Which Project Integration Strategies Deliver High Performance Projects?

By

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Significant Results
There were two parts to this research. The scope, goals, research methods and contribution of each part are described below.

PART A: SUPPLY CHAIN INTEGRATION PRACTICES (SCIPs) AND HP BUILDING PROJECTS

This project looked at the emergence of Integrated Project Delivery as a new form of institutional arrangement for construction project delivery. It identified nine specific SCIPs and qualitatively unpacked the role that each practice plays individually. This was augmented by a comparative analysis that looked at the joint effect of different combinations of the SCIPs for the adoption of systemic design and construction innovations.

Identifying the role of SCIPs
Complex construction projects are using new and innovative project delivery methods to create collaborative teams, yet these project delivery methods show a great deal of variation in how they employ combinations of as many as nine SCIPs. These SCIPs — each defined here as a single formal or informal mechanism with the intent to integrate information, processes, people, firms and/or organizations for the purpose of collaboration within a construction project - should in theory help to overcome the fragmented industry structure and decentralized project organization, resulting in higher levels of adoption of systemic innovations.

This research has contributed by creating a detailed qualitative understanding of how eight previously-identified SCIPs collectively help to facilitate the adoption of systemic innovations. In addition, it identified and unpacked in greater detail one additional SCIP – agile cost shifting - not previously identified in the literature.

Contributions of the Research
The contributions of the research to theory, research methods and practice are presented in this section.

Innovation and Industry Structure
Research on AEC innovation is detailed and exhaustive. Yet as Gambatese and Hallowell (2011) describe: “despite this extensive literature, there has yet to be an attempt to study the project-specific factors that affect contextual innovation and co-innovation on construction projects. In other words, the impacts of construction-specific contextual and inter-organizational factors on the generation, implementation and diffusion of new products, processes, technologies and services, have not yet been addressed through rigorous research.”

This research joins a small but growing body of construction innovation literature (Gambatese and Hallowell 2011; Homayouni 2015; Papadonikolaki and Wamelink 2017; Sheffer 2011) that specifically looks at construction-specific contextual and inter-organizational factors. It further contributes by explicitly building a theory for the adoption of systemic innovations, work that has not yet been done. This research builds upon the work of John Taylor (2006; 2004a; b; c) and Dana Sheffer (2011). Building on Taylor’s pathbreaking work on innovation in construction, Sheffer developed, operationalized and empirically verified an integrated theory to explain the effects of innovation integrality on implementation and diffusion. However, Sheffer’s work is limited to two measures of supply chain integration (procurement approaches as a proxy for vertical integration and
integrated MEP ownership as a proxy for horizontal integration). Sheffer’s work did not yet account for the numerous other integration practices deployed to overcome fragmentation. This work is among the first to use a comparative analysis to study the joint complexity of SCIPs on the adoption of systemic, or what Sheffer called “integral”, innovations.

**Advancing QCA as a Methodological Approach to Study Project Integration**

This dissertation contributed to the growing number of AEC studies (Apa and Sedita 2017; Bekdik and Thuesen 2015; Gross and Garvin 2011; Homayouni 2015) that use the fsQCA methodology to account for the complex relationships between hypothesized causal conditions and outcomes of interest. With the rise in relational contracting and IPD, projects are frequently adopting different recipes of SCIPs. Comparing projects by overarching delivery methods (IPD v. Design Build v. Design Bid Build) does not account for the complex joint effects of these contractual, social and technological practices (Franz and Leicht 2016). Instead of a singular test of an independent variable’s relationship to a dependent variable, fsQCA offers an appropriate methodology to investigate how different combinations of conditions (c.f. independent variables) can produce an outcome (c.f. dependent variable) (Jordan et al. 2011).

