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AIDING ORGANIZATIONAL LEARNING: THE CASE OF INTEGRATORS IN FERTILITY CARE

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Abstract
Although management scholars have recognized that organizational learning is an indispensable constituent of strategic management, there are still fundamental questions about the contextual factors that influence the ability of organizations to learn from their experience. More specifically, this study seeks to test if organizational learning is influenced by different types of "integrators"– formally mandated managerial roles which cut across departmental structures and link interdependent specialists. These effects are analyzed using longitudinal data from the medical domain of *in-vitro* fertilization in the United Kingdom. The analyses illustrate how integrators, as elements of formal structure with varying levels of formal authority and relational coordination, influence collective outcomes in terms of organizational learning rates.

Keywords:
organizational learning, integrator, relational coordination, formal influence

INTRODUCTION

Characterizing the formal structure of organizations and its role in coordinated action has preoccupied scholarly inquiry for many decades (Burns & Stalker, 1961; Chandler, 1962; Eisenhardt & Brown, 1999; Galbraith, 1973; Lawrence & Lorsch, 1967a; Thompson, 1967). Most of this line of research has concluded that the optimal organization structure is dependent on a host of contextual factors ranging from the technology employed by the firm to the dynamism of its environment and the prerogatives of its strategy and operations. However, while recent research has suggested that managers may be able to use organizational structure as a lever for improving the balance between exploration and exploitation (Argote, McEvily, & Reagans, 2003; Benner & Tushman, 2003; Siggelkow & Levinthal, 2005), we still have limited empirical evidence for the relationship between learning outcomes at the organizational level and elements of formal structure that enable or mitigate such learning to occur.

As of yet, studies that has looked at organizational learning curves have largely overlooked the organizational context outside the team boundary, focusing primarily on factors in a team's local, or micro context, such as group composition (Hyatt & Ruddy, 1997; Pelled, Eisenhardt, & Xin, 1999), leader characteristics (Edmondson, 2003; Sarin & McDermott, 2003), and rewards for team performance (Gladstein, 1984). According to this perspective, the micro context influences team learning by increasing or decreasing the frequency of behaviors associated with information gathering, reflecting on work processes, testing assumptions and comparing opinions (Edmondson, 1999; Edmondson, 2003; Gibson & Vermeulen, 2003). Moreover, this stream of research highlights the considerable variance that exists across organizations in terms of other contextual features, that are superodinate to the team-level features and influence their ability of organizations to learn more readily (Argote & Ophir, 2002; Thompson, 2010).

This study zooms in on a particular feature of formal organizational structures that enables coordination across specialized subunits of the organizations – the integrator. Moving beyond classical organizational design characterizations of this role, which attributes higher coordination benefits to organizations who make use of them (Davenport & Nohria, 1994; Mintzberg, 1979; Nadler, Tushman, & Nadler, 1997), this study argues that its impact on performance is not monolithic, but that the integrator influences intra-organizational learning processes in a more nuanced way, as it operates on the basis of higher *relational coordination* (e.g. Gittell, 2002) as well on the basis of the *authority* that is vested in them (Wheelwright & Clark, 1992). Moreover, while both functions are embedded within the role of integrator, some integrators may rely more on one than the other, with consequences for the quality of the learning processes and outcomes at the collective level. More specifically, this study seeks to explore whether this is the case in a healthcare setting where integrators can be either nurses enacting their role mainly on the basis of relational coordination, or doctors who carry the role of integrator mainly on the basis of their higher authority levels in the healthcare organizations. Hence, while the main focus of the analysis is to establish if integrators benefit organizational learning in general, there is a particular focus on determining which kind of integrators may enable higher benefits of cumulative experience.
The theoretical predictions are tested in the context of fertility care in the UK, with a focus on the clinics which have provided *in-vitro* fertilization (IVF) for the interval 1998-2006. There are a number of reasons why the domain of IVF constitutes an appropriate setting to study the role and impact of integrators. First, this medical sector allows the identification of two modes of coordination achieved in workgroups: clinics which integrate efforts on the basis of programs, rules and feedback channels allowing ongoing communication, and clinics which in addition to these mechanisms also employ integrators[1] who coordinate across the functions of doctors, nurses and embryologists. Second, the performance of each IVF provider can be assessed objectively using the live-birth rate for the standard patient group, which is a commonly used method to assess clinical performance in IVF. Third, the setting provides detailed longitudinal data for a relatively large sample of clinics and their portfolio of activities, prior experience and technologies used. This research design permits to isolate the effects of structure on operational performance over time while controlling for various other factors.
The findings have practical significance because they raise attention to the value-creating role of integrators and to the mechanisms through which they enable superior learning outcomes. The primary contribution of this paper is to identify and contrast two important functions of the integrator, relational coordination and authority-based intervention, which impact knowledge management processes across intra-organizational boundaries and over time, resulting in steeper organizational learning curves. While this study cannot make normatively strong statements, the results have important implications for our understanding of the relationship between organizational structure and learning as an organizational outcome.

