus, motivations in the countryside restaurant tended to focus on the nature of the work itself.

Analytic Approach

During initial fieldwork at the chain restaurant's parent company to explore the ways in which organizations developed capabilities for making traditional Korean food in modern settings, it emerged that the company found challenges in performing even basic tasks. This led me to explore a number of field sites in the countryside, where most Koreans lived until about 40 years ago, and thus has historically been where capabilities for making Korean cuisine evolved. I hoped that these field sites would generate insights about the source of the challenges faced by the chain restaurant; I wondered if certain aspects of the cuisine created distinct challenges in modern contexts, and I wanted to trace sources of these challenges.

In my fieldwork in the countryside, I observed routines for making traditional Korean cuisine at multiple households, restaurants, and Buddhist temple kitchens. Though capabilities in these sites on first glance appeared simply to differ from the chain restaurant's as a result of evolving in an era lacking in modern technology, with further observation, interviews and reading of primary sources, I identified sophisticated

structural aspects of these sites — namely, in the spaces, task structures, and representations — that appeared to correspond to sources of action beyond just, for example, tacit knowledge, artisanship or custom. It occurred to me that my project might explore not just the challenges of the chain restaurant in adapting a traditional cuisine, but rather a broader exploration of distinct sources of action for performing routines for local production.

I therefore targeted fieldwork on one restaurant each (a chain and a countryside restaurant) that exemplified the larger populations (all the restaurants of the chain parent company, and countryside restaurants more generally), corresponding to different spaces for performing routines. This fieldwork adopted methods of observation and interviews broadly consistent with a grounded theory approach (Eisenhardt & Graebner, 2007; Corbin and Strauss, 2008). At the same time, my interest in capabilities for local production led to focus not just on how individuals and groups performed work but, consistent with approaches from artificial intelligence on routines (Agre, 1997), on how structural aspects —facilities, equipment, tools, materials, representations — also served as sources of action.

My analytical process began by open coding and memoing of the data to generate themes about the two restaurants' structural aspects and the relationship of these to how workers performed routines there. I developed a view that distinct challenges arising from the proximity of consumption was critical in both restaurants, and created distinct challenges from those of a conventional factory or office. I then iterated between coding and memos to generate themes based on instances relating to local production.

Developing themes and frameworks by using two distinct spaces required carefully and iteratively uncovering commonalities and differences. I observed that both restaurants

drew on structural aspects to handle the need to perform routines in real-time. For example, the chain restaurant embedded artifacts displaying information such as customer orders into and around its equipment, while the countryside restaurant made use of types of equipment that afforded collaborative work without such displays. I eventually categorized these under a common theme of 'structuring the physical space'.

In looking at the existing organizational literature, I found that issues of local production had been explored primarily in terms of knowledge-based views on the transfer of routines from headquarters to local outlets, and thus did not directly address the challenges of performing routines proximate to consumption (Winter and Szulanski, 2000; Bradach, 1998). In contrast, I found that issues of local production related more directly to literature in artificial intelligence, in which scholars explore the ways in which robots, computing systems or other artifacts might perform consistently in real-time (Agre, 1997; Pickering, 2010). Since the overarching theme of the categories I developed had to do with designing ways of performing routines proximate to consumption, I chose to center the paper on a construct of 'local production', and about how the two settings developed distinct capabilities to perform local production routines.

In analyzing my data again with a focus on local production, I found that a broad difference in the two spaces concerned the sources of action that they afforded for performing routines (abstract versus perceptual). Drawing on the constant comparative method (Glaser & Strauss, 1967), I identified that the sources of action for performing local production routines are dramatically shaped by a space's particular structural aspects — its facilities, equipment, tools, types of tasks, and representations. Finally, I developed

inductively generated categories into an analytical framework, more generalizable beyond restaurants to the diverse contexts of local production as a whole.

Findings

Challenges of local production in performing routines appeared in both the chain and countryside restaurants, and emerged in virtually all observational sessions and interviews. In both restaurants, these challenges related to the proximity of consumption, such that routines had to be performed within limited time and space, and based on the need to rearrange tasks, materials and customer flow in ways that could not be fully anticipated.

During the lunch rush in the chain restaurant, for example, the restaurant manager remarked on the difficulty of coordinating service when one party ordered a dish that took three minutes, and another that took 10 minutes. To enable these dishes to arrive at the table together, the restaurant had to develop capabilities for performing distinct tasks concurrently, in real-time. In the countryside restaurant, the owner took into account the weather and ripeness of plums she had purchased in the annual making of fermented plum syrup, a flavor base for many dishes. To enable the syrup to mature and last year-round, she had to monitor the plums and the weather to time the day when she made it.

Other instances of local production called for more ongoing responses. The owner of the countryside restaurant remarked that each ingredient varied in its characteristics throughout the year, as well as with abnormal weather conditions (i.e., a period of heavy rain would raise the water content in vegetables), requiring close attention to the structure of ingredients. In the chain restaurant, supervisors at headquarters described challenges

from high employee turnover, necessitating continual transfer of the knowledge for executing tasks.

Analysis of my field data suggested that the restaurants' capabilities for responding to these and other challenges of local production were rooted in the logic of the production spaces in which routines were performed. These production spaces in turn afforded distinct task characteristics, and uses of representations for coordinating these tasks in real-time. Along these lines, I use the rest of this section to describe and compare each restaurant in terms of the 'kitchen' (facilities, and these facilities' equipment, tools and materials), the 'cooking' (types of tasks), and the 'recipes' (representations).

The 'Kitchen': Production Spaces based on Factory and Workshop Logics

I found that capabilities for performing routines in both restaurants depended most fundamentally on sources of action afforded by the logic of their production spaces. By production spaces, I refer to the structure of the physical facilities of the restaurant, as well as the equipment, tools and materials contained in them. The importance of issues of space in local production makes sense as, compared to a distant factory or office, local production requires organizations to perform tasks flexibly without much leeway to add machines, tool or workers due to the fact that everything has to happen proximate to consumption.

I observed the production space of the chain restaurant to be consistent with a 'factory logic', and that of the countryside restaurant consistent with a 'workshop logic'. I describe these logics as they relate to distinct ways of containing space (restricting how materials interacted with the immediate environment), arranging space (distributing equipment, tools, materials and agents), and structuring customer space (establishing a

boundary between cooking and service).

Chain restaurant. The chain restaurant's production space afforded sources of action for performing routines by establishing stable relationships between well-defined equipment, tools and materials, and then assigning each of these to particular places in the kitchen for specialized tasks, as in a factory. I observed that the chain was able to establish this factory logic in its production space by 'maintaining sealed containers', 'nailing down the kitchen', and 'segregating customer space'.

Containing space — maintaining 'sealed containers': Managers described the importance of establishing control over materials used in the production space by, for instance, processing core ingredients at offsite facilities. I observed that sauces used in most dishes came in sealed packages, and most vegetables arrived at the outlet cleaned, trimmed, vacuum wrapped and in cold storage; employees also wore plastic gloves for all kitchen work except tasks done at the stoves. Prior to service, the kitchen had no visible ingredients: all were sealed in plastic containers and placed in stainless steel cabinets, or stored in refrigerators. By maintaining sealed containers, I thus refer to the ways in which the chain restaurant's facilities, equipment and tools limited interaction between materials and the production space such that, as in a factory, materials could be treated as standardized inputs.

Arranging space — nailing down the kitchen: Most equipment in the chain restaurant was connected together or otherwise bolted down, namely a long countertop comprising stoves, connected to a stainless steel prep surface, then to the cabinets for storing equipment and tools, and two sinks. I observed that establishing fixed relationships among equipment and tools enabled each area of the facility to be predictably associated with a set

of specific tasks (i.e., prepping vegetables), and thus for regular spacing of workers, as the fixed elements of an assembly line in a factory.

Structuring customer space — segregating the kitchen: In addition, the kitchen was partitioned from the counter service and customer seating areas, further allowing each space to be associated with specific tools and equipment. The kitchen was 'open', in the sense that customers could look in, but it was covered with glass, such that the order and conditions in the kitchen were kept under full control, similar to how the production and retailing of goods occurs at distinct facilities.

Overall, the chain restaurant's ways of containing, arranging, and structuring customer space thus reflected a production space consistent with a factory logic, where materials, equipment and customers were strictly controlled.

Countryside restaurant. In contrast to that of the chain restaurant, I observed that the countryside restaurant's production space afforded sources of action for performing routines by establishing dynamic relationships both between equipment, tools and materials, and with the immediate physical environment (weather conditions, materials, ambient microorganisms, customers) by establishing a general space for performing routines, as in a workshop. I observed that the chain was able to establish this factory logic in its production space by 'maintaining porous containers', 'enacting the kitchen', and 'blurring customer space'.

