THE ROLE OF INTEGRATORS IN ORGANIZATIONAL ADAPTATION TO INTERDEPENDENCE SHOCKS: EVIDENCE FROM FERTILITY CLINICS

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Abstract

This paper empirically investigates how organizational adaptation to interdependence shocks is influenced by "integrators". These are formally mandated managerial roles meant to promote coordination across specialized but interdependent organizational sub-units without relying on formal authority. While much has been learned about how integrators promote steady state coordination within a known pattern of interdependence, less is known about their impact on organizational adaptation when the pattern of interdependence itself changes. We discuss mechanisms by which integrators may also be useful in such situations, and test our hypotheses in the context of a regulatory shock that affected the IVF clinics sector in the UK.

Keywords: integrator, adaptation, organizational design, coordination

1. INTRODUCTION

This study develops and tests a theoretical framework about the role played by integrators in facilitating organizational adaptation to interdependence shocks. Integrator roles are elements of the formal organizational structure that enable the coordination of efforts across specialized personnel within the organization. These formally mandated managerial roles are meant to enable coordination between (but have limited authority over) sets of specialized but interdependent actors (Mintzberg, 1979, p.165; Mohrman, 1993, p.118). A special case of boundary spanners (Adams, 1976; Aldrich & Herker, 1977), integrators serve as coordination mechanisms within organizations by ensuring common understanding between functional groups (Mohrman, 1993). They are a pervasive feature of today's organizations and when first introduced, were heralded as a significant innovation in organization design (Davenport & Nohria, 1994; Mintzberg, 1979; Nadler, Tushman, & Nadler, 1997).

Organizations today have developed a proliferating set of managerial roles that act as integrators: *project managers* ensuring coherent hand-offs between various functional units involved in product development (Allen, 1984; Wheelwright & Clark, 1992); *case managers* in hospitals ensuring the smooth transition of the patient from one treatment stage to the next (Gittell, 2002); *vehicle-integration managers* coordinating across various stages of car manufacturing (Iansiti & Clark, 1994; Loch, Pich, Terwiesch, & Urbschat, 2001); *account managers* in large, multiple-service banks, who coordinate across the investment banking functions of origination, risk analysis and execution of credit products (de la Torre, Martinez Peria, & Schmukler, 2010); and *court administrators* tying together the dispersed elements that make up the criminal justice system (Gertz, 1977). In each instance, integrator roles are meant to coordinate the smooth flow of work involving specialists housed in distinct organizational units;

they are meant to prevent coordination failures—i.e. delays, misunderstandings and things "falling between the cracks" (Srikanth & Puranam, 2011). Indeed, the integrator often acts as a "progress chaser" driving agreement and engagement across internal departments for the integration of their various inputs to the focal task (Galbraith, 1973; Mintzberg, 1979; Nadler et al., 1997)—as in the work of the "nurse coordinators" at Karolinska Hospital, described by Daft and his colleagues (2009, p. 108); (see also Jacob, 1995). In sum, integrators help to manage the interdependence between functionally differentiated specialists who may have neither the explicit incentives nor the information needed to do so themselves, but critically integrators do so without formal authority.

Organizational contexts, however, are characterized not only by complexity, but also by change (Duncan, 1972; Mintzberg, 1979) – in particular the possibility of shocks that alter the nature of interdependence and coordination required within organizations (Puranam, Raveendran, & Knudsen, 2011). Coordination can be challenging even with static patterns of interdependence (Malone & Crowston, 1994; Thompson, 1967); but adapting to a new and poorly understood pattern of interdependence may be particularly complicated (Ethiraj & Levinthal, 2004; Siggelkow & Rivkin, 2005). When a sudden change to the pattern of interdependence between individuals (henceforth, an "interdependence shock") occurs, we argue that the members of the affected organization lack an understanding of the new pattern of interdependence, and performance must consequently suffer. The key question we investigate is whether integrators effectively exacerbate the problem by locking the organization into previous patterns of interaction that are no longer appropriate given the interdependence shock, or whether they in fact enable the organization to adapt (i.e. regain performance or avoid performance declines after the shock).

We draw on prior literature to propose that the mechanisms through which integrators normally act, namely the creation of information flows between, and the exercise of informal authority (integrators do not have formal authority, by definition) over the individuals whose work they are meant to coordinate, may aid organizational adaptation in the event of an interdependence shock. We build this argument on the foundations of theoretical results from formal models of organizational learning and adaptation, that show that these mechanisms should in fact enable multi-unit organizations to adapt to unknown interdependencies between the units (e.g., Lave & March, 1993; Levinthal & Posen, 2007; Lounamaa & March, 1987; Puranam & Swamy, 2013; Rivkin & Siggelkow, 2003; Siggelkow & Rivkin, 2005; Siggelkow & Rivkin, 2009). Crucially, we do not argue that integrators enable organizational adaptation on the basis of superior understanding of the new interdependence structure, but rather that they enable the organization to achieve this understanding more rapidly by avoiding superstitious learning (Levinthal & March, 1993; March, 1991).

Prior empirical work on integrators has relied extensively on qualitative data (Clark & Wheelwright, 1992; Iansiti & Clark, 1994; Lawrence & Lorsch, 1967b), as well as correlational data linking integrators to work outcomes (Gittell, 2002; Khandwalla, 1974; Lawrence & Lorsch, 1967a). We exploit an empirical context that allows closer-to-causal inference about the consequences of integrators for organizational adaptation. We test our arguments in the context of *in-vitro* fertilization (IVF) clinics in the United Kingdom, which in 2001 experienced a major regulatory change that impacted the patterns of interdependence between the various stages of the IVF process. Clinics varied in whether they already had in place integrator structures to manage the treatment of patients; we could therefore exploit this variation (which could not plausibly be based on anticipated clinic-specific consequences of the shock), to test how effectively they coped with the regulatory change. This is in effect a natural quasi-experiment, with the interdependence structures in clinics being manipulated through regulatory change (hence “natural”), albeit without random assignment (hence “quasi-”). Our data comprises a unique longitudinal dataset relating to 70 clinics providing IVF treatments for a span of 14 years, allowing the estimation of clinic fixed effects that account for stable unobserved clinic attributes that may be correlated with the use of integrators. These data were painstakingly collected over a period of several years through repeated applications under the Freedom of Information Act of the United Kingdom.

The rest of this paper is organized as follows: to contextually anchor our arguments, we first begin with a description of the empirical context. We then describe the nature of the regulatory shock that occurred and the challenges to organizational adaptation it posed, and then describe our hypotheses. After a description of data and methods, we report our results, and conclude with a discussion of their implications for theory and practice.

2. EMIRICAL CONTEXT: IVF CLINICS IN THE UNITED KINGDOM

Interdependence shock in the UK IVF industry

We know that certain technological shocks can alter the pattern of interdependence between specialists within an organization (Burton & Obel, 1984; Henderson & Clark, 1990; Mintzberg, 1979). This was the case for the British clinics that were providers of *in-vitro* fertilization (IVF) treatments, who had to adjust their clinical practices when regulators, recognizing multiple pregnancies as an undesirable complication of IVF, placed a strict limit on the number of embryo transfers that a patient could have. To understand the context, we conducted a total of 19 face-to-face interviews with doctors, nurses and administrators in the industry. For a separate set of eighteen respondents, we elicited job descriptions for integrators in the IVF field by contacting (via email or telephone) both clinics using integrators as well as clinics not using them. We also reviewed published articles on the management and organizational processes of such clinics.

While fertility treatments performed before 2001 allowed for three or more embryos to be transferred in order to increase the chance of pregnancy, a regulatory intervention in this year which is central to our study required clinics to transfer at most two embryos to patients, with single-embryo transfers strongly recommended for women up to the age of 35 (HFEA, 2001). These restrictions on the embryo count—which is a critical input for fertility treatments—prompted IVF clinics to compensate for the decline in the treatment effectiveness through various measures, thus altering the nature of the interaction between specialists involved in IVF (see Figure 1 for the decreasing trend of embryo use after 2001). As we will discuss below, the highly interdependent choices across specialists involved in IVF and the impact of the new policy on embryo transfers raised new obstacles for achieving reciprocal predictability of action – coordination– in clinical care, making this setting a useful one for our purpose.

---- *Insert Figure 1 here* ----

The task of performing IVF 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 several areas of specialization: fertility doctors, embryologists, lab technicians and nurse specialists. Figure 2 illustrates the IVF process before and after the regulation, with the grey boxes representing the areas where there were new patterns of interdependencies that had to be considered between upstream and downstream activities from the stage of embryo transfer.