THEORY AND HYPOTHESES

Organizations are unique social entities consisting of specialized subunits attending to particular parts of the environment. As Thompson (1967), Lawrence and Lorsch (1967b), and Tushman and Nadler (1978) had emphasized, such conceptualization calls attention to the underlying phenomenon of interdependence between different subunits (March & Simon, 1958; Simon, 1991), and the heightened importance of managing cross-unit interactions appropriately. While much attention has been

[1] In the British domain of IVF, the labels used to describe the integrator roles are "*named nurse*" and "*one physician throughout treatment*."

devoted to how organizational structure affects performance, most studies in the organizational design stream have taken a static approach to analyzing the relationship and have discounted the temporal nature of learning processes. Hence, we know relatively little today about the problems of organizational learning in contexts defined by particular structural conditions.

In this study, I draw on the research tradition of organizational design by taking a dynamic perspective in analyzing the link between formal structures and organizational outcomes. For instance, in analyses of organizational structure, "programs" and "hierarchical supervision" are central features of formal structure enabling organizations to overcome the challenges of subunit specialization (Galbraith, 1973; March & Simon, 1958). Programs refer to the use of plans, standards, schedules, forecasts, formalized rules, policies, and procedures (Mintzberg, 1980), and together with hierarchical supervision, they enable reciprocal predictability of actions (i.e. coordination). However, this study reaches beyond a postulate concerning the relationship between structure and coordination to address issues of organizational learning over time.

Organizations can undoubtedly benefit from designs that structure the interaction of their subentities in ways which influence aggregations of local actions, and engender desirable outcomes at the collective level. For example, research employing agent-based simulation has explored the adaptive properties of various organizational designs and found that formal structure may bear differential problem solving advantages (Dosi, Levinthal, & Marengo, 2003; Ethiraj & Levinthal, 2004b; Knudsen & Levinthal, 2007), and could influence the effectiveness of incremental adaptation within a given technological paradigm (Rivkin & Siggelkow, 2003; Siggelkow & Rivkin, 2006). More recent work in this line of research has taken a step further by investigating the role of formal (but fallible) coordinating units in the context of shifting technological paradigms (Ethiraj & Levinthal, 2004a) and joint learning problems (Puranam & Swamy, 2009).

In line with recent developments in this stream, I focus on the role of integrative structures for organizational learning. Integrating specialized contributions in a team task is difficult in most circumstances, but is particularly challenging in firms with strong functional groups, extensive specialization and multiple, ongoing operating pressures. The physical and organizational distance between team contributors turns the leading of an effective cross-functional effort into a major undertaking.

Integrators as enablers of cross-functional interactions

In the functional form of organization, organizational members are grouped principally by discipline, each working under the direction of a functional manager. The different functions coordinate their work through "programs" on which all parties agree at the outset and through occasional meetings where issues that cut across functions are discussed. Over time, primary responsibility for the team task passes sequentially from one function to the next, a process often referred to as handoffs. However, on most cross-functional efforts, not all required contributions are known at the outset, nor can they all be easily and realistically subdivided. Hence, the associated disadvantage is that the feedback received by a contributor as result of her actions is often confounded by the actions of others, further impeding her learning as well as the whole group's ability to map actions to outcomes and learn experientially.

Integrators are formally mandated managerial roles which are superimposed on functional structures and carried out by one individual for the duration of the team task. These individuals have direct access to and responsibility for the work of all contributors to the team task and may exercise a functional role in addition to the integrator role. Integrators may also have authority over the other specialized contributors to the team task, in which case these contributors report both to their functional managers and the team integrator (Galbraith, 1973; Nadler et al., 1997).

By expediting work across individual contributors, integrators enable coordination at the lower levels of the organization in addition to the hierarchical supervision exercised by functional managers. Organizations which employ these structural add-ons, handle cross-functional integration in a particularly effective manner because of the consistency that they enable across subtasks and individual contributions. While prior research has shown that this method of organizational integration affects the time required for coordination and the quality of information flows across functional specialities (Clark & Wheelwright, 1992), evidence of the impact that these organizational arrangements have on learning processes and outcomes has proved elusive. The challenges of investigating the role of integrators for learning reside in the low frequency with which these structural features can be observed reliably in practice, as well as in the difficulty of collecting longitudinal data across a large number of comparable organizational settings.

Integrators as enablers of organizational learning

While much has been learned about how design choices in general, and integrators in particular, can improve coordination, less is known about the impact of integrators on organizational learning rates. For example, we don't know how the presence of integrators affects critical subprocesses of experiential learning, such as the mapping of actions to outcomes at the individual level and its consequences for overall reciprocal predictability of action (e.g., Puranam & Swamy, 2008) and effective learning at the group level (Reagans, Argote, & Brooks, 2005).