Containing space — maintaining 'porous' containers: The owner emphasized the importance of having a facility connected to the immediate physical environment. For example, the semi-outdoor space had a particular orientation to the sun and permeable earthen walls that helped regulate humidity, sunlight and ventilation, which was critical in

regulating the fermented sauces and preserved vegetables central to everyday Korean meals. Also, the fermented sauces were stored in permeable earthenware crocks left outdoors, with the lids opened at certain times of year to let pollen drift in from neighboring pine trees for its antibacterial effect. Many ingredients (chestnuts, acorns, radishes, etc.) were dried in the open-air workspace, on wicker mats. Vegetables were almost never refrigerated, and came caked with dirt and often bugs - the owner reported that keeping the vegetables intact until they were ready for cooking allowed them to remain fresh and thus enable both flavor and storage. Thus, by maintaining porous containers, I refer to a space that, as in a workshop, enables flexible use of materials and equipment.

Arranging space — configuring the kitchen: In addition, I observed that most areas of the production space afforded a variety of tasks. In particular, most important tasks would take place in a semi-outdoor space, with only a small modern 'kitchen' relegated to a back room and used mainly for finishing dishes. The owner and assistants performed in this space using a small number of general pieces of equipment and tools — large bowls for mixing and cleaning vegetables, a 'sink' embedded in the floor, and a large cast iron vessel that could be easily converted into either a pot, steamer or grill. The owner washed cabbage for making *kimchi* in the open sink of the semi-outdoor space. She remarked that doing so enabled flexible use of her body helpful in performing multiple tasks, and for making both large or small batch sizes. Also, virtually all materials were visible at all times, and tools were hung on the wall, or kept on mobile trays. Thus, the production space also followed the logic of a workshop in enabling workers easily to configure equipment for general tasks, batch sizes, and materials.

Structuring space — blurring production and customer space: the spaces where customers sat and where work was done overlapped. The owner remarked that tasks should be done where most comfortable to do so. The tables where customers would be seated during service hours afforded storing large amounts of vegetables, convenient in being adjacent to the semi-outdoor space in which they would be washed and preserved. On one visit, I observed large wicker mats with drying chestnuts placed right next to the customer tables, on top of bushes that also served as decorations.

Overall, as summarized in Table 2.2, the countryside restaurant's way of containing, arranging, and structuring customer space thus reflected a production space consistent with a workshop logic, where materials, equipment and customers were flexibly controlled.

TABLE 2.2
The 'Kitchen': Production Spaces based on 'Factory' and 'Workshop' Logics

Logic of Production Space	Examples (Chain Restaurant)	Examples (Countryside Restaurant)
'Containing Space'		
Factory logic: **Establish strict control of use of equipment and materials**	'Sealed containers' Sealed sauce packers Vacuum-wrapped vegetables Plastic gloves Stainless steel equipment Plastic containers Stainless steel cabinets Refrigerators	
Workshop logic: **Establish flexible control of use of equipment and materials**		'Porous containers' Semi-outdoor facility Earthen walls Earthen crocks, Wicker mats for drying Selective tolerance of insects/dirt Little refrigeration
'Arranging Space'		
Factory logic: **Regular spacing of equipment and workers for specific tasks**	'Nailing down the kitchen' Equipment bolted to the floor Stoves, counter, cabinets, sinks connected Materials mostly not visible	
Workshop logic: **Flexible spacing of equipment and workers for general tasks**		'Enacting the kitchen' No fixed space for tasks Basic equipment only Open sink that afforded rich communication Most materials visible Tools on a mobile tray
'Structuring Customer Space'		
Factory logic: **Keep kitchen space 'contained' and 'arranged'**	'Segregating customer space' Clear separation between kitchen and customer area	
Workshop logic: **Make workspace as flexible as possible**		'Blurring customer space' Preparing materials on customer tables Fermenting crocks and wicker mats for drying next to seating area

The 'Cooking': 'Desensitizing' and 'Sensitizing' of Tasks

I observed that the 'factory' and 'workshop' logics of the production spaces afforded distinct sources of action in terms of the basic characteristics of tasks for running the restaurants, which for the sake of convenience, I collectively refer to as the 'cooking'. I thus next describe how the affordances of the production spaces related to the 'desensitizing' and 'sensitizing' of tasks in the chain and countryside restaurants respectively.

Chain restaurant. As the chain restaurant's production space required maintaining 'sealed containers' and strictly controlled the spacing of equipment and people, managers emphasized keeping tasks well-defined and simple.

'Desensitizing' of tasks: I observed that keeping tasks well-defined and simple tended to relate to removing the need to perform or evaluate tasks based on sensory judgment (feel, taste, smell, aroma, appearance, etc.). One manager from headquarters remarked that developing the ability to execute even simple tasks required extensive communication between restaurant and regional managers. Many of the vegetables, for example, were blanched, but since blanching could produce quite different outcomes if cooking times differed even by a few seconds, headquarters chose uniform, hardy vegetables more robust to these variations.

In the chain restaurant, I also did not observe tasks involving the entire body or sensitive hand movements, such as washing ingredients (most came pre-washed and plastic-wrapped), seasoning vegetables, making fermented sauces (the flavor base of virtually all Korean dishes), making *kimchi* or other pickles, or seasoning vegetables; all these tasks were instead done at a central facility. Tasks instead tended to relate to food prep or assembly, such as chopping vegetables, stirring pre-made mixes together (such as

batter for Korean pancakes), or grilling meat.

Countryside restaurant. As the countryside restaurant's production space required maintaining 'porous containers' and flexibly controlled the spacing of equipment and people, the owner emphasized cooking tasks that required considering the particular situation.

'Sensitizing' of Tasks: I observed that considering the particular situation in tasks related to using minimal equipment and multiple people performing tasks together. Since ingredients varied by time of year and the day's conditions, the countryside restaurant could not fully specify weights, cooking times, or availability. The owner and assistants performed tasks such as prepping vegetables on common spaces, with no counters, chairs or tools beyond large bowls and a knife, affording focus on the particular characteristics of ingredients.

The owner would also continually check the color, smell and outer appearance of jars of fermented sauce, preserved vegetables and dried ingredients. In this regard, I also observed that the production space afforded an *absence* of ambient sound. Whereas in the chain restaurant, fridges, echoes, buzzers, beepers, and restaurant music continually could be heard, none of these sources of noise was present in the countryside restaurant. When the owner checked the fermentation of an herbal extract used for flavoring side dishes, she described the bubbles and the sounds they made as indicating the progress of the fermentation.

Overall then, as summarized in Table 2.3, the chain restaurants' strict control of its production space afforded the 'desensitizing' of tasks, while the countryside restaurant's flexible control of its production space afforded the 'sensitizing' of tasks.

TABLE 2.3
The 'Cooking': 'Desensitizing' and 'Sensitizing' of Routines

Characteristics of Tasks	Challenges of Local Production Shaping Characteristics of Tasks	Responses to Challenges
Chain Restaurant		
'Desensitizing' Tasks **Well-defined, simple**	Hard to time blanching of vegetables	Only choose hardy vegetables, stored in sealed containers
	Hard to transfer knowledge of even simple tasks from headquarters to restaurant	Limit hand movements to basic chopping, mixing, etc.; use of specialized equipment and tools
		Centralize tasks such as washing, seasoning, making sauces, making *kimchi* and other pickles
Countryside Restaurant		
'Sensitizing' Tasks **Vary according to the particular situation**	Need for multiple people to adjust flexibly to the characteristics of ingredients, conditions, and variety of tasks	Use of large flat tables, and general equipment and tools
	Need to evaluate materials based on sensory judgment	Limiting ambient sound

The 'Recipes': Using 'Procedures' and 'Annotations' in Performing Routines

How did the restaurants' particular spaces and tasks in turn shape their capabilities for local production — the ways in which they were able to respond to situations on a moment-to-moment basis? I observed that these capabilities can be understood by describing the ways in which the restaurants represented their routines. Though relating to a variety of tasks and not just the cooking of food, I refer for the sake of convenience to the restaurants' representations of routines as their 'recipes'.

I found it important to characterize the restaurants' 'recipes' not just as sequential instructions, but as the full range of representations brought to bear in performing routines, extending across diverse media (symbolic, such as recipe books, checklists, labels, and memos; and non-symbolic, such as beeps, buzzers, and lights), and including affordances contained in the layout of facilities, tools, equipment and ingredients. Despite their range, however, I found that representations related to distinct logics, afforded by the characteristics of the restaurants' spaces and tasks.

Chain restaurant. In the chain restaurant, since its production space and tasks were strictly controlled, it was able to represent routines using descriptions of fixed, discrete sequences of steps, or 'procedures', I observed that the chain restaurant augmented these procedures with multimedia.

Procedures: I found instances of procedures in the recipe books, (step-by-step descriptions and photos of tasks, along with lists of ingredients), checklists for managing inventory prior to service hours, and checklists that the restaurant manager used in conducting regular quality control during service hours. I observed employees making frequent reference to the recipe books before and during each process, and going through the inventory checklists before each shift.

