INNOVATION IN OFFSITE MANUFACTURING IN THE FIELD OF HOUSING: A CASE STUDY USING BOURDIVIAN AND ACTOR-NETWORK APPROACHES

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The purpose of this paper is to apply the Bourdivian concepts of field, habitus, and capital as theoretical lenses to examine the Australian housing construction sector. Specifically, we demonstrate the usefulness of Pierre Bourdieu's approach in understanding specific factors that drive innovations in offsite manufacturing (OSM), an approach that involves the manufacture and assembly of parts, components, and/or systems in a controlled environment away from the traditional construction site. We begin by exploring field, habitus, and capital. We then explore how these lenses have been applied by Bourdieu and by various authors to analyse the field of housing and the built environment. We explain how an actor-network approach can be mobilized methodologically to apply Bourdivian concepts to analyze the players and dynamics of innovative OSM housing supply chains in Australia. We then present our preliminary findings, one being the argument that the creation/ conversion of different species of capital forged a pathway to successful incremental change.

INTRODUCTION: FIELDS, CAPITAL, AND HABITUS

Pierre Bourdieu (1984, 1986) argues that the modern social world is made up of a series of fields wherein actors, predisposed by habitus and in possession of capital in various forms, occupy different positions and struggle for ascendancy. In this paper, we examine how these Bourdivian concepts can be applied as analytical lenses for understanding innovation in the field of housing construction, in particular supply chains making use of offsite manufacturing (OSM) techniques.

Fields (culture, education, media, religion, economics etc.) are microcosms of mutually supporting "institutions, rules, rituals, conventions, categories, designations, appointments and titles which constitute an objective hierarchy, and which produce and authorise certain discourses and activities" (Webb 2002, p. 44). Fields exhibit varying degrees of differentiation and autonomy (Bourdieu 1986; Mahar et al. 1990; Swingewood 2000). Each field has its own stakes, interests, and practices, collectively defining "rules of the game" and crystallizing into an orthodoxy that is an official and legitimate version of how the good life should be at a given time. Anything outside of this is considered unorthodox, or as *heterodoxa* (Grenfell 2004, p. 28). The privilege of legitimating and consecrating what is "good" in a field is a privilege linked to specific *positions* in a field, and not to others; thus positions in fields, which are occupied by *actors,* can be characterized as more powerful/ less powerful, or as dominant/ subordinated (Bourdieu and Wacquant 1992). The power relations between

and among positions make up a field's structure. Fields are characterized by ongoing struggles among actors for these positions of legitimate authority.

One of the things driving these struggles is capital. Capital functions as both "weapons and stakes" for ascending in a given field (Emirbayer and Williams 2005, p. 691), and covers "all the goods, material and symbolic, without distinction, that represent themselves as rare and worthy of being sought out after in a particular social formation'" (Harker 1990, in Webb 2002, p. 22.). Capital therefore "symbolizes" things that are important in a given field. Symbolic capital can take three forms: economic, social, and cultural. Economic capital refers to money, as well as to goods that can be directly converted into money. Social capital refers to actual or potential resources linked to group membership, or to being part of a network of "more or less institutionalized relationships" (Bourdieu 1986, p. 88). Cultural capital can be *embodied, objectified,* or *institutionalized*. Embodied cultural capital is acquired by investing in resources that "form long-lasting dispositions in the mind and body" (Bourdieu 1986, p. 84). Objectified cultural capital (in forms like paintings, monuments, books) takes material form and becomes transmissible. Institutionalized cultural capital generally takes the form of recognized academic qualifications. Examples of each type, as well as the ways that they are distributed, depend on a given field. Bourdieu (1991, in Grenfell 2004, p. 28) claims that "agents possess power in proportion to their symbolic capital, i.e. in proportion to the recognition they receive from the group"; hence, agents struggle to accumulate more of certain types of capital, or to "convert" capital from one form to another.

Another trump card for ascendancy in a field is habitus (Mahar et al. 1990), the largely unconscious mechanism by which agents internalize the structures and patterns of a given field. Habitus is a set of predispositions implanted during childhood and deepened by social systems that agents participate in over time (Swingewood 2000). It overlaps with capital in the sense that some habitus "constitute a form of capital (symbolic) in and of themselves" (Mahar et al. 1990, p. 12), for example the way that art appreciation can be bred into children from certain classes at a very young age. One's habitus allows one access to multiple, though not necessarily an unlimited, number of choices of action, hence it cannot be described as deterministic.