The question is how do integrators impact the learning dynamics of interdependent contributors to a focal task. While there are many likely mechanisms that affect the learning outcomes of a group in the presence of an integrator, this study focuses on two levels of impact: the integrator (1) ensures better communication through relational coordination (Gittell, 2002), and (2) manages the inputs of learning process on the basis of the level of authority vested in their role (Wheelwright & Clark, 1992). To test the impact of integrators on organizational learning, the study analyzes the variation in learning rates across organizations as indicators for the effectiveness of learning from cumulative experience. Exploring the effect of the integrator on this outcome makes it possible to illustrate how integrators as design choices shape collective outcomes beyond better coordination.

The literature on organizational learning views learning as the process of taking action, obtaining and reflecting upon feedback, and making changes to adapt or improve. Building on Cyert and March (1963)'s behavioral theory of the firm and March and Simon (1958)'s seminal work on the role of hierarchy, recent work in organizational design continues to explore how structure influences the information that is available to actors (Jacobides, 2007; Knudsen & Levinthal, 2007), and how it screens out the information available at higher levels (Siggelkow & Rivkin, 2005, 2006). Although this work is not explicitly directed at distinguishing the roles of integrators, it illustrates the mechanisms by which structural characteristics influence gradient search within stable technological paradigms. In particular, I propose that integrators promote system-level learning by providing more prompt and fine-grained feedback through *relational coordination*, and by exercising *authority* to reinforce successful actions and extinguish unsuccessful ones. More specifically, the relational coordination enabled by the integrator fosters better communication across functional boundaries and translates intermediate task outcomes into the different perspectives of each specialized contributor. In addition, through its second function of enforcing her procedural knowledge on the interdependent contributors, the integrator enables a more consistent mapping of actions to outcomes than representations achieved in the absence of the integrator; this benefit continues to be valuable even if the set of actions imposed on the basis of the integrator's authority are based on an imperfect representation of the problem, as illustrated by the benefits of erroneous maps in military campaigns (Weick, 1995) and experiential learning through trial and error

(Puranam & Swamy, 2012). In conclusion, by fostering better knowledge transfer through relational coordination and by disambiguating each contributor's action and payoff through its vested authority, the integrator enables a more effective use of cumulative experience at both individual and group level, as opposed to situations when interdependent contributors have to carry on their task in the absence of an integrator.

Hypothesis 1: *Learning rates are higher for organizations which employ integrators.*
Organization design theorists have noted the existence of a more spontaneous form of coordination referred to it as relational coordination (Gittell, 2002), mutual adjustment (Thompson, 1967), and teamwork (Van de Ven, Delbecq, & Koenig Jr, 1976). This form of coordination is distinct from the formal coordinating mechanisms described in this literature (e.g., integrators, team-meetings, routines) because it refers to the interactions among participants rather than the formal mechanisms for supporting or replacing those interactions. Relational coordination captures the oft-overlooked role played by the relational web that surrounds the focal task requiring the coordination of interdependent contributions. Specifically, some integrators may encourage or enable the development of stronger relationships among task members through their approachability and sense of mutual respect, in turn enabling them to more effectively coordinate the work processes in which they are engaged.
Some evidence has been found for the performance effects of relational coordination for members of cross-functional provider groups in the airline industry (Gittell, 2001) and hospital care (Gittell et al., 2000; Gittell, Weinberg, Pfefferle, & Bishop, 2008), in terms of improved quality and speed of service in a static sense. These effects hint to the impact that relational coordination might also have dynamically in terms of learning effects, as it has been suggested by this research that higher relational coordination eases knowledge transfer and retrieval. Moreover, when integrator arrangements emphasize relational coordination over the authority component within the integrator role, more conducive conditions for learning are expected to emerge; this may be due to the stifling conditions for knowledge creation and transfer in contexts where cross-functional interactions are governed mainly on the basis of formal authority. Indeed, while relational coordination may lead to "discovery" learning that is more action-oriented and personal, an integrator emphasizing more formal than relational influence over internally differentiated subunits may inadvertently slow the cycle of knowledge creation, transfer and retrieval that is so essential to learning. This leads to the following hypothesis:

Hypothesis 2: *Learning rates are higher for organizations which employ integrator arrangements which emphasize relational coordination over their formal authority.*

METHODS

To test these hypotheses empirically, it was necessary to select a context which allows the examination of organizational outcomes over time and under circumstances characterized by significant division of labour. The medical domain of *in-vitro* fertilization met these conditions because there is known to be wide variation in organizational attributes and performance across providers of *in-vitro* fertilization, as well as well defined clinical roles for health care professionals. In the United Kingdom, performance data and other statistics for establishments providing fertility treatments have been recorded since 1992 by the British Human Fertilization and Embryology Authority (henceforth HFEA), allowing us to avoid the bias of left censoring for the cumulative experience of each the clinics in our sample. However, as data on the structural features of the fertility clinics has been collected only since 1998, the findings in this study concern only the more recent part of the learning curves observed, which also coincides with a more mature stage of the technology and flatter slopes as compared to the initial stages.