Performing routines in real-time: Procedures represented recipe books and checklists were then connected to multimedia in the production space itself. For example, for chopping, stirring and grilling tasks, a frequent activity was taking out an ingredient and placing it on a scale to read off a numerical weight. I also observed various ways in which the production was 'labeled' to enable coordination and quality control of procedures. For example, it put yellow slips on containers for ingredients or stored foods to

indicate the days of the week, which helped augment the inventory and quality control checklists. The chain restaurant also used color-coded stickers to label food, making ingredients easier to find during meal preparation. The restaurant manager remarked above all on the importance of the basic maintenance of 'QSC', or 'quality, service, and cleanliness', as a guiding principle in operations. To accomplish this principle, he commented on his reliance on use of yes/no items on checklists — kept on clipboards and in folders — to monitor inventory and the condition of the facilities before every shift. Finally, the chain restaurant also made use of non-symbolic representations during service, as people often had to perform tasks so quickly as to preclude looking at representations of procedures themselves. Thus, the kitchen was filled with an array of artifacts for communicating: beeping and buzzing sounds on machines to indicate the scheduling of particular tasks, screens indicating the state of customer orders, and walkie-talkies for communication between the restaurant manager, cooks, and servers.

Overall, then, I observed that the chain restaurant represented routines based on a logic of procedures, through direct descriptions of procedures in terms of sequences of tasks, and by handling scheduling of these sequences by embedding the descriptions in the production space with multimedia.

Countryside restaurant. In the countryside restaurant, since its production space and tasks were flexibly controlled, it was more difficult to relate fixed descriptions of sequences of tasks to either particular areas of the space or to reasonably complete descriptions of the tasks themselves. I found that the countryside restaurant instead was able to draw on its 'sensitizing' of tasks to represent routines using descriptions of outcomes, or 'annotations'.

Annotations: I observed that the primary use of representations at the countryside restaurant related to hand-written memos and labels that related to situations — reminders or updates about the ongoing outcomes of tasks as they were performed. These representations not only referred to outcomes of tasks, but that the way of describing these outcomes emphasized spatial aspects of performing the routines. For example, whereas the 'recipes' of the chain restaurant expressed quantities of materials in metric terms (grams, liters, etc.), the countryside restaurant tended to use volume measures, such as wooden boxes used to measure rice or adding water in bottles. The owner drew attention to the need to adjust ratios to the particular materials and situations, such as adding more salt when making fermented chili paste if the weather were unseasonably warm, or adding less water to preserving vegetables during the rainy season. Ratios would thus be recorded during or after a task, rather than described ahead of time, with prior ratios serving as references rather than specific instructions. I thus describe these representations as 'annotations' that emerged from routines as they were performed.

Performing routines in real-time: The owner stressed that representations were likely to make the real-time aspects of performing routines needlessly complicated. In particular, as routines often involved fermentation or drying of materials that spanned days, weeks or months, memos and labels emphasized not so much the content or sequence of tasks, but annotations helpful to monitor the state of materials, such as the ratios used in making preserved vegetables. I observed that the countryside restaurant instead placed a focus on affording visual intuition and facilitating face-to-face communication by configuring the production space itself, with annotations then embedded in this space. For example, there were few cabinets, closed cupboards and only a

small fridge: all essential tools and ingredients were on open shelves or hanging on a wall. Further, the use of flexible equipment, such as an open sink and work table, in the semi-outdoor space afforded close verbal communication and demonstration of tasks between the owner and assistants.

Overall, as summarized in Table 2.4, I observed that the countryside restaurant represented routines based on a logic of annotation, either by using annotations as a reference regarding outcomes of tasks or by using configurations of the production space itself to minimize the need for representations.

TABLE 2.4
The 'Recipes': Using Procedures and Annotations in Performing Routines

Logic Used in Representing Routines	Challenges to Performing Routines in Real-Time	Use of Representations to Perform Routines in Real-Time
Chain Restaurant	**PROCEDURAL**	**PREDICATE**
Representing routines as procedures	Need to control sequences of tasks	Recipe books, photos of recipe tasks, scales for weighing ingredients
		Clipboards with checklists for inventory, cleaning and cooking tasks
Performing routines in real-time	Scheduling and communicating about specific sequences of tasks	Beepers and buzzers to indicate task state
		Screens at cashier and kitchen to indicate customer orders
		Walkie-talkies for communication between managers, cooks and servers
Countryside Restaurant		
Representing routines with annotations	Monitoring outcomes of tasks	Handwritten memos and labels
Performing routines in real-	Performing sequences of tasks flexibly	Minimizing representations
		Flexibly configuring the production space
	Coordination through face-to-face communication	Semi-outdoor space sink and table, and outdoor space for multi-person workspace

Discussion

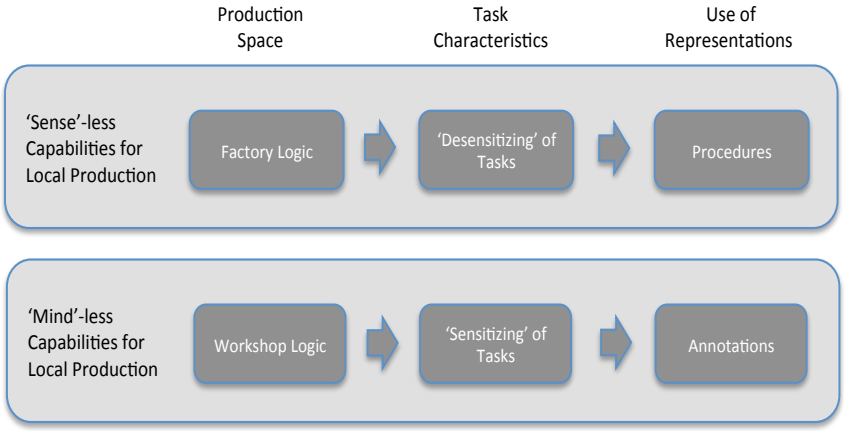
Both the chain and countryside restaurants faced challenges of performing routines in response to situations that were broadly familiar, yet always changing in their details. Although the restaurants shared a nominal goal of making everyday Korean meals, they developed capabilities based on distinct 'kitchens' (production spaces), ways of 'cooking'

(task characteristics), and 'recipes' (representations).

'Sense'-less' and 'Mind'-less Capabilities

Since the chain restaurant's 'factory logic', 'desensitizing' of tasks, and use of 'procedures' relate primarily to abstract sources of action, I characterize capabilities relevant to performing its routines as 'sense'-less. Since the countryside restaurant's 'workshop logic', 'sensitizing' of tasks, and use of 'annotations' relate to perceptual and sensorimotor sources of action, I characterize capabilities relevant to performing its routines as 'mind'-less. I sketch the relationship between aspects of both 'senseless' and 'mindless' capabilities for local production in Figure 2.1 below.

FIGURE 2.1:
'Sense'-less and 'Mind'-less Capabilities for Local Production



By describing the two restaurants' production spaces, task characteristics and use of representations, this paper contributes a novel construct of 'local production' relevant to understanding routines in the growing number of organizations that coordinate external

workers embedded in particular physical, representational and geographic spaces. In particular, in identifying this construct in terms of distinct sources of action, I contribute to the literature on organizational routines and capabilities by offering a framework for theorizing about capabilities in the increasingly important context of external coordination. I next discuss this paper's contributions in terms of how it draws novel attention to spatial and perceptual sources of action in routines and capabilities, and in terms of to how performative aspects of local production can be viewed as dynamic capabilities for exploitation.

Local Production: Bringing Attention to Spatial Aspects in Routines & Capabilities

A focus on particular aspects of local space complements the turn in much recent literature towards practice perspectives that emphasize the role of organizations' particular social and material aspects in performing routines (Parmigiani & Howard-Grenville, 2011; Feldman, Pentland, D'Adderio & Lazaric, 2016). Practice perspectives have offered a valuable contrast to capabilities-based perspectives (March & Simon, 1958; Dosi et al., 2008) by viewing routines as not just formal sources of stability but as generative sources of change (Feldman & Pentland, 2003). At the same time, recent work has arguably tended to focus more on social and interpretive aspects of enacting knowledge and a shared language for performing routines, and less on the material performance itself (Pickering, 2010: p. 380).

By illustrating the two restaurants' distinct ways of containing space, arranging space and structuring customer space, I show how practice perspectives may be enriched

by giving attention also to the distinct challenges arising from limited time and space in performing routines. In the chain restaurant, performing routines related to bringing centrally-held knowledge to bear on particular situations; I suggest that doing so required assuming predictable configurations of the production space's equipment and tools. In the countryside restaurant, I found that performing routines related to continually configuring the production space itself, where the flexibility to do so enabled distinct sources of action to emerge. Thus, I suggest that capabilities for local production may relate both to how the logic of the production space may both afford and constrain different generative sources of action.