---- *Insert Figure 2 here* ----

To understand the challenges of achieving coordinated action among these specialists, it is important to note that IVF continues to be a treatment with modest success rates,[1] and that many biological, physiological and clinical variables confound the outcomes of interventions along the treatment trajectory. While an understanding of the biological and physiological uncertainties in IVF are beyond the aims of this study, the coordination challenges resulting from interdependent specialists having to adapt to a new pattern of interaction are the focus of this study.

The most obvious consequence of restricting the number of embryos used after 2001 was the need to change lab technologies. As outputs of micro-manipulations performed in the lab, embryos resulting from fertilization began to receive greater attention than before. Two major developments in lab technology have taken place in response to embryo count restrictions: morphological scoring of embryos to ensure that the embryos selected for transfer are also the most viable (Baczkowski, Kurzawa, & Glabowski, 2004), and extending in-vitro embryo development until the stage of blastocyst, which is a more developed embryo with a higher chance of implantation (Papanikolaou et al., 2008).

With these changes to the technologies of embryo selection and embryo development, activities in other stages began changing as well. As one doctor we interviewed put it, "*when the freedom to use as many embryos as we wanted was taken away, we began to ask different questions than before (…) and sometimes to do things in a different order*". For example, downstream from the lab, transfers of blastocysts had to occur later and required more sophisticated culture mediums and equipment, as well as closer monitoring of the patient's womb prior to embryo transfer

[1] Currently, the theoretical likelihood of achieving a live-birth in one IVF cycle is estimated to be in the 20-30% range, which is close to the "natural" success rate in healthy patients.

compared to the pre-shock regime. Moreover, upstream from the lab, during the stage of egg collection and handling, adjustments to surgery procedures and culture conditions also had to be made to ensure better selection and greater developmental potential for the fertilized eggs.

To be clear, cross-stage dependencies always existed: drugs regimens for inducing ovulation do not impact just the egg count, but also egg quality and womb functioning, with rippling effects for later stages in the treatment. Cross-stage dependencies also existed after the shock. However, our argument is not about a change in the levels of steady state interdependence before and after the shock. Rather, our point is that when the regulatory shock imposed a sudden limit on inputs or options for one stage, the pattern of interaction across stages had to adapt to take this into account. Thus multiple loops in the process, as well as reciprocal adjustments in upstream and downstream activities resulted from the regulatory intervention in 2001 which restricted the number of embryos to be transferred back to be patient. Put differently, not only "component", but also "architectural" changes (Henderson & Clark, 1990) in IVF provision were sharply triggered by the regulatory change in 2001.

Integrator roles in UK IVF clinics

As crucial points of discontinuity, the moments when health-care workers handover patients to one another involve communication about the patient and/or the transfer of responsibility for the patient (Briscoe, 2007; Cohen & Hilligoss, 2010; Solet, Norvell, Rutan, & Frankel, 2005). In the IVF clinics we studied, clinics varied in their use of integrators prior to the regulatory shock introduced in 2001, and their use of these roles did not change during or after the shock. Our fieldwork revealed that in IVF the organizational arrangements employed for organizing clinic resources around an individual patient fall into two broad categories: relying only on standardized procedures for patient handoff; or using a specific individual (doctor or nurse) to set the treatment course and to intervene for patient-specific adjustments (see also Gittell, Hagigi, & Weinberg, 2009) .

These individuals in our framework are integrators and have objectives very similar to “case managers” (Gittell, 2002) or “nurse coordinators” (Daft et al., 2009), and were in existence since the entry of the clinics into our observation window, before the regulatory shock in 2001. Our field and interview notes corroborate that the primary purpose of the integrators is to ensure smooth handovers between stages, and to improve the quality of the patient experience. Moreover, our informants agreed that these roles have been employed mostly by clinics using a patient-centered approach to care, and that the job descriptions tend to be all-inclusive in terms of contingencies that the integrator should be prepared to address during the fertility treatment.

3. THEORY

The adverse consequences of an interdependence shock

In a world of near-decomposability, interdependence and communication constraints between specialized organizational units are pervasive. In general, “as the specialization of tasks proceeds, the interdependency of the specialized parts increases” (Simon, 1991, p. 42). Specialization inevitably leads to interdependence in the sense that the specialized parts must eventually work together (March & Simon, 1958). Regardless of the basis for partitioning organizations into specialized units, interdependence across units is ubiquitous in a world of near-but not perfect decomposability (see also Heath & Staudenmayer, 2000; Nadler & Tushman, 1997; Thompson, 1967).

The challenge of organizational learning and adaptation in situations of interdependence are well known (e.g., Alexander, 1964; Eppinger, 2001; Thomke, 1997; Thompson, 1967). Effective learning requires being able to form valid connections between one’s actions and observed outcomes. Interdependence obscures the links between individual actions and outcomes, because the observed outcomes may be the result of the actions of many interdependent actors (Levinthal & March, 1993; March & Simon, 1958). When the nature of these interdependencies is well understood, then it is possible to account for the impacts of other's actions on the observed outcome; but when it is not, as is the case of an interdependence shock, a serious challenge to organizational learning is posed. The dangers of learning superstitiously- of drawing misleading conclusions from performance feedback- are high in such situations because the feedback contains information not only on the value of one's own actions, but also the unobserved actions taken by others (Levinthal & March, 1993). In sum, when an outcome depends on many interdependent actions, then inferring whether a particular action contributed to positive outcomes is challenging; when the manner in which the actions are interdependent, or the actions themselves are unknown, the problem is significantly compounded (Denrell, Fang, & Levinthal, 2004).

These challenges are very real in our empirical setting. In IVF treatments, for instance, only at the end of a sequence of medical interventions, stretched over many weeks of treatment, is there a discernible outcome in terms of clinical pregnancy. The final outcome is the result of a series of interdependent actions taken by different individuals at different stages. This leads to difficulties in attributing the success or failure of the IVF treatment to an action in the overall sequence, which is likely to be compounded after an interdependence shock, when the manner in which these actions are interdependent is no longer understood.

While IVF practitioners share a common background in reproductive medicine, differences in expertise still exist due to the functional specialization that characterizes this medical field. As an illustration of the different perspectives that are brought to bear in IVF, solutions for the drop in treatment effectiveness as a result of the regulatory restriction came from a variety of medical subspecialties ranging from gynecology, embryology, endocrinology and nursing. Our interviewees noted that some stressed the importance of more precise investigations of the patient health profile and the need for expanding the battery of tests; others championed the use of more invasive lab procedures; while still others argued for building patient trust and providing reassurance in the face of their diminished chances of success. Inferring the value of any one of these changes in response to the interdependence shock, in the context of other changes being made simultaneously by others is the key challenge to organizational adaptation. A failure to understand the true consequences of any particular intervention because of the confounding effects of others actions is the essence of superstitious learning (Levinthal & March, 1993). It is expected to lead to a decline in organizational performance.

H1: *IVF clinics suffer a significant immediate performance decline as a consequence of the regulatory shock restricting the number of embryos to be transferred*

We note that it is plausible for an interdependence shock to decrease ex-post the level of interdependence. However, in the absence of knowledge about the new pattern of interdependence, even a shift to a less interdependent pattern can be destabilizing to those involved in the task. Our hypothesis takes as a premise that interdependence shocks are destabilizing in the immediate aftermath because the new nature of the interdependence is not known, regardless of whether after the shock there is greater or lesser interdependence per se.

Why integrators may aid organizational adaptation to interdependence shocks

Traditionally, integrators in a static interdependence context provide the effort and possess the information needed to coordinate interdependencies across individuals who may themselves not possess either. Thus, whether we consider *project managers* (Allen, 1984;

Wheelwright & Clark, 1992); *case managers* in hospitals (Gittell, 2002); *vehicle-integration managers* (Iansiti & Clark, 1994; Loch et al., 2001) or *account managers* in large, multiple-service banks (de la Torre et al., 2010) , in each case we see integrators managing interdependencies that are in principle well understood, but which the functional grouping structure of the organization leaves unmanaged. Integrators are thus a classic instance of a linking mechanism (Nadler & Tushman, 1997), and they operate by being *channels of information flow* (e.g. Allen, 1984) as well as through the *exercise of informal authority* (Mohrman, 1993, p.118; Wheelwright & Clark, 1992).