The setting: In-vitro fertilization (IVF)

The setting offers the rare opportunity to measure learning outcomes in multiple organizations for the same task and at the same time. The task of completing an IVF cycle for the female patient consists of several stages (i.e., ovarian stimulation, egg extraction, gamete manipulation, and embryo transfer), and requires the joint participation of medical personnel coming from three areas of specialization (i.e., fertility doctors, embryologists and nurses). To understand the challenges of achieving coordinated action among these specialists, it is important to note that IVF continues to be a highly uncertain treatment[2] with many biological, physiological and clinical variables confounding the outcome of the interventions.

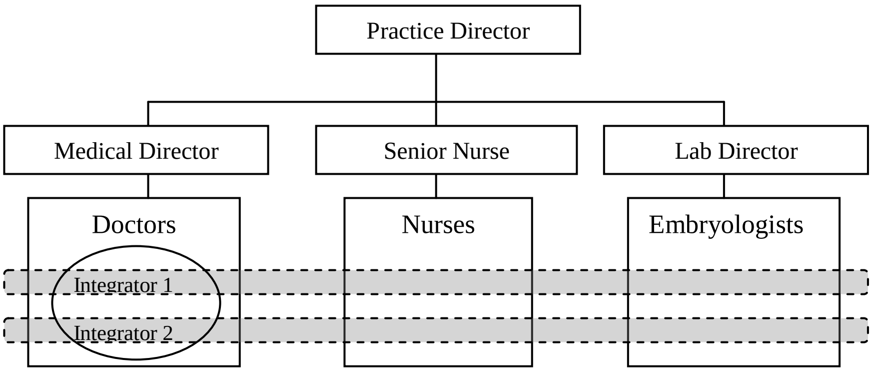
In addition to unknown biological factors that routinely confound feedback, coordination failures resulting from interdependent specialists having different domains of action and learning rates constitute an important and most debated[3] aspect of this medical domain. For example, IVF cycles require doctors, nurses and embryologists to leverage technology and know-how within their departmental boundaries (see Figure 1). Due to conflicts between the timing of patient visits and internal rota systems, the continuity of care (i.e., the stability of the IVF team which treats the patient throughout the treatment timeline) is often compromised. To address these challenges, some IVF clinics display organizational arrangements in which a dedicated doctor or a nurse (i.e. an integrator) sees the patient at each visit and acts as liaison with the other specialists involved.

In the IVF context, for instance, while both nurses and doctors play the role of integrators, and have the same broad objectives, it is generally recognized that doctors and nurses do not discharge their roles in the same way (Baumann, Deber, Silverman, & Mallette, 1998; McGarvey, Chambers, & Boore, 2000; Savage, 1995). Doctor-integrators are generally known to exercise higher levels of authority than nurses, while nurse-integrators add a layer of informational richness and ease of communication with and about the patient which is superior to that of doctor-integrators. The medical management literature refers to two normative models — 'care' vs. 'cure', with the cure model having been associated with physicians, and the care model with nursing and other allied health professionals (Baumann et al., 1998). As this literature suggests, the differences in the positional power of the two roles have emerged through the professional self-regulation of physicians as practitioners that would be judged only by their peers and by standards mutually agreed upon by physicians. Indeed, in this field, it is commonly known that doctors enjoy considerable autonomy and that their role, as independent experts, had been to employ the resources available to diagnose and 'cure' the patient if possible.

[2] The theoretical likelihood of achieving a live-birth per egg in any one IVF cycle is estimated to be in the 20-30% range. However, increasing age of the female patient lower significantly the probability of per-cycle success.

[3] Ongoing conversations and studies published in this field emphasize the importance of establishing "action plans", refining codes of practice and developing tools that synchronize the inputs of IVF specialists involved in a particular cycle (cf. interview data).

FIGURE 1. Integrators as structural add-ons to functional structures in IVF



While intermediate outputs (e.g. achieving fertilization) and partial checklists may still guide the action of IVF specialists, joint interventions performed by doctors, embryologists and nurses within a given IVF cycle are characterized by both sequential and reciprocal interdependence (Thompson, 1967). In these conditions, the reciprocal predictability of action is often muddled by noise and problems of shielding.