Future research — sources of action for local production: This paper's framework on spatial aspects in routines thus may be useful in future work to examine capabilities in terms of generative sources of action. For some routines, such as serving customers at a fast-food chain or conducting pre-flight checks on an airplane, adherence to centrally-held knowledge can be critical. My findings, however, suggest room for future work on the spatial aspects of using this knowledge to enable 'sense'-less capabilities for performing routines. Pilots' checklists, for example, have to be on-hand, and relate to cockpit displays laid out in specific ways.

For other routines such as those of the countryside restaurant, however, it may be critical to *avoid* adherence to centrally-held knowledge in order to enable local learning while performing routines. Facebook, for instance, learns how to adapt features of its social media site by enabling users to interact with it flexibly, rather than building extensive manuals or checklists about how to use features, as in Microsoft Word. Future research could thus examine firstly how this paper's framework relating spatial aspects to

capabilities applies in other organizations.

Perceptual Sources of Action & Capabilities

By relating the two restaurants' 'sense'-less' or 'mind'-less capabilities to a need to perform routines in real-time, this paper also draws attention to the importance in routines not just of codified or articulated knowledge, but also of perceptual sources of action.

Much prior work on routines has tended to assume, implicitly or not, that organizations perform routines in a distant factory or office. Here, capabilities tend to be driven by codified or articulated knowledge within the domain of an industry (Jacobides & Winter, 2005), which in turn may need to evolve in response to changes in industries that take place over periods of months or years. I suggest that, when proximity to consumption poses distinct challenges of limited time and space, performing routines also may be understood in terms of capabilities for responding to changes that occur on a moment-to-moment basis.

In the countryside restaurant, for example, people relied on the flexibility and generality of the production space's 'workshop logic' to develop capabilities for performing routines that relied on 'sensitizing' its tasks — or making use of visual, auditory and physical sources of action. And even though the chain restaurant, consistent with the 'factory logic' of its production space, performed routines based more on abstract descriptions of tasks (recipe books, checklists, etc.), responding to the lunch rush also relied on embedding these descriptions through visual or auditory multimedia into the production space. By connecting perceptual sources of action to the restaurants' production spaces, I provide a way of connecting spatial aspects of organizations to

capabilities for performing routines in real-time.

Future research — capabilities in internet-based organizations. One possibility for future research would be to draw on the perceptual sources of action described here to analyze routines and capabilities in internet-based organizations. Google, Uber and Airbnb, for instance, their capabilities for internet search, ride services, or accommodation relate to challenges of consistently responding within the limits of a user's screen in real-time. These capabilities are based not just on codified or articulated knowledge reposited in individuals, as on the organization's ability to learn to respond to the moment-to-moment actions of users. Although much recent work has examined internet-based organizations' business models and incentive structures, we still have little understanding of how to describe their routines and capabilities. Thus, future work might make use of the perceptual sources of action described in this paper to describe and analyze routines and capabilities in internet-based organizations.

Capabilities for Performing Routines as a Source of Stability in Organizations

Finally, by drawing attention to how particular spatial and perceptual sources of action can lead to reliable capabilities for local production, I suggest that local production also highlights how performative aspects can serve as sources of stability and not just change (Feldman, et al., 2016). Specifically, by showing how the production spaces, task characteristics, and representations enabled the two restaurants to respond to moment-to-moment change, I find that facilities, equipment, tools, materials and representations can also be embedded in performing routines consistently (Pickering, 2010). A view of 'performing' as a source of stability has implications for both capabilities- and practice-

perspectives on routines.

Capabilities perspectives on stability in routines. Scholars adopting knowledge-based views of the firm have often emphasized the need for organizations to develop capabilities for change by 'exploring' novel sources of action (Eisenhardt & Martin, 2000; Di Stefano, Peteraf & Verona, 2014). In local production, however, 'exploring' can also be thought of in terms of the moment-to-moment performing of broadly stable routines (LeBaron, Christianson, Garrett & Ilan, 2016), and thus where capabilities relate more to 'exploitation', (also see discussion of routine dynamics and inertia in Yi, Knudsen & Becker, 2016). For example, the countryside restaurant developed capabilities for making everyday Korean food consistently by interacting with situations that were broadly similar, yet always evolving in their details. Future work thus might draw on the sources of action identified in this paper to examine how organizations characterized by local production develop valuable capabilities for exploitation.

Routine dynamics and capabilities. Meanwhile, scholars from a sociological background have often emphasized agential processes by which workers enact patterns of activity, or practices. These practices in turn afford performative aspects of routines as sources of change (Feldman & Pentland, 2003). In this paper, I suggest that performative aspects can also be located in structural aspects and also act as a source of stability. Though performing routines in both the chain and countryside restaurants were often shaped by the motivations of the workers who worked there, the way these motivations played out in practice were also shaped by distinct performative aspects of the production space and representations. Thus, while workers exhibited agency in both restaurants, agency related more to 'sense'-less capabilities in the chain restaurant (such as developing ways of

communicating about customer orders), and to 'mind'-less capabilities in the countryside restaurant (such as developing ways of configuring equipment and tools). Future work might draw on these distinct types of capabilities to examine how performative aspects of workers in organizations can be mediated by performative aspects of structure.

Conclusion

The chain and the countryside restaurant performed routines for local production by responding to broadly familiar yet always evolving situations on a moment-to-moment basis. Since their capabilities for performing routines was bound up in these organizations' particular production spaces, task characteristics, and use of representations, my description of these aspects of structure offers rich insights into issues of local production. In identifying local production as relevant to understanding a growing number of organizations across diverse areas, I suggest attention to the importance in performing routines of spatial aspects and perceptual sources of action.

CHAPTER 3. MODULARITY IN STRATEGIES FOR LONG-RUN ADAPTATION

Modularity, defined as a form of design in which the components of a system are highly independent (Baldwin, 2008), has been a core concept for relating organizational design to firm strategy. Scholars have found that a firm's ability to group and recombine similar units such as tasks, product features or individuals into mostly independent components, or modules, can reduce the need to process information and transfer knowledge, as well as serve as a powerful source of options for reconfiguring products, processes and strategies (Sanchez & Mahoney, 1996; Siggelkow & Rivkin, 2005). Modularity has, in turn, been linked to efficiency and flexibility in diverse strategic processes, from innovation (Ethiraj and Levinthal, 2004) to new product development (Ulrich, 1995), operations (Sosa, Eppinger and Rowles, 2004), outsourcing (Schilling and Steensma, 2001), and business model design (Zott and Amit, 2007).

In recent work, scholars find that, with continued expansion in digital and communications technologies (Altman, Tushman and Nagle, 2014), modular products and processes can be developed efficiently and flexibly to the extent that firms must continually evolve in order to compete (Adner *et al.,* 2012; Baldwin, 2012). Likewise, organizational design increasingly relates to the use of modularity to enable strategies of rapid adaptation — whether through the disaggregation of single-firm products into multi-firm product platforms (Gawer, 2014), of value creating processes into components of business models (Zott and Amit, 2007), or of work processes into tasks outsourced over the internet (Johns, Laubscher and Malone, 2011).

Scholars have also noted how the continued advances in digital and communications technologies increasingly enable coordinating adaptive processes at a scale and scope beyond that of a single industry (Jacobides & Tae, 2015). As such, the growing need for firms to rapidly adapt products and processes may coincide with increasing possibilities for adopting strategies based on developing broad systems. Such strategies may require complementing product development processes with initiatives that generate low or negative returns for extended periods. For example, Tesla has pursued a long-run strategy of developing massive transportation and energy systems dependent on extensive subsidies, while Amazon has been developing large-scale distribution capabilities while tolerating years of low profitability.

Given their scale and long period of development, we may expect strategies for developing broad systems particularly to benefit from good organizational design. Yet while modularity has been a guiding concept in this regard, the typical understanding of it in the strategy and organizational literatures may be in some respects problematic. Namely, a focus on firm's products or processes can constrain one's view of a firm's environment towards technological or competitive forces alone. Design in the context of systems development, however, requires also accounting for the environment in terms of the external world in which a firm's activities are embedded. For example, a key aspect of Tesla's strategy concerns enabling self-driving vehicles able to navigate local road environments, while Amazon's distribution capabilities must tackle the notorious 'last-mile' problem. To the extent, then, that strategies increasingly involve developing not just products and processes but broad systems, we may benefit from exploring the question of how organizational design can help guide processes of long-run adaptation.

In this paper, I thus seek to explore how the idea of modularity — taken as any design composed of mostly independent components — may be viewed in the distinct context of developing a broad system. To do so, I draw on field data regarding the design activities of an entrepreneurial firm in Seoul seeking to develop a general knowledge base — spanning kitchen design, recipe software, and manuals — to support the operations of diverse businesses within the domain of Korean cuisine (i.e., restaurants, food manufacturers, brewers of Korean alcohol, etc.). Complementary to much prior use of the metaphor of recipes to refer to knowledge at the industry- or firm-level (e.g., Spender, 1989; Kogut & Zander, 1993), I take cuisines as a metaphor for broader systems.