An interdependence shock, by definition implies that none may truly know the new pattern of interdependence between functional units; how then can an integrator be useful? Indeed, one possibility to consider is that integrators may impede organizational adaptation by acting as constraints on the actions of the individuals they are meant to coordinate. If integrators could effectively block changes, then they could de facto lock the organization into existing patterns of action and so make it harder to adapt to interdependence shocks. However, we believe this is unlikely because integrators, unlike traditional hierarchical superiors, lack the formal authority to block such changes and because they also provide a channel of communication between the individuals they are coordinating. Rather building on results from formal models of organizational adaptation and learning, we develop the idea that integrators may help organizations cope with the challenge that interdependent individuals adapt in a decentralized and uncoordinated manner- to a situation that requires more coordinated adaptation. Integrators may serve to make these adaptation processes more coordinated. In particular, we argue that even if they are as ignorant as the other individuals in the organization about the true nature of the interdependence structure that connects them, integrators may minimize the prospect of superstitious learning arising from uncoordinated adaptation by individual agents (Lounamaa & March, 1987).

In keeping with the extensive research on coordination within modular systems, we take as a premise that system integrators are non-programmed means of coordination, whose functions encompass both integration and adaptation as modules within the system change (Brusoni & Prencipe, 2006; Brusoni, Prencipe, & Pavitt, 2001) and which, as compared to programmed means of coordination, enable organizations to respond more effectively to input uncertainty (Argote, 1982) and equivocality (Daft & Lengel, 1986). However, by relaxing the key assumption that integrators posses knowledge about the new pattern of interaction, we depart significantly from current research on firm modularity which implies that systems integrators ideally possess high levels of systemic or architectural knowledge (Baldwin & Clark, 2000). In this sense we extend the line of work suggesting that system integrators with higher levels of system knowledge may play a lesser role in coordination than those with lower system knowledge (Gittell et al., 2009, p.17). Thus our arguments are not reliant on the level of knowledge that integrators posses, but rather on the functions that they serve to ameliorate superstitious learning, on which we elaborate below.

Our arguments draw on the two well-documented features of how integrators function (e.g., Allen, 1984; Gittell, 2001; Mohrman, 1993; Wheelwright & Clark, 1992). First, integrators provide a channel for information flow that allows for coordinated adaptation. The exogenous shift in the pattern of interdependence between IVF professionals creates the problem of their having to find new patterns of mutually consistent ways of working, that preserve or even increase overall performance. The challenge of doing so is great when each specialist makes independent choices that are not visible to others; but through their common presence across stages, integrators may have kept interacting specialists better informed. By their nature, integrators occupy dual “thought worlds” (Dougherty, 1992), and are able to communicate and keep informed the individuals they link about the actions and intentions of each other. This reduces the likelihood of superstitious learning (Lounamaa & March, 1987).

Second, integrators through the exercise of informal authority may be able to control the rates of adaptation. In coupled learning processes, both too rapid and too slow learning by individuals is problematic (Lounamaa & March, 1987; Puranam & Swamy, 2013). Integrators can help moderate learning rates away from the extremes. In our empirical setting, these learning effects arise from two sources. Integrators constitute a point of constancy in the team of professionals dealing with a patient (see also Edmondson, Bohmer, & Pisano, 2001, p.9-10, for insights on the learning benefits of surgeons choosing fixed teams). They therefore naturally become the locus of learning over the multiple cycles of treatment a patient undergoes. At the same time, integrators, particularly when they were doctors, also provided an overall template for treatment that can limit individual specialists from excessive experimenting with other alternatives within their domain of action. In fertility care for example, the dedicated physician often sets the course of treatment and elicits precise treatment inputs following the assessment consultation with the patient. The ability to moderate learning in this way is very likely related to the informal authority the integrator can exercise.

In sum, existing theory suggests that integrators can help improve coordinated learning (and suppress superstitious learning) following an interdependence shock, which should allow organizations that employ them to recover their performance faster than organizations that do not have integrators. Integrators can achieve this result by enabling a mutually aware set of responses by acting as information channels, as well as by overlaying a common and standardized approach to the problem through the exercise of informal authority. For these reasons, we expect that:

H2: *The use of integrators enables IVF clinics to mitigate the adverse performance consequences of the regulatory shock limiting the number of embryos to be transferred.*

Table 1 summarizes some of the different concerns and issues raised by those working in clinics with integrators vs. those who worked in clinics that did not use integrators (Table 1). These quotations suggest some face validity to our arguments.

---- *Insert Table 1 here* ----

3. METHOD

Sample and Data

In the United Kingdom, data on all IVF centers have been collected and published by the Human Fertilisation and Embryology Authority (HFEA), which is the independent regulator that oversees the use of gametes and embryos in infertility treatment and research in the UK. By applying to the HFEA under the freedom of information act, we were able to access past data on variables such as success rates, integrator roles and patient mix for the population of all fertility clinics based in the UK since 1991—the year prior to the introduction of IVF as an authorized treatment—and up to 2006 (the final year for which data were made available).

The IVF setting and our comprehensive data are ideal for testing the relationship between integrator roles and organizational adaptation to an external shock, for several reasons. First, there is a well-established and widely agreed upon measure of success: the rates of success of IVF treatment at the clinic (i.e. what fraction of patients experience a live birth). Second, because published Annual Patient Guides contain information on whether a clinic offers the service of a "patient liaison" (i.e. integrator) we can access reliable data on the existence of the integrator role in IVF clinics. Finally, and most importantly, this setting provides a quasi-experimental design which helps to rule out some alternative explanations about the impact of integrators by observing clinics before and after the restrictions placed on the number of embryo transfers in 2001.

With the entire population of clinics being subjected concomitantly to the same exogenous shock, we can pinpoint the effect of having an integrator separately from the possibility that the decision to have an integrator was made because of the shock, or to account for the possibility that a particular pattern of interdependence was in fact selected by the organization. Thus, the regulatory shock serves two purposes that regular business as usual conditions cannot fulfill: the shock changes the interdependence that underlies the production process within our clinics (so that any knowledge advantage that integrators may have had in terms of understanding the patterns of interdependence would no longer hold), at the same time, it enables us to develop a quasi-experimental design.

We obtained data for all the 98 IVF clinics in the U.K. which had at least two consecutive years of performance data between 1992 and 2006. We screened out 28 clinics which did not have continuous data for the five-year time window before and after the regulatory shock of 2001 (i.e., years 1999 to 2003 inclusively), either because they ceased their operations before 2001 (N=13) or because they were founded after 1999 (N=10). In the three years following the shock, 7 exited the IVF domain (5 in 2002), and only one of them had an integrator. Since our analysis requires data for a clinic both before and after the shock, these had to be eliminated, and we recognize this can pose a conservative bias on the estimates of the effect of integrators in adapting to an interdependence shock. A test of the differences between the excluded clinics and the 70 clinics remaining in the sample reveals that those excluded were on average younger, smaller and had less cumulative experience; also, clinics that ceased their operations before the shock window had lower success rates, while those founded after the shock had higher success rates than those in the sample. While these differences are significant, the exclusion of these clinics is necessary because they do not meet the important criteria for useful inclusion in our study, of having to cope with the regulatory shock. Summary statistics for the characteristics of these clinics are presented in Table 3.

---- Insert Table 3 here ----

While the proportion of clinics reporting the use of integrators is similar for both the excluded clinics and those that remained in the sample (i.e., approximately 50%), almost none of the clinics have changed their integrator status throughout the duration of observation. From the remaining 70 clinics, none have adopted the integrator at a later stage, after operating without an integrator from its inception; however, three clinics which used integrators since founding did cease to report using them after 2004. To guard against confounding effects due to the change in the integrator status, we remove from the sample those clinic-year observations that occurred after these clinics implemented the change, and we keep the rest of their clinic-year observations because they still allow for a reasonable post-shock observation of at least two years. In other words, the sample conveniently allows us to observe the performance of 70 clinics which have a) made their choices about the use of an integrator prior to the regulatory shock at birth and b) have not changed their integrator status during the window of observation.

Our interviews suggest that the very low within-clinic variation for the integrator status (which is to our advantage from the point of view of statistical inference) can be traced to the existence of strong imprinting effects of the founding conditions, with clinics upholding the integrator role throughout the period of observation due to deeply embedded patient-centered approaches to care (Beach & Inui, 2006). In contrast, in clinics which do not use integrators, efficiency rationales revolving around staffing schedules seem to perpetuate standard collaborative approaches to care, with patient visits being handled by *any* available member of staff instead of a *dedicated* professional who saw the patient during her previous visits. We contacted the three clinics which stopped reporting the use of integrators in order to gain deeper understanding of the reasons behind their changes. The interviews revealed that all three clinics were facing increased logistical costs for maintaining the integrator setup due to high increase in patient enrolments for the years prior to withdrawing the integrator options. Indeed, the patient enrolment at two of the centers has been consistently more than one standard deviation higher than the mean, with all three centers growing at rates between 10% and 25% as compared to the average growth rate of 6% in the years prior to abandoning the integrator setup. Thus the decision to discontinue with the integrator in these three clinics cannot be linked to the regulatory shock of 2001.