Sample

While many studies in this area are hampered by selection bias and serious left-censoring effects, this study includes the prior experience of all UK medical clinics that provided IVF from 1998 to 2006. The unit of analysis is the IVF clinic and the total number of clinics with at least three consecutive years of performance data is 81, with a final sample of 562 clinic-years. These clinics have performed over 400,000 IVF cycles on approximately 300,000 female patients, resulting in over 75,000 IVF babies by the end of 2006. Data on clinic-level live-births and patient base came from the database maintained by HFEA, while supplementary data on other clinic attributes have been obtained from published patient guides. The information in the HFEA database and patient guides has been collected annually and is subject to regular verifications during internal audits and onsite inspections at the supervised clinics. Table 1 provides more descriptive statistics regarding the sample.

Dependent and independent variables

The *dependent measure* in the main set of models is the annual IVF success achieved by the clinic. As the patients' main aim is to "have a baby", this measure of operational performance allows for cross-clinic comparisons in IVF is the chance of success in each clinic.

Independent variables. The testing of Hypothesis 1 requires the development of two measures which must be interacted: the cumulative IVF experience of the clinic, and whether the clinic uses integrators to coordinate the workgroups that emerge around each patient. To measure *clinic experience*, I follow the learning curve tradition by cumulating all prior IVF cases since 1992 and applying a log-linear transformation.

Descriptions of the structures employed by clinics to conduct their work are published in the annual patient guides as listings of "support services" offered by each clinic. To interpret this data, I drew on my field notes[4] to clarify the terminology and identify whether in addition to functional managers (e.g., medical director, head of laboratory

[4] This study is part of a larger project which involves ongoing and extensive consultation with IVF practitioners. To date, I have participated in 15 field interviews, 6 site visits and numerous industry events and conferences. In addition to recording and transcribing the majority of the meetings and interviews in which I took part, I am also constantly surveying the medical publications in human fertility to gain a deeper knowledge of the clinical, therapeutic and administrative aspects specific to IVF.

and head of nursing), clinics have different setups for coordinating the work of interdependent contributors at the patient level. The investigation led to the identification of the constructs of "*named nurse system*" and "*one physician throughout treatment*" – which denote the type of integrator arrangements available at the focal clinic. I coded the occurrence of the term as a binary variable (*integrator*) which takes the value of 1 if one or both types of integrators are reported as being available at clinic, and 0 otherwise. Surprisingly, this characterization of clinic structure displays very low within-clinic variation with no instances of integrator adoption and only three clinics eliminating the option of offering integrators.[5] To improve the empirical strategy and the clarity of the results, I excluded the clinic-years observations which occurred after the integrator option was abandoned by the three clinics in question. This measure addresses the concern that structural changes may be behind the results of the analysis.

To test the second hypothesis, which zeroes in on the impact of different types of integrators on learning from experience, it was necessary to specify three additional binary variables: *only doctor-integrators*, *only nurse-integrators*, and *both doctor and nurse integrators*. All these measures take the value 1 if the clinic reported the corresponding integrator arrangement as being available. The omitted variable for this test of the effect of each integrator arrangement is *no integrator* (taking the value 1 if the clinic reported none of the setups identified).

Clinic capacity measured as the number of patients treated in the year of observation was used as a control for clinic size. The variable for the age of the clinic was measured as the number of years since the clinic was established, and to control for vicarious learning and the state of the art in IVF in each year,[6] I include a measure of industry-level experience which consists of a log transformation for the count of patients treated in the UK prior to the year of observation.

As the chance of success through IVF decreases with the age of the female patient, and displays a particularly sharp decrease after the age of 35 (HFEA, 2007), it was also important to control for the age profile of the patient population at each clinic by specifying the percent of patients who are over the age of 35. To control for the nature of the IVF technology used, I specify the percent of cycles which involved more invasive micro-manipulation of gametes during the year of observation (i.e. *intra-cytoplasmic sperm injection*, henceforth ICSI). Finally, I also include clinic dummies to control for other unobserved clinic characteristics which may affect clinical performance (e.g. they are training clinics for junior specialists or may be affiliated with a university or a research clinic; they may have certain patient selection policies in place or different structures not captured by the integrator variable; they may operate in areas where the population has lower fertility rates, etc.).

Analysis

The statistical analysis used standard procedures for longitudinal data. The modelling approach consists of linear regression analysis for cross-sectional time-series data with robust estimation. Preliminary analyses considered Tobit models (as the dependent variable is a fraction, and hence non-negative), random effects estimation and general linear models (to attempt estimating the effect of *integrator*), and estimation with clinic fixed effects. For brevity and in accordance with standard tests[7]

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[5] Two private clinics and one clinic affiliated with the National Health System (NHS) ceased to report the use of integrators towards the end of the period of observation (post 2003). Their subsequent clinic-year observations were dropped from the analysis to guard against misleading results.