My analysis identified a similar focus in design as in prior perspectives on modularity on supporting individuals' activities by facilitating efficient information processing and knowledge transfer, and by enabling flexibility in reconfiguring modules. I found, however, that the broader set of activities that the firm sought to support led to a focus in design more on structuring the physical space (the workstations, overall layout, equipment and tools of a kitchen, brewery or other facility) and representational space (i.e., the visual software interface for creating, sharing and managing representations such as recipes), and less on the details of the products or processes themselves.

Discussions of modularity have tended to view the key organizational design issues as relating to how to structure an organization's individuals, products or processes into modules, at least implying a more or less straightforward mapping of these dimensions to the structure of the production space — whether a blueprint for a facility or documents for representing codified knowledge. In my research setting, however, I found that key design issues concerned identifying a small number of goals underlying processes, then enabling

these goals to be maintained efficiently and flexibly by structuring the production space itself into modules. The basic idea was that, given the need to support the wide scope of activities within a cuisine across diverse production settings, even core components of products and processes would to be too unstable to express reliably in terms of modules.

Though little explored in the organizations literature, these ideas have much in common with systems design perspectives within the artificial intelligence (AI) literature (e.g., Brooks, 1991). I draw on this lens in connecting my findings to several implications for our understanding of modularity and design. First, I show how a strategy of achieving modularity in the production space shifts the key design issue from reducing interdependence among modules, to reducing the number of modules themselves. I also show how such shift leads to a strategies of long-run adaptation in stages to develop capabilities for reasoning and coordination within a production space. Finally, I discuss how reconceptualizing modularity in terms of long-run adaptation adds to recent work finding that firm-level organizational design choices may be more endogenous to industry structure and evolution than previously thought.

Background — Modularity and Adaptation Processes

Existing work on modularity in the organizational and strategy literatures has roots in traditions of both product engineering and theories of administrative processes from the Carnegie School (Alford & Baldwin, 2016). Both traditions are consistent with a view of systems in terms of interdependent units, where modularity refers to the extent to which interdependence can be reduced.

Such a view, however, implies a focus in design on fairly internal aspects of organizing — product engineering tends to assume the well-defined product components of Taylorism (Baldwin, 2008), while Carnegie School theories tend to focus on the processes of employees within the boundaries of a single firm (Grant, 1996). Other scholars of design, in particular from the AI literature (e.g., Brooks, 1991), have found that a focus on interdependence may in fact impede on a a design's efficiency and flexibility when relating to a broad system — where activities are diverse and embedded in an external world. Here, the emphasis in design is not primarily on the reduction of interdependence among compenents of a system, but on the parsimony of components — or a small number relative to the activities they support (Ingalls, 1981; Agre, 1997). The implications of these distinct approaches to design for understanding modularity can be illustrated by revisiting its foundational text — Simon's *Sciences of the Artificial* (Simon, 1969).

Modularity as used in most existing work in organizational design is well-captured in this text by Simon's famous parable in which a watchmaker achieves exponential gains in task efficiency by grouping watch parts prior to assembly into relatively independent, hierarchical components. Simon finds, in turn, that hierarchy (i.e., of tasks or parts) best enables reducing interdependence between modules, where he considers interdependence as the key drag on efficiency and flexibility. He implies that a watch can serve as a metaphor for any product or process in firms, where an ability to identify clear modules enables performing tasks, reconfiguring products, or adapting strategies more efficiently and flexibly.

Simon's text also is known, however, for his parable of an ant walking on a beach. He describes how an ant maintains its behavior by using a small set of relatively independent

actions to interact with the contours of the sand. Though little discussed in organizational design, scholars from other systems design literatures have pointed out that, whether inadvertently or not, the main idea Simon introduces here — that efficiency comes from a simple mechanism for interacting with the environment — could hardly be more different from that of the watchmaker parable (Agre, 2003). Whereas the watchmaker parable suggests a view of efficiency based on hierarchy, of flexibility as relating to internal parts, and of goals regarding finished products, the ant-on-a-beach parable suggests a view of efficiency based on parsimony (the simple machinery of an ant's body), of flexibility as relating to the environment (the diversity of the contours of the sound), and of goals regarding the ability to maintain basic behaviors (exploring the beach without getting stuck or in danger) (Agre, 1997).

Unlike his clear description of a watch in terms of an intricate set of hierarchical parts, Simon leaves the ant itself as mostly a black box. Other systems design scholars, however, found that the idea of using parsimony to maintain goals across environments could be related to modules by observing the long-run evolution of biological or cultural systems. They noted that fundamental units for performing tasks in such systems — whether ants in a colony, higher-level organisms of a species, social groups within cultures, cooking facilities within a cuisine, or modes of housing in a city — tended to develop efficiency and flexibility over long periods and based on a small set of punctuated changes (Brooks, 1991). In turn, they developed an approach to design based on the long-run implementation of a parsimonious set of general goals, as opposed to rapid change based on identifying particular interdependencies among internal parts (Brooks, 1999; Pickering, 2010).

These scholars' ideas relate to a view of modularity distinct from that in existing organizational design literature and, I argue, potentially useful in understanding strategies for developing broad systems. As the AI literature has usefully explored issues of systems design through broad biological and cultural phenomena, I suggest it may also be useful in the domains of strategy and organizational design to explore modularity in terms of ways organizing a broad system.

Given that prior perspectives have explored issues design and coordination at the firm- and industry-levels through the metaphor of recipes, I suggest that the metaphor of cuisines can serve as a lens on similar issues in the context of organizing broad systems. Before presenting and analyzing field data, I next describe my methods and research setting.

Research Context

Re-evolving Korean cuisine. In 2008, the Korean government announced new supports for both businesses and non-profit organizations to develop infrastructure in the food and beverage industry specific to Korean cuisine. The supports targeted diverse initiatives from knowledge creation, training, and branding, to overseas marketing, franchising and new product development. While momentum for innovation and growth in the domain of Korean cuisine had been building for decades prior, 2008 arguably boosted the legitimacy of Korean cuisine in terms of its potential to become a high-value industry. This potential stemmed both from observation of Korea's growing cultural capital (i.e., in popular culture), as well as in perceptions that rapid modernization and urbanization of

Korea's economy had led to an excessive focus on efficiency and productivity over value creation in the food and beverage sector.

When I began my research in 2011, a prominent concern in the food and beverage sector that many potentially value-creating aspects of Korean cuisine required knowledge embedded in practices that had become less common since the onset of modernization in the 1970s, such that the core knowledge base was being lost. For example, in Korean brewing, only two small firms produced the essential starter culture, with only a nascent understanding of the techniques for doing so. As a result, whether aspiring brewers, restaurant owners or food manufacturers, value creation strategies in Korean cuisine faced challenges of a lack of systematic knowledge and technologies to support innovation and growth.

The initiative. Korean Food Systems, henceforth KFS (a pseudonym), was a startup launched out of a public-private incubator for businesses in the Korean food and beverage sector that sought to design and develop a general knowledge base and technologies for supporting value creating businesses using capabilities from Korean cuisine. Its technical co-founder was a software designer, while its other co-founder was a marketer, both trained in Korean cuisine institutes. When I began my research, the founders were in a planning stage and it was six months before the company would actually be launched. They announced their vision of developing software within the design of a small-scale facility for making Korean food. They envisioned the facility as a kind of test lab, in which assumptions underlying the design of a knowledge base could be continually evaluated, as well as a basis for developing principles of facilities design specific to Korean cuisine. The company comprised five members, and opened its facility within a space for food entrepreneurship

in central Seoul. In addition to the technical co-founders, the other members had all met while enrolled at an institute for Korean cuisine and brewing. I focused on understanding the design of the knowledge base and technologies themselves that the company chose through observing its facilities and artifacts.

All members had been immersed in training at leading institutes, both culinary academies and academies teaching fermentation and brewing. I obtained the materials used by members through these institutes, ranging from syllabi, to recipe databases, forms for tracking processes, and overall manuals. Of particular note was members' frequent reference of older texts (written from the 15th to 19th centuries), which they found essential for many of the aspects of Korean cuisine (such as processes for making the starter cultures used in fermentation) that had diminished in recent decades in Korea. Given the focus of the study on the design of a knowledge base, these documents were foundational to the study — members took care to ground their own assumptions with these classic texts and the materials they received at the institutes.