In sum, for the 70 clinics in our unbalanced panel there are 914 clinic-year observations, a minimum of 6 years of observation per clinic, and an average of 13.1 years of observation per clinic. More importantly, all clinics in our sample had to undergo fundamental changes in their clinical processes to cope with the regulatory restrictions on embryos, without changing their integrator status throughout the period of observation. Thus, because the integrator status is stable for all clinics and predates the shock, the effect of using an integrator cannot be attributed to reactions to the shock. While there may be clinic-level unobserved attributes that correlate with using integrators (and also with how clinics fare in response to the shock), we are able to control for clinic fixed effects, which capture such attributes, besides control variables that capture time varying attributes of clinics.

Dependent variable. The main measure of operational performance that allows for cross-clinic comparisons in IVF is the rate of success in each clinic. We calculated the measure *success rate* as the percent of female patients who had a live-birth as a result of undergoing IVF at the focal clinic in year *t*.

Independent variables

Integrators. To identify which clinics offered integrators, we used the Annual Patient Guides to IVF (HFEA, 2004). If the clinic reported the availability of a "patient liaison" during treatment, the variable *integrator* was coded as 1; if no liaison role for the patient was reported, *integrator* was coded as 0.

Regulatory shock. The 2001 policy change was unambiguously determined by public health considerations regarding the risks of obstetric and neonatal complications following multiple pregnancies, thus placing its occurrence beyond the control of the IVF clinics (HFEA, 2001). To account for the change introduced by the technological shift in IVF, we include a binary variable, *post-shock,* indicating whether the observation occurred after (i.e. equal to 1) or prior to the policy change regarding multiple embryo transfers (i.e. equal to 0) to test Hypothesis 1. The interaction term between *integrator* and *post-shock* is used to test whether the use of integrators enables firm-level adaptation to the disruptive shock, as predicted by Hypothesis 2.

Control variables. Clinic capacity, measured as the number of patients treated in the year of observation was used as a control for *clinic size*. The number of years since the clinic was established, *clinic age*, is included to offset for the lack of data concerning the experience accumulated in the 1980s by nine clinics in the sample which have left censored data. To control for vicarious learning and the state of the art in IVF in each year, we include the measure *industry experience*, which consists of a log transformation for the count of IVF patients treated in the UK prior to the year of observation. To account for improvement in success rates due to organizational learning, we include the variable c*linic experience* constructed by cumulating all IVF patients treated previously at the clinic; in line with prior research (e.g., Argote, 1999), we computed the natural log of this experience measure. In line with recommendations from the medical literature on fertility, which identifies patient age as the most important dimension for characterizing the patient mix of each clinic (Johnson et al., 2007; Sharif & Afnan, 2003 pp. 484), we include a measure accounting for the percent of patients who are 36 years of age or older (*complex cases*). Finally, to control for the nature of the IVF technology used at the clinic (*technology*), we include the percent of treatment cycles performed in the current year which involved the more invasive procedure of intra-cytoplasmic sperm injection (ICSI); ICSI is an innovation introduced in the IVF industry during our period of observation, with clinics adopting it at different points in times.

Model specification. Because the data consist of a panel of clinic-year observations, our modeling approach uses linear regression analysis for cross-sectional time-series data. Panel estimation procedures allow us to control for unobserved firm level heterogeneity and thereby reduce the possibility of biased parameter estimates (Greene, 2003). The equations used to test hypotheses 1 and 2 have the general form:

$$wsr_{i,t} = \delta.PS_t + \phi PS_t..I_i + \beta[Controls_{i,t}] + v_i + u_{i,t} \qquad (1)$$

Where subscripts refer to firm i at time t, $v_i = (\alpha_i + \theta.I_i)$, α_i is the clinic specific unobserved effect, and $u_{i,t}$ is the error term. $wsr_{i,t}$ is the success rate of IVF procedures (percentage of women who had live births as a consequence of the treatment) of clinic i in year t. PS_t is a time varying dummy variable that takes on the value 1 after the shock. I_i is a clinic specific dummy variable that takes on a value of 1 if the clinic in question has an integrator.

Note that the integrator variable I_i does not change over time for a clinic in our sample. Therefore it is not possible to estimate θ separately from α_i in a fixed-effects estimation- they will be estimated jointly as the firm fixed effect v_i. However, this does not pose a problem as our theory makes predictions about ϕ not θ. This minor inconvenience seems worth bearing as the alternative, a random effects model makes the strong assumption that v_i is uncorrelated with the other variables in (1). A Hausman test rejects the hypothesis of random effects in our data (p=0.0053). For this reason we do not consider random effects models as appropriate for our analysis. Note that Hypothesis 1 implies that $\delta>0$, Hypothesis 2 implies $\phi>0$.

4. RESULTS

Table 3 presents summary statistics for the variables included in our models. Consistent with existing industry analyses, the average IVF success rate for the clinics in our sample is 21.5%, with nearly half of the clinics employing integrators for IVF cycles. The oldest clinics have been offering IVF for 26 years and the largest clinic had treated over 13,000 patients during the window of observation.

----- *Insert Tables 3 and 4 here* -----

The fixed-effects OLS regressions predicting the success rates in each clinic are reported in Table 4. The estimated clinic fixed effects are significant and provide strong evidence in favor of using panel data techniques which address the problems of correlation between regressors and the time-invariant portion of the error term. The first column in Table 4 reports the results for the control variables and shows that, in general, clinic success rates increase with the age and the cumulative experience of the clinic, and are lower for clinics treating larger proportions of older patients. As expected, the more invasive the IVF technology used the higher the rates 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.

----- *Insert Figure 4* -----

Testing the Hypotheses

In Table 4 model 2, we introduce the dummy variable *post-shock*, which has a negative and significant coefficient (β = - 0.013; p<0.10). In model 3, we introduce the interaction between *post-shock* and i*ntegrator* as a test for hypothesis 2. The interaction is positive and significant (β = 0.021; p <0.10), while the coefficient of the main effect of *post-shock* is negative and significant (β = - 0.024; p<0.05), suggesting that the success rates of clinics that did not use integrators have suffered as a result of the embryo restrictions imposed by public legislators. As reflected in the size of the coefficient, and given that the average baseline success rate in the sample is 21.5%, the policy shock decreased success rates by 2.4% for clinics without integrators, and left the success rates of clinics with integrators effectively unchanged. This is not a trivial effect for a treatment which continues to involve a high degree of uncertainty. A statistical test summing the coefficient of the interaction term and that of *post-shock* indicates that the point estimate of 0.003 is not statistically different from zero (t(69)= -0.29, p= 0.769), thus suggesting that the success rates of clinics with integrators have not been affected by the shock, while those without integrators have suffered.

We also estimated models that included year dummies in addition to controls for industry experience, clinic age and technology. In such models, the post-shock dummy is not separately estimated because of collinearity; however the interaction between post-shock and integrator can be estimated, and the post-shock effect can be obtained by comparing the average effects of the year dummy's before and after the shock. Our results are qualitatively identical with this approach to those reported in the paper.

Additional analysis

We conducted three sets of additional analyses to test the robustness of our conclusions about the role of integrators in enabling organizational adaptation.

The effects of integrators on intermediate stage outcomes

To unpack to some degree the black-box of how integrators may have influenced the overall success of IVF processes at clinics, we obtained data on intermediate outcome data for three key stages of the IVF process for the whole sample of our data. These were (also see Figure 2) Stage I: Percentage of cycles achieving egg collection, Stage II: percentage of cycles with egg collections achieving embryo transfer and Stage III: percentage of cycles with embryo transfer achieving implantation. We examined whether our arguments about the value of integrators also allow us to predict outcomes at each stage of the IVF value chain, after the shock.

The results in Table 5 represent a broadly consistent, but weaker pattern of results. Note that parsing out the overall impact of integrators into these intermediate stages necessarily reduces the power to detect the effect of an integrator. In Stage I, neither the shock nor the presence of integrators has a detectable effect. Stage II shows a clear and negative effect of the shock on performance ($\beta = -0.019$, $p<0.05$), but the presence of the integrator does not a have statistically significant ameliorating effect. In stage III, while the shock has no detectable impact on outcomes, the presence of an integrator significantly improves the outcomes at this stage in terms of production yields (Model 6).