[6] Early model specifications have included year dummies in addition to controls for industry experience, clinic age and technology. However, year effects were not significant.

[7] In deciding whether to use the fixed or the random effect technique, I carried out the Hausman specification test which justified the use of the fixed effect estimation (p-value < 0.01).

for determining the appropriate estimation method, I present only the results of the last approach.

The following regression models were developed to test H1 and H2:

i. $Y_{it} = \alpha_1 + \beta_1\, EXP_{it} + \beta_2\, INT_i + \boldsymbol{\beta_3} INT_i \times EXP_{it} + \Sigma\, \eta_j Z_{ijt} + v_i + \varepsilon_{it}$

ii. $Y_{it} = \alpha_2 + \delta_1\, EXP_{it} + \delta_2\, NURSEINT_i + \delta_3\, DOCINT_i + \delta_4\, BOTHINT_i$
$+ \boldsymbol{\delta_5}\, NURSEINT_i \times EXP_{it} + \delta_6\, DOCINT_i \times EXP_{it} + \delta_7\, BOTHINT_i \times EXP_{it}$
$+ \Sigma\, \eta_j Z_{ijt} + v_i + \varepsilon_{it}$

Where Y_{it} is the success rate of the clinic *i* in year *t*, EXP_{it} is the prior experience, and INT_i indicates whether the clinic uses integrators of any type (i.e., equal to 1 if the clinic uses one clinician throughout treatment, and 0 otherwise). To identify the learning effects at the level of integrator types and test H2, the binary variables $NURSEINT_i$, $DOCINT_i$ and $BOTHINT_i$ are entered into model (ii) to account for the effects of having only nurse integrators, only doctor integrators or the availability of both at the clinic. *Z* is a set of control variables, v_i the firm-specific residual, and ε_{it} is a standard residual (with mean zero, homoskedastic, and uncorrelated with itself, v_i and independent variables). Coefficient β_3 tests H1, and δ_5 tests H2, both coefficients being expected to be positive; additionally, to test H2a and H2b it is expected that $\delta_5 > \delta_6$ and $\delta_5 > \delta_6$.

As there are multiple observations for each clinic, I used fixed effects regression to correct for clinic-specific autocorrelation. As discussed in the previous section, clinic-specific characteristics affect success rates across clinics and also mean that the longitudinally clustered data violate the underlying assumption of independence. One way to account for unobserved heterogeneity with this type of data is to estimate an OLS regression with fixed-effects estimation which accounts for within-effects information. Note that due to the measures for integrator (*INT* and its variants) being time-invariant, model specifications which include clinic fixed effects do not allow direct estimation of $\beta_{2,}$ δ_2, $\delta_{3,}$ and δ_4,.

RESULTS

Table 1 presents the descriptive statistics and correlations for key study variables. The only high correlations among independent variables occur between clinic experience and three other covariates: clinic size (0.64) and clinic age (0.76). However, the relatively large sample size produces high level of statistical power, which can overcome even extremely high correlations among variables (Mason & Perreault, 1991).

TABLE 1. Descriptive statistics and pairwise correlations

Note: The analysis represents a longitudinal examination of 81 clinics, with an average of 6.9 years of observation per clinic (min of 2 years; max of 8 years).

Level of analysis: clinic-year observations	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. Success rate for the standard patient group (%)	562	0.241	0.075	0	0.53	-									
2. Clinic size (count of current patients)	562	334.46	261.29	2	1467	0.308									
3. Age of clinic	562	10.863	4.952	1	26	0.123	0.517								
4. (Log) Industry prior experience	562	12.175	0.237	11.78	12.53	0.162	0.143	0.366							
5. Use of invasive technology (% ICSI)	562	0.370	0.146	0	0.81	0.270	0.297	0.122	0.388						
6. Incidence of complex cases (% patients >35)	562	0.504	0.099	0	0.84	0.082	0.144	0.171	0.373	0.131					
7. (Log) Clinic prior experience	562	7.188	1.715	0	9.48	0.233	0.642	0.759	0.232	0.176	0.105				
8. Integrator (binary)	562	0.521	0.500	0	1	0.085	-0.048	-0.103	0.035	-0.024	0.119	-0.151			
9. Only doctor-integrator (binary)	562	0.098	0.297	0	1	-0.067	0.219	0.190	0.023	-0.009	-0.080	0.124	0.316		
10. Only nurse-integrator (binary)	562	0.313	0.464	0	1	0.135	-0.050	-0.125	0.036	0.057	0.161	-0.107	0.647	-0.222	
11. Both nurse and doctor integrator (binary)	562	0.110	0.314	0	1	-0.002	-0.209	-0.159	-0.019	-0.115	0.027	-0.200	0.337	-0.116	-0.238

TABLE 2. Regression results for IVF success rates
(Fixed effects models)