Findings

I identified a strategy of enabling efficiency and flexibility in products and processes indirectly, by enabling aspects of interactivity, generality, and flexible centrality in the production space. In my analysis, I first show modules can be related primarily to physical or representational space (as opposed to primarily to tasks, information, specialized knowledge, product features, or individuals), and where these modules support individuals' capabilities for *spatial reasoning* and *concurrent coordination*. I identify design in terms of the physical and representational spaces involved in production. I then describe my design

of an organizational unit for producing Korean cuisine to relate this analysis to the context of organizations, and discuss distinct aspects of the design process. Finally, I discuss how this system relates to an alternative view of modularity as a source of long run, punctuated change for developing general systems.

The initiative is aimed at long-run adaptation — of developing a general knowledge based slowly — the period of observation only covered the beginning stages of design. While thus only a partial observation, the results of the initiative were broadly consistent with its goals. Based on interviews and observation, members demonstrated improved capabilities for working together, and across numerous sites of production. Further, the online knowledge base grew to hundreds of recipes, yet remained intuitive.

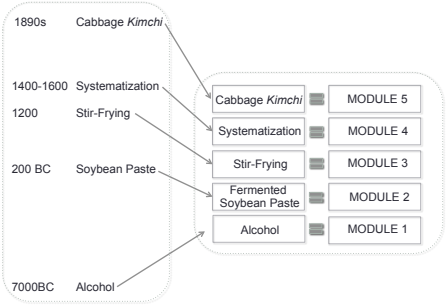
Achieving Modularity — Focusing on General Goals & Modularizing Space

I found that the initiative's ability to support efficiency and flexibility in activities was enabled by a design strategy of limiting its focus to a small number of general goals for behavior (as opposed to interdependent product features or strategy components), and on modularizing the physical and representational space over the details of processes.

Focusing on general goals. They first identified a possible set of modules for describing Korean cuisine in terms of general goals to maintain. Drawing on archival and inductive work, I identified an ability to perform tasks for making Korean alcohol consistently well as a plausible initial general goal. In Korean cuisine, one of the earliest behaviors would have been making alcohol, which dates back at least several thousand years (see Huang (2001) for an analogous discussion about the evolution of brewing

practices and cuisine in China). Archival research suggests that behaviors evolved from alcohol to include soybean pastes (fermented soybeans, used to flavor most dishes), perhaps dating to around the 2nd century BC (Huang, 2001; Han, 2003). As indicated in Figure 3.1, one hypothetical set of goal modules, in rough historical order, might include major behaviors such as stir frying (around 1200 AD), building and maintaining a text archive for the systematization of food concepts (1300-1600AD), and *kimchi* made from cabbage (late 19th century).

FIGURE 3.1
Identifying Korean Cuisine in terms of General Goals



General goals in Korean brewing practices. Both fieldwork and theories from system design suggested that the most basic aspects of Korean brewing practices would be important to, or at least consistent with, higher-level goals (i.e., making cabbage *kimchi*). In addition, fieldwork suggested that Korean alcohol processes are among the most sensitive in the cuisine, where small changes in facilities, practices or conditions could have large effects on the end result. Thus, the logic was that developing an ability to perform Korean brewing practices consistently would be a valuable initial goal for the long run.

General goals and systems design. In the earlier example of self-driving vehicles, 'avoid hitting objects' might be an example of a general goal module, while a task for

making a particular part of a car would not. In identifying general goals as a set of modules, I followed Brooks (1991) in assuming that each of them could be considered as small in number and mostly independent beyond a basic prioritization. Thus, I assumed prior concerns in organizational design regarding the reduction of interdependencies between product features or process tasks (e.g., Siggelkow and Rivkin, 2005; Thompson, 1967) could be ignored. I assumed instead that a key design concern was that the content of goals captured general aspects of performing tasks, and that goals could be measured in terms of criteria related to spatial reasoning and concurrent coordination. To continue with the self-driving vehicle example, a goal of 'avoid hitting objects' might have measurement criteria such as response time of a car's sensors to the surrounding environment (spatial reasoning) and of how the sensors collectively performed the response (concurrent coordination).

Modularizing the space of production

Efficiency and flexibility — metaphor of the *madang*. Kwon (2005) identifies a hallmark of a *madang* as its 'spatial ambiguity', arising from its permeable boundaries with its immediate outdoor environment and largely empty central area. She finds that spatial ambiguity allows a *madang* to support efficiency and flexibility in terms of performing tasks fluidly by drawing on all the modules in the system concurrently.

I illustrate three sources of concurrency in a *madang*. 'Interactivity' can be seen in the mixing of indoor and outdoor space to interact selectively with the environment, such as the enclosing structure of buildings that partially shields the *madang*, use of yellow mud as a porous building material to filter the surrounding air, and an empty area of gravel to

radiate heat from sunlight to regulate temperature. 'Generality' arises from equipment and tools for performing a range of activities concurrently, by multiple people, such as a work table and open sink that can support multiple tasks and people, positioned in any direction, and a circular, portable dining table). Finally, the *madang* is characterized by its 'Flexible Centrality', as concentrations of people, equipment, tools and materials may occur anywhere in the empty space, such as the ability to focus behavior anywhere on the work table or empty central area, including moving tools around).

By limiting design to supporting a small number of goals, the initiative sought to account for the fact that the potential users of the knowledge base would be situated in distinct production environments. The initiative instead focused design on structuring the space in which those goals could be performed to enable particular processes to be performed efficiently and flexibly.

I also identified a possible set of modules for describing the space in which tasks in Korean cuisine are performed. I drew primarily on archival and inductive work firstly to identify aspects of a physical space that afford general goals for Korean cuisine. In prior literature on modularity, physical space might be depicted in terms of a blueprint of a facility that would be largely fixed, and has not been as much of a focus of organizational design as, for instance, tasks or product features. In contrast, in a *madang*, the affordances for both using and reconfiguring spatial elements is central.

Linkage to AI. Based both on the physical space and on theories on the spatial representation of work processes (Engelbart, 1962; Kay, 1996; Victor, 2014) I identified a representational space in the form of a software prototype to support knowledge tasks

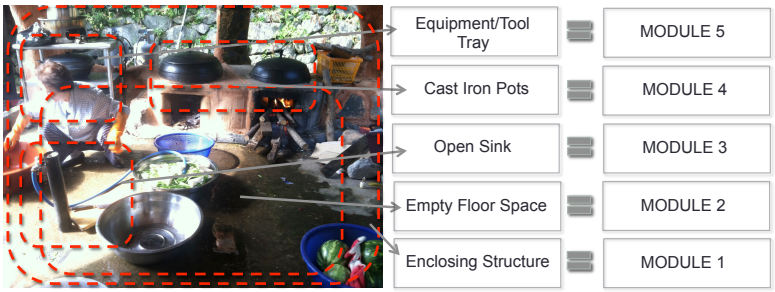
regarding Korean cuisine. In prior literature on modularity, representational space would correspond to the files, software programs, computers and other artifacts used to represent tasks, such as manuals, contracts, or standard operating procedures. While the extent to which an organization makes an effort to codify the content of tasks has often been viewed as strategically important (e.g., Zollo and Winter, 2002), the form has typically not been. Consistent with early perspectives on systems design (e.g., Engelbart, 1962), however, an increasing number of organizations arguably rely critically on developing flexible representations of knowledge. Airbnb, for instance, has invested heavily in a proprietary visual design language for supporting communication (Saarinen, 2016).

I sought to identify and decompose a physical and representational space to support performing tasks for Korean cuisine in terms of modules that afforded aspects of *interactivity* with the external environment*, generality* in use, and *flexible centrality* in their configuring. Given these aspects, I assumed that prior concerns in organizational design with reducing interdependencies between modules (e.g., Thompson, 1967; Siggelkow and Rivkin, 2005) could be ignored. I assumed instead that a key design concern was that the number of modules be kept to a minimum. Systems design scholars similarly emphasize the need for as parsimonious a decomposition as possible — whether of the physical space (e.g., Alexander *et al.*, 1977), the types and layout of artifacts (Agre and Horswill, 1997), or the representational space (Ingalls, 1981; Victor, 2014) — to support performing tasks as generally as possible.

Modularizing the Physical Space.

I drew on fieldwork and archival work on the Korean *madang* to identify one possible decomposition of the physical space for performing tasks in Korean cuisine. First, I identify an 'Enclosing Structure' to refer to the distinct boundaries of a Korean *madang* (affording, i.e., interactivity by using its shape and materials to regulate sunlight, temperature and humidity); an 'Empty Floor Space' (affording, i.e., flexible centrality by enabling reconfiguring of people, materials and equipment (Kwon, 2005); a third module of an Open Sink (affording, i.e., generality for cleaning and washing various amounts of materials, sizes of equipment by multiple people (from fieldwork)); a fourth module of Cast Iron Pots (affording, i.e., generality in its use across diverse tasks from boiling, steaming, grilling, frying and even distilling alcohol (from fieldwork and archival work)); and a fifth module of an Equipment/Tool Tray (affording, i.e., flexible centrality in enabling key tools to be both mobile and visible (from fieldwork)). I depict this identification of a Korean *madang* in terms of physical spaces of production in Figure 3.2 below.