While we could not a priori have hypothesized which stages the integrator and shock would have the largest impact on, these results improve our confidence in our theory for two reasons. First, the existence of effects of the shock and the integrator on intermediate process variables increases our confidence about the underlying processes in our theory. Second, the effects of the shock and of the integrator, when they exist are always in the direction we expect. In Stage II, we see the effect of the constraint on number of embryos that can be transferred; in Stage III, we see how the presence of an integrator helps to improve yields, which would not have been the case if the shock merely lowered performance by constraining inputs without affecting interdependence.

The effects of different types of integrators

Hypothesis 2 does not allow for a distinct test of the two mechanisms through which integrators function (information channels and informal authority). Therefore, we develop an approach that allows us to indirectly validate the operation of these two mechanisms. We rely on the fact that while integrators in general operate on the basis of their ability to provide channels of communication as well as exercise informal authority, all integrators cannot exercise both aspects equally. Thus if we could observe differences across clinics with integrators that primarily used either type of mechanism (or a combination), we should expect meaningful differences in the effectiveness of integrators across these types of clinics. Fortunately, our context allows us to undertake such a test, albeit for a much smaller sub-sample.

From 1999, the reporting terminology in the patient guides allows us to distinguish between integrator roles filled by doctors (i.e., “one physician throughout treatment”) and integrator roles filled by nurses (i.e., “named nurse system”). Thus, if only the option of a dedicated physician was reported, *doctor-integrator* was coded as 1 and 0 otherwise; similarly, if only the option of a named nurse was reported, *nurse-integrator* was coded as 1 and 0 otherwise. Finally, if both options of a dedicated physician and a named nurse were reported, the measure *either doctor or nurse integrator* was coded as 1 and zero otherwise.

In the IVF clinic context, while both nurses and doctors can 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; Wicks, 1998). Doctor-integrators are generally known to exercise stronger informal authority than nurses (Edmondson, 2003, p.1424; Tucker, Edmondson, & Spear, 2002, p.129), 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 (Nembhard & Edmondson, 2006, p.943). 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; Wicks, 1998). Our interviews in the field reinforced the impression that doctor-integrators and nurse-integrators work quite differently from each other (see Table 2 for details).

---- *Insert Table 2 here* ----

If we accept the premise that each kind of integrator has a relative advantage at one of the two ways in which an integrator functions—through providing a communication channel, and through exercising informal authority, then Figure 3 illustrates how these integrator arrangements may differ along the dimensions of informal authority and lateral communication.

---- *Insert Figure 3 here* ----

Clinics employing flexible arrangements allow both types of influence—strong informal authority and strong lateral communication on behalf of the patient—to co-exist under the same roof and to reinforce each other, (albeit not at the same time for every patient, but across patients). Consequently, the professionals being coordinated alternately by nurses and doctors may experience spillovers between the experiences. When working with a nurse-coordinator, they may improve knowledge sharing across specialization; when working with a doctor, they may more readily make local concessions for global benefits. But to the extent these knowledge benefits or willingness to adapt survive beyond the current patient and transfers to the next, there are effectively spillovers across patients. Consequently, clinics with flexible integrators should be able to benefit more from these spillovers, leading to better performance.

The tests of this conjecture are reported in Table 6. In model 1, we report results from the pooled sub-sample in which instead of the variable *integrator*, we now use three different dummy variables, for doctor, nurse, and flexible integrators respectively. The results show that flexible integrators significantly improve performance after the shock. Clinics using either doctors or nurses as integrators have success rates that are on average 4 percentage points higher than clinics that do not use any integrators – the omitted category in Model 1 ($p<0.05$). However, this coefficient is not statistically different from the other two types of integrators. In models 2, 3 and 4, we also present the split sample estimates, in which we compare the coefficient of post-shock in three sub-samples samples: clinics that have no integrator, clinics that have only nurse or only doctor integrators, and clinics that have flexible integrators. In these split sample analyses, the coefficients of the controls are not constrained to be identical by type of clinic. We find that the coefficient of post-shock is significantly more positive (0.075 vs. -0.007, $p<0.01$) in the clinics with flexible integrators compared to clinics in which either a nurse or a doctor alone performs the role, as well as clinics that have no integrator at all (0.075 vs. -0.02, $p<0.001$).

These results provide some support for the idea that the integrators act through two different kinds of channels of influence, and that their joint use is more valuable than either alone in coping with interdependence shocks.

Patient sorting after shock

The quasi-experimental design along with our control variables helps to rule out many but not all possible alternative explanations. One important possibility we have to consider is that post shock, patients who were concerned that they were unlikely to conceive under the new regulations restricting the number of embryos transferred, may have selectively dropped out of the IVF market. In particular, if only those candidates who felt they still had good chances opted to go to an IVF clinic that offered an integrator (as a more expensive service feature), then we might observe the pattern of results we do, for reasons unconnected to our theory. One easily observable and reliable indicator by which patients may judge their own chances of conceiving is their own age. If this alternative explanation we have outlined holds, then we should expect that the age mix of patients post shock should change, and in particular towards younger patients in clinics with integrators (thus boosting the performance of such clinics post shock). However in additional analysis (not reported here) we find that the shock does not alter the ratio of complex cases (36-year old patients and older) to total cases for clinics either with or without integrators; nor does it alter the total number of patients for ether type of clinic. Therefore, patient sorting into clinics with and without integrators cannot explain our results.

5. DISCUSSION

We have shown that the use of integrators—managerial roles that are mandated to coordinate the contributions of specialized but interdependent agents—enable superior performance in the face of interdependence shocks. The British IVF clinics in our study that used integrators to manage interdependent activities around focal patients enjoyed greater success after the regulatory shock than clinics which did not employ such means of lateral coordination. Our findings have implications for the literature on organizational design, especially the tradition that examines the relation between organizational structures and adaptive performance. While there has been much progress in terms of identifying correlational effects for various design elements and processes outcomes (Gittell, 2002; Khandwalla, 1974; Lawrence & Lorsch, 1967a), as well as theoretically modeling the underlying mechanisms (Ethiraj & Levinthal, 2004; Levinthal, 1997; Levinthal & Warglien, 1999; Rivkin & Siggelkow, 2003), causal empirical evidence has been limited, especially on those features that constitute genuine choices for the management of organizations.

Our findings suggest that using integrators to coordinate interdependent interventions on a patient enhances the ability of the organization to adapt to shifts in the underlying interdependence of the work. This study complements prior work that examines differences in the coordination benefits enabled by various integrating mechanisms within an organization. Clark and Wheelwright (1992), for example, draw on their observations of product development teams to contrast “heavyweight” and “lightweight” integrators in terms of level of influence across functional boundaries. In a study of acute-care hospitals, Gittell (2002) found that boundary spanners and team meetings strengthen the reciprocal predictability of action among participants. In a similar vein, Pisano and colleagues (2001) examined the role of feedback activities and cross-functional communication in cardiac surgery and found positive associations with the learning rates of the teams in the study. More recently, Srikanth and Puranam (2011) have assessed the impact of integrative information technologies in process offshoring, and found that they mitigate the adverse performance consequences of interdependence between onsite and offshore locations.

Uniquely, we venture beyond arguments of integrator-enabled coordination in steady-state environments to explore the role of integrators in a context involving an interdependence shock, when the stability of the technological regime is challenged by disruptive shocks. We showed that such shocks lower performance (H1), and that integrators enable organizations to adapt to such shocks (H2). In additional analysis, we also documented evidence that is consistent with the impact of integrator on the underlying processes of the technology of IVF, as well as for the two mechanisms through which integrators act (information flow and informal authority).

Our focus on organizational adaptation to shocks is complementary to prior research on organizational learning (Argote, 1999; Argote & Ingram, 2000; Thompson, 2010). The studies in this tradition have begun to disentangle what underlies the transfer of knowledge (Almeida & Kogut, 1999; Szulanski, 1996) and the contextual factors that enable learning from experience (Baum & Dahlin, 2007; Haunschild & Sullivan, 2002; Pisano et al., 2001; Stan & Vermeulen, 2012). In our own data, we also tested whether variation in the learning rates of clinics is explained by the presence or absence of integrators within these clinics (Argote, 1999; Argote & Ophir, 2002; Thompson, 2010). More specifically we tested whether or not learning rates displayed different slopes for clinics which used integrators versus those which did not use any type of integrator in the full sample. We found no evidence for such a difference, suggesting that adapting to interdependence shocks and learning within a fixed pattern of interdependence (through learning by doing) may be qualitatively distinct problems, with the integrator more useful in the former.