Homayouni *et al.* (2014) introduce measurements for five categories of integration, but IPD projects typically involve many more practices. Building on the work of Homayouni, this research determined, calibrated, and organized measurements for the broad range of SCIPs adopted by IPD projects. Future researchers will be able to use these calibrations and the fsQCA methodology to develop new process theories and to evaluate their own additional outcome variables of interest. By explicitly identifying and calibrating SCIPs, it will be much easier for future researchers to replicate and expand upon the QCA methodology used in this dissertation (Jordan 2012).

**Roadmap for Advancing the Adoption of Systemic Innovation**

As projects are using SCIPs more frequently, project managers are searching for the most effective combinations of these practices to apply to their projects. Many industry leaders emphasize the need for more innovation in construction, but can be hesitant to commit to the high overhead required by SCIPs such as colocation, imposing stringent requirements for use of BIM, or early involvement of key participants. This dissertation contributes by identifying two possible ‘roadmaps’ for promoting the adoption of systemic construction innovations. By following one of the two pathways proposed, project leadership can emphasize the implementation of certain sets of SCIPs that will put their project teams in the best possible position for the adoption of systemic construction innovations.

In addition, this research project has unraveled the current understanding of systemic design innovations. It has clarified that SCIPs are not causal in the adoption of systemic design innovations, something that can be overpromised by proponents of integration. Instead, this work demonstrates that projects with high levels of systemic design innovation will benefit significantly from the application of SCIPs. In these situations, evidence shows that the extra overhead costs of SCIPs (and more generally of IPD) can be justified by their effect on total project cost and schedule containment. Both of these contributions offer a starting place for owners, managers and other practitioners to justify the application of SCIPs in order to adopt or more-effectively manage projects with globally-optimal systemic innovations.

**Framework to Strategize Informal Integration Practices**

Additionally, the creation of the two-dimensional framework offers a starting point for project managers to conceptualize project integration. Often project managers have little agency over
elements of the formal system, such as the type of contract used for the project or the allocated budget for colocation of project teams. However, the framework shows that managers can have agency and influence over informal SCIPs, such as creating an environment of fiscal transparency or specifically improving the change management process to allow for more agile cost shifting between firms.

Technical difficulties and solutions
The researchers acknowledge two limitations imposed by the methodology and research design that constrain the generalizability of its results. The first limitation of any fsQCA methodology is that it cannot be applied mechanically. FsQCA requires familiarity with the nuances of the data and it is essential not to underestimate the case-based knowledge necessary to employ the method (Jordan et al. 2011). This research employs structured interviews instead of a survey; and it cross-checks each SCIP score across multiple interviewees. However, with only three interviews per project, there is still the potential that the data collected does not inform the full complexities of each case. When pursuing a “medium-N” (i.e., more than a small-n set of deep dive cases, but less than a statistically significant sample size) data set of 10-20 projects versus a small-N data set, this tradeoff is unavoidable. Nevertheless, it remains a limitation and the findings presented here are positioned as initial steps in theory building and testing theory, a process that can and should be refined by future case-based work. In addition, the use of large-N regression studies could be future steps to validate and refine the theories proposed here.

The second limitation is that the research focused only on healthcare facilities in California, and it is possible that findings for complex healthcare facilities would not hold for other types of construction. For example, the regulatory environment of healthcare facilities is far stricter than for many other types of buildings. It is possible that the stringent OSHPD regulations and oversight associated with building healthcare facilities in California generates a unique and different causal pathway for the adoption of systemic innovations in this sector that is different from the causal pathway for other types of buildings. Due to the need to limit the number of input conditions for the fsQCA, we could not include ‘control’ conditions for project size, complexity and regulatory environment conditions in the final analysis. To mitigate this concern, however, these ‘control’ conditions were explored using a follow-on “necessity” analysis in additional runs of fsQCA. The results of these studies did not point to these control conditions playing a role in the causal pathway. However, the application of the findings presented here to other construction types or locations, especially those with significant differences in the project sizes, complexities and regulatory environments from California healthcare projects, should be done with care.