FIGURE 3.2
Identifying Physical Spaces of Production



Modularizing the Representational Space

I next identified a possible decomposition of representational space for performing knowledge tasks regarding Korean cuisine (i.e., creating and exploring recipes, scheduling shifts, storing data through a screen-based interface in a software program). In the systems design literature on developing general representations of work processes (e.g., Engelbart, 1962; Winograd, 2001), scholars advocate schematizing the overall workspace within a screen — perhaps the most well-known example being the 'desktop' interface developed by Xerox PARC and loosely adopted by Apple and Microsoft in their designs for personal computing environments. In line with this literature, I used the Korean *madang* as a way to relate knowledge tasks to the physical tasks performed in Korean cuisine.

In particular, I drew on the modules that I identified to develop a graphical, schematic depiction of the physical space. Similar to the physical space, the focus was on identifying a small number of modules to enable interactivity, generality and flexible centrality in regards to creating, sharing or retrieving knowledge about Korean cuisine. The representational space corresponded to graphical depictions of both the physical spaces and key areas of knowledge. I identified fermentation crocks (to infer, i.e., the size of and required materials/equipment for a making a batch of alcohol), boxes to measure ingredients (to infer batch composition), shapes to symbolize fermentation phases (batch length), and an Enclosing Structure and Empty Floor Space for annotation of exceptions and contingencies. I depict this identification of a Korean in terms of representational spaces in Figure 3.3 below.

FIGURE 3.3
Identifying Representational Spaces of Production

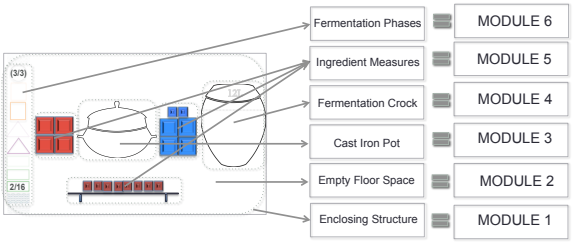


Figure 4 represents a complete 'recipe' for making a batch of Korean alcohol. These recipes were created with a graphical software program, and used on both PCs, messaging programs on mobile phone, and printed out in paper form (i.e., as labels on fermenters). In the design project, the group from the incubator used the modules to construct their own recipes, as well as for a variety of other knowledge tasks, such as anticipating materials or equipment requirements, keeping track of batch progress, and communicating about possible recipes to try.

While the primary purposes of the design project was to flesh out the earlier conceptual work, and thus not about hypothesis testing per se, the initial feedback was broadly consistent with the themes that emerged from the inductive and archival work. Overall, the group reported that they felt the design facilitated performing tasks for making Korean alcohol.

Analysis — Modules, Modularity and the Design Process

Aspects of interactivity, flexible centrality and generality differ from prior understandings of efficiency and flexibility in organizational design in terms of low interdependence and high interchangeability of modules (Thompson, 1967; Baldwin, 2008).

These differences correspond to a distinct understanding of what modules are, where modules' interfaces are located and, in turn, the overall structure of a system.

Reconceptualizing Modularity in terms of Spaces of Production

Whereas in prior views of modularity, modules correspond to groupings of tasks, the focus here was on spatial modules, such as the enclosure itself, the areas in which work is flexibly performed, and the areas over which equipment or materials are placed.

To return to the systems design literature discussed earlier, this physical space also has some analogs to the flexible arrangement of graphical windows within the representational space of a personal computing screen. Engelbart (1962), for instance, describes a way to represent organizational processes using computers by using graphical 'windows' that afford performing tasks flexibly. In the context of organizational design, I suggest that modules relating to the spaces of production can therefore be considered in terms of areas of or equipment in physical facilities, as well as the graphical windows and layout of a computer screen. I refer to these modules for decomposing space — whether physical or representational spaces.

Interfaces with the environment. Interfaces describe how a module relates to the rest of the system (Baldwin and Woodard, 2009). In prior understandings of modularity, interfaces describe how modules are interdependent with one another, as in the parts of a watch. Here, modules are instead interdependent primarily regarding the particular external environment, as with Simon's ant in relation to the beach. I suggest that, in a system for performing tasks in Korean cuisine, the effects of the modules depends on particular individuals' goals, weather conditions, and variation in ingredients.

Beyond being located within the same space, the modules themselves are only interdependent in regards to particular situations. For example, in Figure 1, the arrangement of the table, bowls and people may be interdependent to the task at hand, but can be easily reconfigured. I suggest that a view of interfaces as relating to the environment also can be important in firms designing general systems. For example, a self-driving vehicle depends on a collection of sensors and cameras that concurrently help perform driving tasks, dependent on the particular passenger destinations, roads, and conditions.

Form as spatial arranged. Finally, whereas in prior views of modularity, the overall form of modules and their interfaces corresponds to hierarchy (Simon, 1969; Baldwin, 2008), here it corresponds to a spatial arrangement (Arnheim, 1969). In the systems design literature, the basic idea of such a form is that, since the entire system might interact with the immediate environment at any given time, modularity results not from reducing interdependence between modules, but by having a small number of independent modules for interacting with the environment.

Spatial reasoning. In the systems design literature, Agre and Horswill (1997) argue that tasks in organizational processes can be factored in numerous ways, and thus that modules must enable responding to particular situations on a moment-to-moment basis. Along these lines, one way to consider the 'dynamic flow' of performing tasks is in terms of the ability of individuals continually to reconfigure the space according to the needs of a particular process. Scholars have found that this ability can be helpful in performing diverse tasks both in physical spaces (i.e., the mise-en-place used by a short-order cook (Kirsh, 1995)), as well as in representational spaces (i.e., displaying and rearranging computer simulations of diverse work processes (Engelbart, 1962; Victor, 2014)). Overall, I

suggest that the need continually to reconfigure space for supporting general goals can be described as a need to enable spatial reasoning by individuals.

Concurrent coordination. Considering 'dynamic flow' in terms of continual reconfiguring also extends to the ability of multiple people to work together flexibly. In this sense, I suggest that modular structure also can support general goals by affording concurrent coordination — or having multiple people and spaces involved in one overall task.

Modularity as a Strategy for Long-Run Adaptation

I found that identifying a modular system in terms of the physical and representational spaces of production also suggested a distinct understanding of the nature of goals to which modularity relates and the strategies for achieving them.

Maintaining goals. In prior literature, modularity is discussed as a design strategy for efficiently and flexibly performing tasks regarding specific production or innovation processes. Here, task modules each relate to specific goals regarding sequential aspects of tasks. Here, however, I suggest that the spatial modules primarily relate collectively to general goals to be maintained regarding tasks embedded in particular situations. For example, the interactivity, generality and flexible centrality enabled support the production of all aspects of Korean cuisine under various weather conditions. My analysis found that the modular structure supported general goals by affording spatial reasoning and concurrent coordination in individuals.

Developing general goals in stages. In prior literature, modularity relates only to systems with a complete set of goals. In Simon's watchmaker parable, for example, a watch is not functional until all of its parts are put together, where the idea of modularity is to make the process of getting there more efficient.

In contrast, since performing tasks in a modular system based on space also relies on the particular situations (i.e., individuals, materials, external environment) in which its embedded, I find that a modular system may be related to a single goal within a general system. In the context of firms, a strategy of developing general goals in stages has some resemblance to strategies in startups for prototyping large systems based on milestones for the behavior that the systems can maintain (Graham, 2014).

Overall, then, I found that describing a *madang* as a decomposition of the space in which tasks are performed leads to a view of modularity as a strategy for supporting the maintaining of general goals.

Discussion

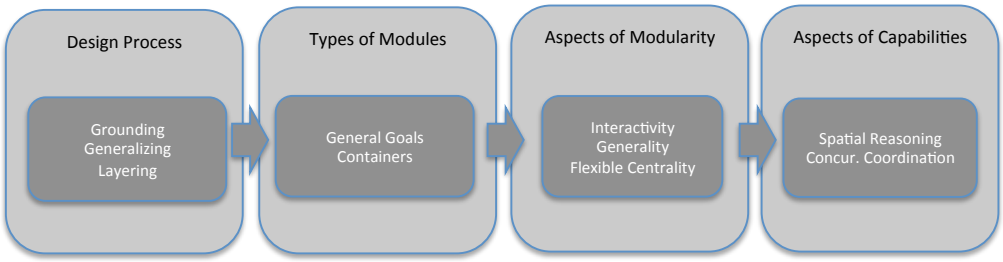
Research in organizational design and strategy suggests the importance of modularity (Simon, 1969; Baldwin and Clark, 2001; Gawer, 2011; Benner and Tushman, 2015). This research, however, has given less attention to the relationship between modularity as a source of long-run punctuated change important to the strategies of a growing number of firms. In this paper, I have drawn on the concept of a Korean *madang* as a metaphor and source of concepts for identifying systems of modules consistent with

developing general systems, adding to existing concepts identifying specific systems in terms of tasks, information, or knowledge.