Collectively, the findings also provide an important implication for researchers and practitioners in the medical domain. Our study shows that in healthcare as in other domains, the organizational setup matters; the way patient handoffs are coordinated across departmental boundaries has a significant impact on a patient’s rate of successful treatment. It is not only the use of advanced medical technologies that matters, or the skill of the medical team; the technology of organizing is also important.

Limitations

A significant weakness of this study is that it does not provide direct evidence for how integrators help to cope with interdependence shocks- only that they do (and that these effects are visible even at intermediate performance stages). Yet, the evidence that they do matter is valuable because our results are obtained from a quasi-experimental setting that allows us to rule out most possible confounding effects.

While we have attempted to overcome many empirical 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 as those that we found in fertility care. For example, Wheelwright and Clark (1992) identified the presence of integrators in the context of cross-functional teamwork at Motorola; similarly, car manufacturers specifically employ engineers that can enact the role of *vehicle-integration managers* and can coordinate the contributions of various functional departments to a focal car model. Therefore, although direct generalizability of the study may be limited, we would expect the use of integrators to carry adaptive benefits in industries with similar concerns for coordinating efforts across distinct domains of knowledge.

As mentioned earlier, another potential limitation relates to the regulatory change "hitting" all fertility clinics at the same time—which is what makes our study a quasi—rather than a real experiment (which would feature random assignment). Additionally, the time-invariant measure that captures the presence of integrators as formal elements of structure prevents accurate estimations for the primary effect of the integrator and doesn't account for the possibility that features of this formal arrangement may also evolve over time. This poses an interesting question for further exploration, namely to account for the more granular details of lateral structures and how they impact organizational adaptation.

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 staffing restricts the ability to control for possibly relevant time-variant features of human capital.

6. CONCLUSION

In this paper, we investigate the role of integrators in overcoming the challenges of adapting to an interdependence shock when the nature of interdependence among workers shifts. For empirical corroboration, we investigate the impact of integrators on organizational adaptation in a healthcare domain—the providers of *in-vitro* fertilization in the UK. The analyses indicate that integrators enhance the ability of medical clinics to adapt to this discontinuous change in the industry, measured both in terms of final medical outcomes (successful births) as well as intermediate medical outcomes. We also find some support for the idea that clinics employing flexible integrator arrangements (i.e., where the role can be filled either by a nurse or a physician) have greater success with their IVF procedures despite the technology shock than clinics that use only doctor-integrators or only nurse-integrators. More broadly, our novel results enrich our understanding about the relationship between organizational structure and organizational adaptation.

Figure 1. Average number of embryos used in an IVF cycle

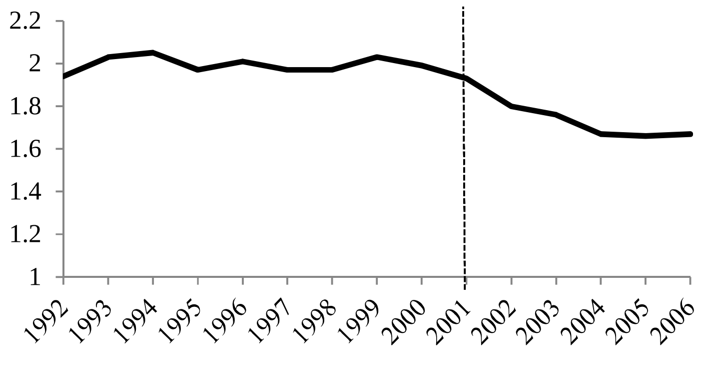


Figure 2. Intermediate steps in fertility treatments involving *in vitro* fertilization (IVF)

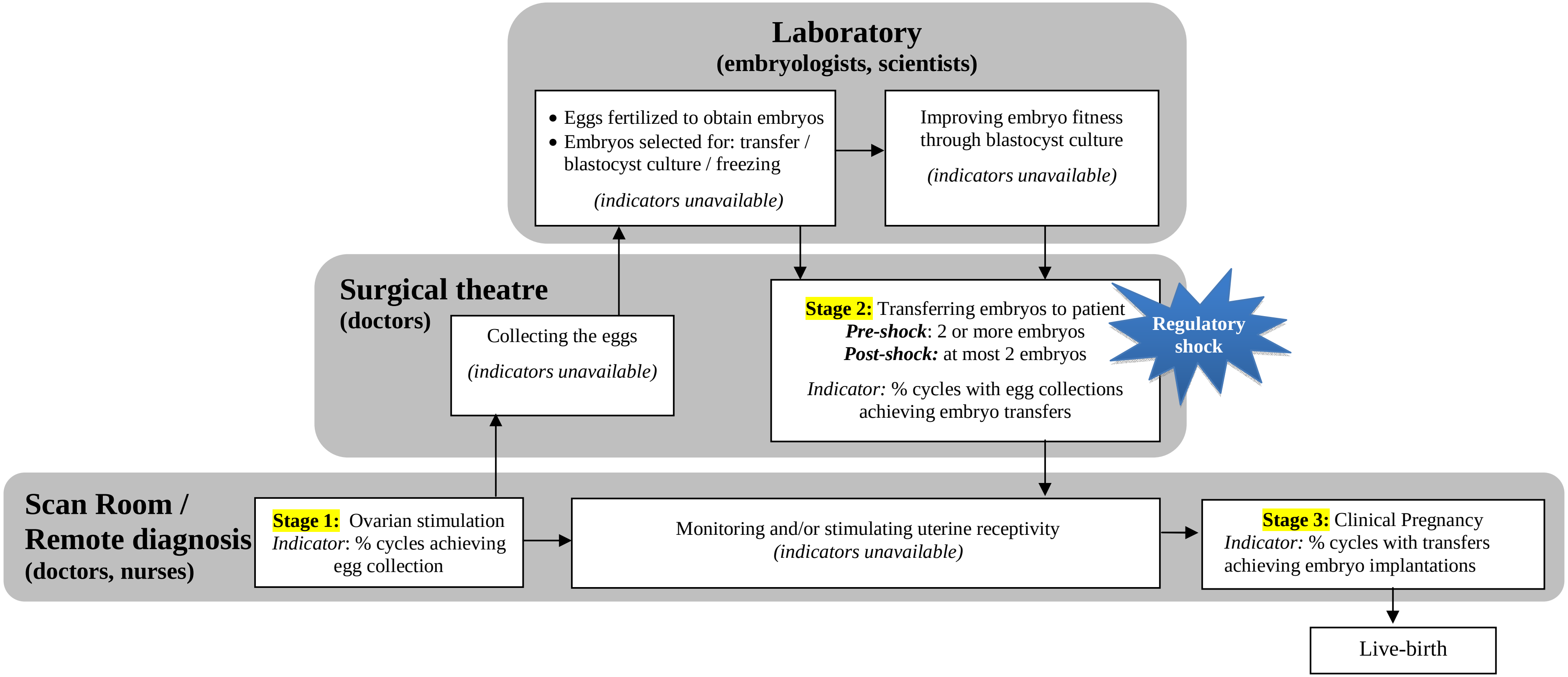


Figure 3. Informal authority and lateral communication for each integrator arrangement in IVF

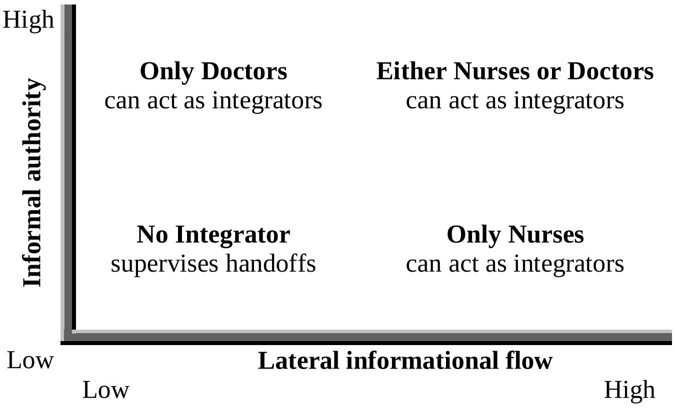
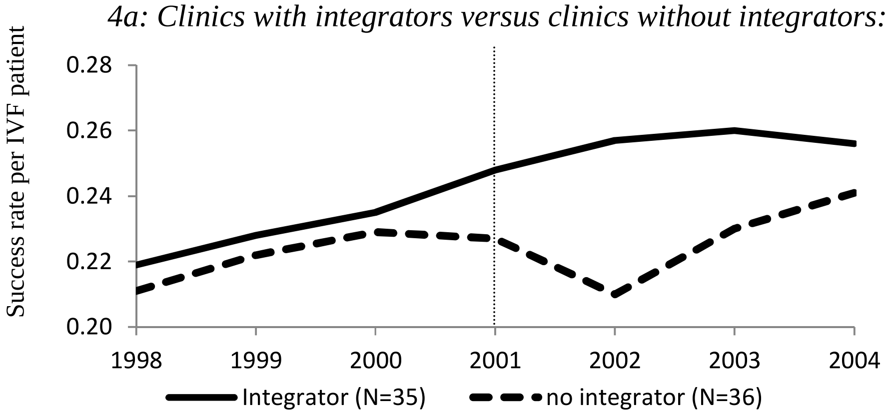