Part B: A Motion Tracking Pilot to Evaluate ‘Usable’ High-Performance buildings

Research Overview
This report represents an exploratory pilot of a methodology to measure the impact of hospital design on daily walking distance for healthcare staff.

Early involvement, BIM, co-location, and on-time delivery: these are some of the “best practices” principles used on construction projects today following decades of stagnation, fragmentation and hostility among project stakeholders. But do these principles, when employed in integrated project delivery methods, result in more operable buildings from the users’ standpoint?
The objective of the study was to see whether enhanced collaboration among project designers, builders and owners resulted in a better hospital design when viewed from the user’s standpoint. This part of our research devised a methodology to understand how hospital design impacted the walking distance for nurses during a hospital shift. In this pilot stage of the project, three nurses volunteered to wear a trackable fitness device (Fitbit One) for a month. Using the Fitbit One and the web-based interface that comes with it, the nurses recorded the distance they travelled during their shifts and the researcher was able to access this data as planned for two of the three nurses. The only input needed for the Fitbit was a unique email and a password.

**Findings**

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<th>Distance (miles)</th>
<th>Minutes Lightly Active</th>
<th>Minutes Fairly Active</th>
<th>Total non-sedentary minutes</th>
<th>Nurse B</th>
<th>Date</th>
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Figure 1 - Raw data collected

**Observations**

Shifts were every 3 or 4 days, with between 400 and 500 hours of non-sedentary work and an average of 4-5 miles travelled each time. The dissonance of the number of non-sedentary minutes between the two nurses is concerning. Theoretically, since the nurses were in the same department, doing similar work, the number of non-sedentary minutes were meant to be uniform. A misunderstanding of the types of tasks the nurses do may be the root cause of the error. A follow-up survey of their specific roles and the demands of each would help to shed light on this discrepancy.

That said, the exit interview with the nurses confirmed that measuring distance travelled was an effective way to determine good hospital design. The strategic placement of supplies, ideally centrally located in relation to the patient rooms, helps to make the nurses’ tasks more efficient. Other things like the placement of sinks outside patient rooms, and easy access to refreshments for families so that they do not add to the non-medical tasks of the nurses cannot be captured by measuring the distance travelled during a nurse’s shift. A combination of Fitbit data collection with a few interviews and site visits gave us a robust insight into which hospitals are well-designed from this point of view.

**Evaluation of Pilot Study**

Retain these aspects of the study:

- Training and an exit interview for 20 minutes each at the beginning and the end of the study was adequate time. There was no need to collect the nurse’s stride length or height since it was only the distance travelled that is being measured.
- Use of Fitbit One: This worked well for nurses because of the clip-on feature.
- Nurses thought the Fitbit was simple, it worked and was easy to use. As far as incentives were concerned, keeping the Fitbit after the study was a good enough incentive, the first nurse interviewed said she planned on using the Fitbit One which has a nice clip on feature, later.
• Two of the nurses had prior experience with the Fitbit, the third did not and the training was not long enough to explain how to use the Fitbit to her. In future, we might specify that the study should select nurses with prior Fitbit experience.

• Future researchers should add to the research description “If there are any issues, we will let you know” so as to not disturb the nurses’ work unless absolutely necessary whilst reassuring them that all is well.

**Future Research**

• This research should be expanded to include more participants, and more hospital sites, to provide more robust data collection.

• Data can be collected and evaluated horizontally by comparing the walking distance done by nurses with the same role at different hospitals.

• Data can be collected and evaluated vertically by comparing the predictive values of automated design software that predicts the distance travelled by nursing staff with the actual distances once construction is complete.

• Data can be collected and evaluated longitudinally by comparing the distance travelled by the same individuals before and after the move to a new hospital facility, to determine whether, in fact, the new building is a High Performance building that is more ‘usable’ and productive for the occupants relative to previous hospital or other buildings.
List of publications