Framework: Modularity as a Strategy for Long-Run Adaptation

My primary contribution is a framework for conceptualizing modularity as a strategy for long run adaptation. Prior understandings of modularity have considered systems as decomposable into tasks, information or knowledge, with a focus on rapid, exponential change. In contrast, I showed how a system can be operationalized in the context of organizations in terms of modules of general goals and physical and representational spaces of production. Finally, I identified processes for designing a system of grounding, generalizing and layering with a goal of parsimony, in contrast to processes in prior literature on modularity with a goal of reducing interdependencies. I outline the relationship between the design process, modules, aspects of modularity and capabilities in 3.4 below.

FIGURE 3.4
Modularity as a Strategy for Long-Run Adaptation



Prior concepts of modularity relate to challenges of managing interdependencies regarding processes such as innovation and new product development. The literature thus has tended to emphasize the strategic value of modularity in fast-changing industries and competitive markets (e.g., Gawer, 2014; Thomas *et al*., 2014). In contrast, modularity here relates to challenges of performing tasks in particular situations. Here, the strategic value of modularity rests in building a distinct system for value creation and capture from the ground up.

Further, the focus in prior literature on how specific tasks, information, knowledge, product features or people can be changed, recombined or added relates to the development of a system that is, for the most part, already presumed to exist. In contrast, the focus here on how general goals and aspects of space can be identified and implemented relates to the development of a novel system.

The distinct focus on long-run dynamics in the design suggests, in turn, that modularity might be usefully conceptualized as a source of punctuated change. In the strategy literature, much recent work has discussed the need to theorize the origins of organizational processes and to conceptualize firm behavior as a more entrepreneurial and open-ended process of discovering new opportunities, rather than recombinations of existing data (Felin *et al.*, 2014). I suggest that one implication is that conceptualizing organizational design in such terms may require a distinct understanding of tasks and goals consistent with a focus on long-run adaptation.

These differences — of rapid adaptation of an existing system, versus long-run adaptation of a new system — are further illustrated by scholars' choice of evolutionary metaphors for narrating the dynamics of modularity. Organizational design and strategy

scholars developing prior concepts of modularity have, for instance, made heavy use complex adaptive systems theory that assumes exponential change based on the specialized knowledge of interdependent agents (e.g., Ethiraj and Levinthal, 2004). In contrast, the systems design literature on which I have repeatedly drawn to formalize this paper's inductive and abductive findings have made heavy use of theories on the evolution of cells (e.g., Turing, 1990) or species (Dobzhansky, 1937) that assume punctuated change based on general structural properties (e.g., Pask, 1962; Brooks, 1991).

Organizational Design Capabilities

In prior work on modularity, design processes relate to the analysis of interdependencies (Thompson, 1967; Baldwin, 2008). Analyses might relate to processes regarding the engineering of tasks (Galbraith, 1974), evaluating consumers' willingness to customize product features (Schilling, 2000), exploring how knowledge underlying tasks fits together or can be recombined (Henderson and Clark, 1990), assessing the value of allowing greater flexibility in modules (Baldwin and Clark, 2001), or organizing individuals into cross-functional teams (Sanchez and Mahoney, 1996). In all of the examples, the focus of design is characterized by analyzing interdependencies to generate modules that enable adapting to rapidly changing technological and competitive environments.

I found that design instead related to a focus on parsimony, or identifying the smallest amount of equipment or the minimal facility for supporting general goals. The focus of design was thus characterized by processes of reducing the number of modules to enable a manageable basis for adapting to technological and competitive environments

over the long run. I found that this approach to design could be described in terms of processes of grounding, generalizing, and layering.

Grounding. In prior literature on modularity, scholars suggest that tasks, information or knowledge do not map precisely to specific products, and thus that we observe phenomena such as multiproduct firms and forms of external collaboration such as alliances and crowdsourcing (Baldwin, 2008). Many scholars in the systems design literature, however, suggest that a need to distribute information or knowledge may be reduced by identifying more parsimonious descriptions of tasks, which in turn also enables designs to remain more relevant beyond particular technological contexts (e.g., Ingalls, 1981; Agre, 1997; Graham, 2001b). In my design project, I found that parsimony could be achieved by a focus on relating information and knowledge to the inherently limited physical and representational *spaces* in which tasks were performed. Thus, I found that a key aspect of design processes for long-run change relate to 'grounding' analyses of tasks in the space in which they are performed.

Generalizing. Much recent literature on platforms and business models gives attention to how design processes may enable flexibility through changing, recombining or adding new modules (e.g., Gawer, 2011). In my context, I found that the enabler of flexibility instead related to design processes for iteratively identifying the most essential modules to performing a variety of tasks. At the start of this research, for instance, it was not obvious to me that Korean alcohol might make a plausible initial goal for Korean cuisine as a whole. Similarly, the incubator Y-Combinator describes how startups go through processes of developing an initial vision into an essential set of specs and milestones for developing and evolving a product into a general system over the long run.

Thus, I found that a key aspect of design processes for long-run change also relate to 'generalizing', rather than changing, recombining, or adding, modules.

Layering — designing for punctuated change. Finally, the focus in prior literature on analyzing interdependencies leads to design processes for generating exponential, rapid change. Scholars have remarked, for example, on how increasing the modularity of a system can lead to exponential growth in options for product design (Baldwin and Clark, 2001). In my context, I found that a focus on parsimony led to a design process for generating punctuated change. Archival work that suggested that Korean cuisine evolved in stages, for instance, enabled a design project based on a step-by-step implementation of general goals. Brooks (1991) describes a similar process in systems design of identifying 'layers' of general goals, where each layer is implemented and tested before an additional layer. Here, a layer might be considered as any general goal, plus its relevant physical and representational spaces. Since each of these 'layers' relates to a mostly independent general goal, the implication is that design processes relate to generating punctuated change.

Industry Evolution & Modularity

Recent literature has given attention to how ecosystems of value can emerge when a firm can establish a few relatively stable modules — i.e., core product components, a software protocol, or knowledge base — to enable greater overall innovation and flexibility (e.g., Baldwin and Woodard, 2009; Gawer, 2011). This literature offers a view of industry evolution in terms of force of change rooted in collaborative processes within modular ecosystems, in contrast to earlier views in terms of competitive processes within the value

chains and supply chains of industries (Porter, 2006). This literature views modularity as a form of design to enable rapid adaptation in continuously changing ecosystems.

This paper suggests, however, that key forces shaping strategy in a growing number of firms also relate to long-run punctuated change. By identifying modules in terms of general goals, it offers a way of framing organizational design distinct from the focus on issues of short-run innovation or new product development in existing literature on modularity. By identifying modules in terms of the physical and representational spaces in which tasks are performed, it further offers a way of designing for efficiency and flexibility over the long-run through a focus on parsimony, rather than the focus on interdependencies in existing literature.

Scaling based on small production units. I suggest that an assumption that the key forces of change relevant to strategy take place over the long run further leads to distinct issues of scaling and organizational design. Prior literature implicitly assumes that scaling relates to developing flexible modules regarding products (Schilling, 2000) or business models (Zott and Amit, 2007), or of generating a certain threshold of users (Parker and Van Alstyle, 2005). In this literature, a rise in demand is not typically considered as having a large effect on efficiency and flexibility, such that a firm can easily add another factory, procure more materials, or develop additional knowledge.

Knudsen, Levinthal and Winter (2014), however, find that interdependencies in a firm's activities may increase as it scales, which may thus affect its operations and even the very nature of its capabilities. Their view is broadly consistent with much systems design literature, which finds that scaling up any interdependent system for performing tasks is likely to work well only for specific goals where there is tolerance for large information

processing and knowledge transfer requirements (Beer, 1962; Agre, 1997; Graham, 2001b). Instead, the strategy for developing and maintaining a general system is to design fundamental units for performing tasks (Brooks, 1991). I suggest that similar strategies may also be important in a growing number of firm contexts. For example, novel technologies for manufacturing (i.e., FabLabs or Rethink Robotics) are developed within small-scale spaces for general use, rather than large factories with specialized divisions of tasks.

Conclusion

Analyzing diverse qualitative data, this paper developed a distinct concept of modularity as a strategy for long-run, punctuated change. My emergent framework indicates that such a strategy can be described in terms of a design based on modules of general goals and regarding the physical and representational space in which tasks are performed. I found that such a system relates modularity to the use of parsimony, and aspects of interactivity, generality, and flexible centrality. This system in turn may enable capabilities of spatial reasoning and concurrent coordination in performing tasks. In addition to the framework, I contribute by expanding our understanding of processes distinct to designing for long-run punctuated change. Overall, this paper is a first step in addressing the relationship between design and forces of change in firm strategy that go beyond prior focuses on rapid adaptation.

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