Figure 4. Average success rates in IVF for years 1998-2004

<u>Note</u>: 4a and 4b are smoothed graphs, based on raw data, unadjusted for covariates

4a: Clinics with integrators versus clinics without integrators:



4b: Trends for each integrator type:

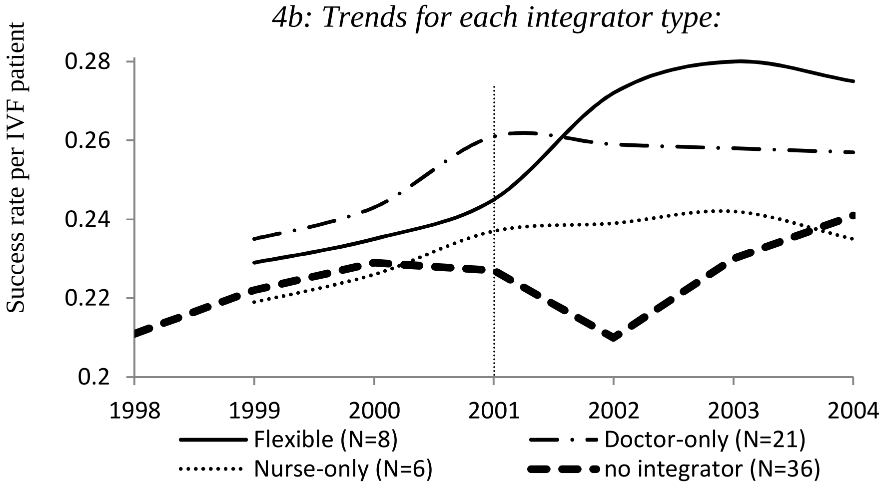


Table 1. How fertility clinics handled greater task interdependence after the 2001 restriction on embryo transfers.

	Before 2001	After 2001
Clinics without integrators	**Patient handoffs handled in a Tayloristic fashion:** "*They might see me for the first consultation, then they might see the junior doctor for a scan, a third doctor for egg collection, and a fourth doctor for embryo transfer - it's possible. We tried to streamline it as much as we could, but it didn't always work. People were on leave, people were on study leaves, people went to conferences and meetings, so we had to work around all that. Sometimes patients complained they saw a different doctor every time – sorry, that's the way it works. I can't help you. If you want to see the same doctor, then go to a clinic who offers this*." Doctor, Hackney **Patient information encoded in data repositories:** *"Day-to-day appointments, like dispensing drugs or taking a blood test would be handled by a member of the nursing team or the doctor on-call; patient notes, tests and shift reports are carefully reviewed and audited."* Nurse, London *"Due to different working days and rota patterns of the staff, a new IT system had to be put in place to record patient medical information and to allow for smooth transits through treatment stages."* Nurse, Ninewells	**Protocols updated to meet regulation, often without mitigating the effects:** *"We only allow single embryo transfers in women under 35-years of age. This change in the Code of Practice had to be implemented - no questions asked. Everyone had to reduce the incidence of multiple births at their centre, even if that meant a drop in the overall success rates. It was a necessary evil in order to deal with a greater evil [i.e. multiple births]."* Nurse, King's College *"My friend was also worried that they won't transfer more than two embryos back to her. But [her clinic] provided embryo freezing and screening, and seemed to have a better equipped lab. My experience was different (…) If we must have less quantity, why can't we have more quality?"* Patient, London **Greater task interdependence if aiming to increase viability of embryos:** *"Not all clinics can handle the complexities of some procedures such as embryo screening, genetic diagnosis and close patient monitoring. They are certainly for the benefit of patients treated under the new regulation, who want to make sure that two embryos give equal chance to a pregnancy as three, but handling the intricacies of such technologies is not easy, the atypical steps in the process have to be managed not only for the patient but also for the staff involved."* Doctor, London
Clinics with integrators	**Improved communication with all those involved:** "*As a named nurse or dedicated physician you represent the patient. You know the [other specialists] well, so you communicate with them better. Also your patient has more trust in you, and you can communicate better with her; you can say you've seen her before, so you can try this now. And those little points are important things*." Doctor, Hackney **Personalized care and better management of patient information:** "*Seeing the physician each time is possible in clinics offering individualized care. This way there is less information loss from one visit to the other*." Doctor, Plymouth "*The coordination of the treatment would be done by the named nurse and any questions would be directed to her over the course of treatment. If the nurse is unsure then she would ask the doctor for further advice*." Nurse, Swansea	**Integrators manage interdependencies between functional specialists**: *"We upgraded the lab, hired new embryologists and had the nurses go through new training (…), everyone was learning and getting new skills. It was exciting, but also a bit messy. We had many new pieces of knowledge to consider and few knew how to glue them together. I think that's why having one doctor or nurse keeping track of what was going on with each individual patient helps. It's a less messy process and things get done."* Doctor, Bath **Integrators as conduits for tacit knowledge acquired in the new context:** *"When you know that only one embryo can be transferred back to her, it is better to have someone walking through this labyrinth with the patient, from the first visit, to the embryo transfer with the nurse. This way there are fewer loose ends to tie up, there is less miscommunication in doing things and everyone is more confident in what they are doing."* Doctor, Hackney *"If I'm there for all her visits, phoning lab results, checking her drug prescriptions (…) then I know things really well for her. If something is wrong, I go directly to the nurse who did the scan or the embryologist who prepared her samples."* Nurse, Birmingham

Table 2. Indicative quotations from interviews showing differences in how doctors and nurse perform the integrator role

Informal Authority **is higher for doctor-integrators than for nurse-integrators**	**Lateral communication** **is higher for nurse-integrators than for doctor-integrators**
Nurses have limited prescribing powers For me it feels like a double life, where as a nurse one chases up the others like a doctor, but without the doctor's robe and without the doctor's prescribing powers. *(Nurse, interview 2)* **Nurses are less forceful in their interactions** Unlike the doctors who do this job, I cannot use the thundering tone on everyone. And I accepted that this is the way it is. The others can pull the carpet out from underneath my feet at anytime and I must be able to stand on my feet and carry the can to the next stop. *(Nurse, interview 2)* **Nurses are more inhibited by protocols** Many clinics allow nurses to expand their role from general staffing to the named nurse role, but they are still restricted by what the managers and doctors will let us do and by the vicarious liability aspect. I can see the risks from their point of view, because they are still responsible for our actions, but it still doesn't make it any less frustrating to navigate the bureaucratic maze. *(Nurse, interview 3)* **Doctors are responsible for the mistakes of others** I take the embryologist's word that they've performed the right procedures in the right order and so forth. Now if they [the patient] had no embryos following that, I must be the one to take responsibility and explain what happened. *(Doctor, interview 5)*	**Doctors engage less in coaching behaviors** Perhaps I should, but I often don't provide coaching. Doctors are more focused on the biological dysfunctionalities of the patient rather than the patient as a whole or the other members of the team; you'd rather hand the soft issues to the nurse than fill your plate with that as well. *(Doctor, interview 1)* **Nurses are more able to translate technical terms** It's my impression that they [the nurse-integrators] approach this task with a broader perspective. I think with doctors, they're more technical, much more decision-making orientated. The named nurses, because of their training, not so much. They are much more able to explain complex issues in simpler terms. *(Doctor, interview 4)* **Doctors may lack soft skills in lateral communication** I would expect that if a mistake is made in the lab, or in the operating theatre, or on the phone with the patient, a consultant handling the case would generally be less versed in people skills than a named nurse. He will know what to do, but much less how to say it to the others. *(Embryologist, interview 6)* **Doctors may socialize less with the rest of the team** As a doctor, my shifts start and end at different times, so I don't come on duty with anybody and I don't go off duty with anybody. I do see all of them at various points in time, but I have fewer opportunities after work to go for drinks or have off-the-record chats. *(Doctor, interview 5)*