Variables	Model 1		Model 2		Model 3	
Clinic size (hundreds of patients)	0.00002		0.003		0.003	
	0.002		0.003		0.003	
Clinic age (years)	0.004	***	0.013		0.012	
	0.002		0.011		0.011	
(Log) Industry experience	0.005		0.105		-0.100	
	0.005		0.101		0.101	
Use of invasive technology	0.037	**	0.050	*	0.051	*
(% ICSI cycles)	0.017		0.031		0.031	
Patient age profile (%patients	-0.078	***	-0.062	†	-0.064	†
35 and older)	0.029		0.043		0.044	
(Log) Clinic experience	0.007	***	0.0003		0.0001	
	0.002		0.004		0.004	
Integrator x (Log) Clinic exper			0.011	**		
			0.005			
Only nurse-integrator					0.021	**
x (Log) Clinic experience					0.010	
Only doctor-integrator					0.010	*
x (Log) Clinic experience					0.006	
Doctor or nurse integrator					0.012	*
x (Log) Clinic experience					0.007	
Constant	0.104	**	1.35		1.281	
	0.046		1.11		1.114	
Nt (clinic-years)	562		562		562	
N (clinics)	81		81		81	
ll	1522		944		942	
F	61.02	***	5.05	***	4.01	***
Clinic fixed effects	Yes		Yes		Yes	

*** $p < .01$; ** $p < .05$; * $p < .10$; two-tailed tests.† $p < 0.10$ one-tailed test

<u>Note</u>: As the measures for integrator are time-invariant for the duration of observation, they cannot be estimated in a fixed-effect specification. Nevertheless, their effect is captured in the fixed effect of each clinic.

Table 2 presents the results of the fixed-effects OLS regression, with Model 1 including only the control variables and showing that older clinics tend to have better results than younger clinics. This may suggest that that in addition to accumulated experience, the age of the clinic taps into a distinct dimension of capability which contributes to performance. As expected, the more invasive the IVF technology used the higher the chances of success, further corroborating industry accounts that advances in the micromanipulation of human gametes have played an important role in overcoming the challenges of achieving pregnancies through IVF. Finally, clinics with older patient profiles tend to have lower success rates due to the age-related challenges to achieving a pregnancy.

Cumulative experience has a positive and significant effect on the likelihood of treatment success and validates the existence of productivity gains from experience for clinics in this medical domain. Finally, the estimated clinic fixed effects are significant and provide strong evidence in favour of using panel data techniques which address the problems of correlation between regressors and the time-invariant error term. Regression models using random effects lead to similar results. In these models I was able to estimate the effect of the variable *integrator* as having a positive impact on the success rate. Although the fixed effect model does not permit the estimation of the impact for employing integrators, a Hausman test comparing fixed-effects and random-effects specifications indicated that the fixed-effects model is the appropriate specification (p-val <0.05).

Hypothesis 1 states that the positive relationship between operational performance and experience is expected to be stronger for organizations employing integrators. The positive and significant coefficient of the interaction term in Model 2 supports this hypothesis. The findings show that IVF clinics which coordinate the collective action of various contributors involved in treating a patient through a dedicated coordinator achieve better learning outcomes (i.e. higher learning rates). This result supports the argument regarding the role of integrative structures in reducing the confounding effects of interdependence. Surprisingly, the significance of the experience measure disappears when its interaction with *integrator* is included. This is to be interpreted as evidence that clinics without integrators are not generating productivity gains from experience. Yet again, this result is not due to the clinics having superior capabilities – which is an alternative explanation ruled out by the significance of clinic fixed effects, rather the results confirm the role of the integrator in enhancing the learning ability of these clinics.

Hypothesis 2 states that the organizations which make use of integrators to coordinate specialized contributors mainly on the basis of their strong relationships (i.e., relational coordination) would learn more effectively than those organizations whose integrators operate mainly on the on the basis of the authority that has been delegated to them to coordinate the inputs to the focal task. The positive and significant effect for the interaction between only nurse-integrators and cumulative experience, in combination with tests for the difference between its coefficient and those of the other two interactions (p-val < 0.05 for both tests), provides evidence for this hypothesis. Thus, it appears that the presence of organizational setups that allow for nurse integrators in IVF clinics enables for success rates that are 9 to 11 percentage points higher than clinics offering the other two types of integrator arrangements. This is not a negligible effect in a medical domain where treatment success rates were at an average of 24% during the interval of observation.

Alternative explanations and further analysis

One alternative explanation for the results relate to the integrator possibly attracting additional resources for the clinic, such as an influx of additional cash which would allow clinics to invest in better technology and hire versatile staff, and thus learn more effectively. I ruled out this alternative by performing two tests for the differences in the extent of invasive technology employed and research undertaken by the clinics. Both tests found no significant difference between clinics which employ integrators and clinics which do not. In addition, the clinic fixed effect specification accounts for unobserved time-invariant characteristics (e.g., clinic capability, intrinsic quality of management) which may vary across clinics.