Table 3. Descriptive statistics and pairwise correlations

	Level of analysis: clinic-year	Obs	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Success rate per patient	914	0.21	0.08	0	0.53	1													
2.	Clinic size (hundred patients)	914	3.30	2.59	0.01	14.67	0.31	1												
3.	Clinic age (years)	914	8.94	5.04	1	26	0.12	0.49	1											
4.	(Log) Industry experience	914	11.48	1.01	8.56	12.53	0.15	0.17	0.50	1										
5.	(Log) Clinic experience	914	6.71	1.79	0	9.48	0.23	0.69	0.74	0.34	1									
6.	Complex cases (% patients over the age of 35)	914	0.46	0.10	0	0.84	0.07	0.16	0.23	0.38	0.13	1								
7.	Technology (% ICSI)	914	0.21	0.21	0	0.77	0.29	0.33	0.20	0.38	0.29	0.10	1							
8.	Post-shock (binary)	914	0.33	0.47	0	1	0.11	0.13	0.42	0.86	0.29	0.34	0.31	1						
9.	Integrator (binary)	914	0.49	-	0	1	0.10	-0.02	-0.06	-0.0001	-0.11	0.10	-0.06	0.002	1					
10.	Doctor-integrator (binary)	513	0.31	-	0	1	0.14	-0.06	-0.12	0.02	-0.14	0.16	0.03	0.02	0.67	1				
11.	Nurse-integrator (binary)	513	0.09	-	0	1	-0.03	0.28	0.26	0.003	0.25	-0.15	-0.01	0.0002	0.31	-0.21	1			
12.	Either doctor or nurse integrator (binary)	513	0.11	-	0	1	-0.01	-0.20	-0.16	-0.03	-0.19	0.06	-0.13	-0.02	0.34	-0.23	0.11	1		
13.	Performance stage 1	914	0.92	0.06	0.57	1	0.27	0.08	-0.02	-0.02	0.03	0.04	0.21	-0.04	0.16	0.19	-0.04	-0.002	1	
14.	Performance stage 2	914	0.91	0.06	0.67	1	0.48	0.04	-0.05	0.003	-0.02	0.04	0.14	-0.01	-0.06	0.15	-0.42	0.06	0.16	1
15.	Performance stage 3	914	0.12	0.04	0	0.30	0.84	0.36	0.27	0.39	0.34	0.11	0.31	0.33	0.01	0.004	0.07	-0.05	0.41	0.27

Note: The analysis is a longitudinal examination of 70 clinics, with an average of 13.1 years of observation per clinic (min of 6 years; max of 15 years).

Table 4. Regression Results for Clinic Success Rate

Variable	*Model 1*	*Model 2*	*Model 3*
Clinic size (per 100 patients)	-0.0001	-0.0001	-0.0005
	(0.002)	(0.002)	(0.002)
Clinic age	0.004**	0.006***	0.006***
	(0.002)	(0.002)	(0.002)
Industry experience	0.006	0.001	0.001
	(0.006)	(0.007)	(0.007)
Clinic experience	0.007*	0.007*	0.007*
	(0.004)	(0.004)	(0.004)
Complex cases	-0.112**	-0.109**	-0.109**
	(0.051)	(0.050)	(0.050)
Technology	0.050**	0.045*	0.047**
	(0.022)	(0.022)	(0.024)
Post-shock		-0.013*	-0.024**
		(0.008)	(0.010)
Integrator X Post-shock			0.021*
			(0.012)
Constant	0.107*	0.149**	0.146**
	(0.060)	(0.062)	(0.061)
N_t (total clinic-years)	914	914	914
N (total clinics)	70	70	70
Years	1992-2006	1992-2006	1992-2006
F statistic	31.72***	28.10***	26.55***
Clinic fixed effects	Yes	Yes	Yes

<u>*Notes:*</u> Robust standard errors are in parentheses. The time invariant main effect for the integrator is captured as part of the clinic fixed effect. Two-tailed tests: ∗significant at 10%; ∗∗significant at 5%; ∗∗∗significant at 1%.

Table 5. Additional Analysis: Regression results for intermediate IVF stage performance

Variable	*Performance Stage 1: Percentage cycles with egg collection*		*Performance Stage 2: Percentage of cycles with egg collections resulting in embryo transfer*		*Performance Stage 3a: Percentage of cycles with embryo transfers resulting in implantation*	
	1	*2*	*3*	*4*	*5*	*6*
Clinic size (per 100 patients)	-0.0005	-0.0003	-0.005*	-0.005*	0.0002	0.00001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)
Clinic age	-0.0006	-0.0007	0.004**	0.004**	0.007***	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Industry experience	0.003	0.003	0.008	0.008	-0.006*	-0.006*
	(0.008)	(0.008)	(0.006)	(0.006)	(0.004)	(0.004)
Clinic experience	0.002	0.002	0.005*	0.005*	0.0003	0.0002
	90.004)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
Complex cases	-0.071	-0.072	-0.083***	-0.083***	-0.041	-0.040
	(0.052)	(0.052)	(0.030)	(0.030)	(0.030)	(0.028)
Technology	0.064***	0.063***	0.028*	0.029*	0.008	0.008
	(0.021)	(0.021)	-0.016	(0.016)	(0.013)	(0.013)
Post-shock	-0.004	0.002	-0.016***	-0.019***	0.003	-0.003
	(0.006)	(0.007)	(0.005)	(0.006)	(0.004)	(0.006)
Integrator X Post-shock		-0.010		0.006		0.012*
		(0.0102)		(0.008)		(0.007)
Constant	0.898***	0.899***	0.808***	0.807***	0.146***	0.144***
	(0.078)	(0.077)	(0.054)	(0.054)	(0.035)	(0.035)
N_t (total clinic-years)	914	914	914	914	914	914
N (total clinics)	70	70	70	70	70	70
Years	1992-2006	1992-2006	1992-2006	1992-2006	1992-2006	1992-2006
F statistic	3.81***	3.40***	14.92***	14.88***	32.30***	30.78***
Clinic fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors are in parentheses. The main effects for the integrator drop out in all models because they are time invariant and thus captured in the clinic fixed effect. Two-tailed tests: ***significant at 1%; **significant at 5%; *significant at 10%

Table 6. Additional Analysis: Regression results for clinic success rate while accounting for integrator types

Note: Measures of integrator types are available only for years 1999-2006 (compared to the original 1992-2006 sample)

Variable	*1 Pooled sample*	*2 Flexible integrators*	*3 Other integrators*	*4 No Integrators*
Clinic size (per 100 patients)	0.002	0.041**	0.001	0.0003
	(0.004)	(0.016)	(0.006)	(0.006)
Clinic age	0.009	-0.045*	0.000	0.027
	(0.012)	(0.024)	(0.018)	(0.020)
Industry experience	-0.046	0.316	0.042	-0.20
	(0.116)	(0.213)	(0.176)	(0.181)
Clinic experience	0.0003	-0.003	0.013	-0.006
	(0.004)	(0.003)	(0.007)	(0.006)
Complex cases	-0.155***	-0.083	-0.227	-0.10
	(0.057)	(0.188)	(0.077)	(0.102)
Technology	0.064*	-0.030	0.106	0.085
	(0.034)	(0.073)	(0.049)	(0.057)
Post-shock	-0.016	0.075***	-0.007	-0.02*
	(0.011)	(0.021)	(0.017)	(0.010)
Doctor-integrator X Post-shock	0.017	-	-	-
	(0.013)			
Nurse-integrator X Post-shock	0.024*	-	-	-
	(0.014)			
Either doctor or nurse integrator X Post-shock	0.040**	-	-	-
	(0.019)			
Constant	0.740	-3.218	-0.280	2.39
	(1.274)	(2.378)	(1.941)	(1.975)
N_t (total clinic-years)	513	54	203	256
N (total clinics)	70	8	27	35
F statistic	3.66***	139.26***	4.03***	1.68
Clinic fixed effects	Yes	Yes	Yes	Yes

Notes: Robust standard errors are in parentheses. The main effects for integrator types drop out in all models because of time-invariance, but are captured in the firm fixed effect. Two-tailed tests: ***significant at 1%; **significant at 5%; *significant at 10%

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