Another alternative explanation was suggested during interviews with IVF practitioners and relates to the integrator representing a comfort factors for the patient. It is commonly accepted in fertility that the psychological disposition of the parents-to-be influences their fertility and thus the outcome of fertilization techniques (Campagne, 2006), and interviewees were prompted to suggest that having the same doctor or nurse throughout treatment may positively impact the chances of success. However, none of the claims for the psychological impact of the integrator on the patient's wellbeing can explain how it could also lead to better learning for the specialists treating the patient. At best, the comfort factor generated by the integrator is captured in the constant term.
In combination, these additional analyses undertaken as part of this investigation offer more convincing evidence of the role played by the integrators as elements of organizational structure in enabling learning processes and shaping learning outcomes.

DISCUSSION

This study builds on the research traditions of organizational learning and organizational design to investigate an understudied dynamic implication of integrative structures for collective learning. I use the healthcare domain of *in-vitro* fertilization in the UK to examine the relationship between organizational structure, learning processes and subsequent operational performance. Uniquely, I examine the impact of integrators, as structural add-ons to the functional forms, and their impact on collective learning as operationalized in the tradition of the learning curve literature.
The positive effect of integrators on learning from cumulative experience was largely attributable to their role of managing the interdependence that arises between specialists coming from different domains of action. By enhancing the relational coordination and by exercising their influence to simplify to reduce the confounding effects of learning the in an ecology of other learners, these forms of lateral coordination enhance the reciprocal predictability of action which in turn enables more effective system level learning. I provide both factual and empirical support for these mechanisms.
The results substantiate existing theory that effective organizational action requires an accommodating organizational environment, not only task mastery achieved through experiential learning alone (Edmondson, 2003; Edmondson, Bohmer, & Pisano, 2001; Pisano, Bohmer, & Edmondson, 2001). Therefore, the way learning is managed affects the rate of improvement. The study demonstrates this on a unique dataset by providing compelling evidence for a neglected dimension characterizing the intra-organizational context – the structure within which interactions among interdependent agents take place.
As is usually the case, some potential limitations of this investigation should be explicitly recognized and taken into account when interpreting the findings. First and most critically, this research utilizes panel data to examine the relationship between operational effectiveness and cumulated experience over an extended period of time. Thus, one must be extremely cautious about interpreting efficiency improvement as a measure of learning in other contexts where work does not involve repetition of the same task.
While I have attempted to overcome many limitations in the analyses, a few remain. Because the data for the study were from a single industry, one potential limitation relates to the generalizability of the findings to other industries. Research indicates that many manufacturing industries share similar characteristics and norms regarding structural mechanisms for coordination with health care, the setting for this study. For example, Wheelwright and Clark (1992) identified the presence of integrators (i.e. "heavyweight" and" lightweight" team managers) while studying cross-functional teamwork at Motorola; similarly, TATA Motors and other car manufacturers

specifically employ engineers to fulfil the role of *vehicle-integration managers* to coordinate the contributions of various functional departments to a focal car model (Shelton, 2003). Therefore, although generalizability of the study is somewhat limited, I expect that the use of integrators would affect learning dynamics of cross-functional teams in industries with similar concerns for coordinating efforts across several distinct domains of knowledge.

Another potential limitation relates to the stable measure that captures organizational structure, thus preventing accurate estimations for the cross-sectional effect of the integrator and masking the nature of structure as also evolving with and being changed by experience. This poses an interesting question for further exploration, namely how the learning outcomes of firms using integrators with authority differ from the learning outcomes achieved when integrators possess less or no authority over interdependent contributors.

Finally, some measures may not adequately account for the constructs intended – for example, clinic capacity (measured as the number of patients treated in the current year) imperfectly approximates the size of scale economies achieved by some clinics. Similarly, while clinic fixed effects account for the time-invariant component of differences across clinics, the lack of data on turnover rates and experience of staff (useful to account for the individual learning of integrators) restricts the ability to control for possibly relevant time-variant components.

Collectively, the findings inform an understanding of the processes by which organizational-level learning and adaptation occur in the presence or absence of integrative structures. More specifically, the analyses emphasize the significance of integrators as choices of organizational design not only for the coordination of internally differentiated subunits engaged in repetitive operations, but also for the learning outcomes achieved at the organizational level. In addition to documenting the role of the integrator, this study also raises interesting questions about the role of organizational structure in shaping collective action. Together, these results enable a further refinement of our understanding of the factors that enhance firms' abilities to learn more effectively from their experience, thus offering a novel contribution to the strategy and organization field.

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