BOURDIVIAN CONCEPTS AND THE BUILT ENVIRONMENT

Bourdieu has used the concepts of field, capital, and habitus to examine a broad range of issues: education, art, media, culture, even life in Algeria (Grenfell 2004). Notably, he also used his theory of fields to analyze the issue of housing in France in 1977, unpacking the complexities associated to the demand side of housing, the supply side of housing, and the role of the state. Based on his findings, he concluded that housing transactions and practices could not be reduced to economic laws of supply and demand, and that such economistic views tended to be oversimplified and limiting (Bourdieu 2005).

There is a growing body of work that has likewise sought to extend the application of Bourdivian concepts not just to housing, but also to different subfields of the built environment. Sang and Powell (2012), for example, explored the persistence of gender inequality in the construction industry, showing that the field was characterized by symbolic violence (a Bourdivian concept) towards women. Stevens (1998) explored how using the concepts of field, capital, and habitus (specifically socialization via the educational system) can yield insights into the field of architecture, which he claimed is split into the field of mass production driven mainly by economic (temporal)

capital, and the field of restricted production driven mainly by cultural (intellectual) capital.

While Stevens (1998) focused primarily on two types of capital (temporal and intellectual), Skaates et al. (2002) built on Bourdieu's original conception of three species of capital (economic, social and cultural), and used this framework to propose a hierarchy of architectural firms occupying different positions. An important contribution by Skaates et al. (2002) as far as this paper is concerned is that they operationalized the definitions of different species of capital with respect to the field of architecture.

Other work has proposed new species of capital. Nahapiet and Ghoshal (1998, p. 245) argued that social capital can facilitate the creation of intellectual capital, defined as "the knowledge and knowing capability of a collectivity". They ground their argument by proposing that social capital has three dimensions: structural (for example, network ties and configurations), cognitive (shared language and narratives), and relational (trust and norms). A specific element of (structural) social capital like network ties can yield network benefits, for example quick access and referrals to sources of information. These benefits can then facilitate the process of combining and exchanging existing knowledge, leading to new intellectual capital. Nahapiet and Ghoshal's (1998) study is a conceptual one, and is not specific to the built environment, but their arguments have rich potential application in the sector. The link between social capital and knowledge has, in fact, been explored empirically in construction (see Stryhe 2009).

Apart from work exploring the link between capital and knowledge, research has also been done to explore the relationship between capital and innovation. London and Siva (2011) explored the diffusion of innovation across the construction industry by tracing the creation, development, and adaptation of a waffle pod footing system originally developed in South Australia. They argued that one way to address barriers to innovation was to build reflexive capability, which enabled actors to consciously identify stocks of social, cultural, and intellectual capital, to strategize on how to create, use, and maintain these, and if necessary, to change these strategies.

Having examined Bourdieu's concepts of field, capital, and habitus, as well as how these have been applied to analyses of issues in the built environment, we frame our research question as follows:

How can the Bourdivian concepts of field, capital, and habitus be applied to understand innovation in the Australian housing construction industry, specifically in relation to offsite manufacturing?

METHODOLOGY

To address the research question, we are conducting five qualitative case studies in the Australian housing sector. The findings presented here are preliminary; they relate to an early-stage analysis of data involving our first case site, referred to here as Organization A.

The case site

Organization A is an Australian developer that has in recent years begun to focus specifically on the construction of medium-density, five-to-six storey dwellings, in response to the Australian governments' push for increased density in the inner and middle suburbs. In 2012, Organization A spearheaded efforts to design and construct a

five-storey timber apartment building in the Australian state of Victoria, an initiative that we refer to here as The Project. Early into The Project, concerns emerged among key managers regarding the length of time required to lay the floors using traditional methods, along with the safety issue of possible fall from heights in the course of installation. In an early meeting with engineers, contractors, and suppliers, an executive from Organization A presented the idea of introducing prefabricated cassette floorings. The idea was taken up by the group, and gradually a team was formed to develop a prototype within a six-month period. The prototype development period involved intense collaboration, with members discussing and refining the idea in a series of weekly, then bi-monthly meetings. In the process, one contractor (Contractor B) brought another entity on board (Contractor C) to lead the design and the initial fabrication of the cassette, with the understanding that Contractor B would later take up full-scale commercial fabrication. The cassette flooring that was eventually developed was made primarily from cross-laminated timber, although variations of the product are offered. One of these incorporates a floor joist made of a patented element, a composite of lightweight steel and timber. It was this variant that was used in The Project. Contractor B claimed these floor cassettes had the spanning capabilities of reinforced concrete, could be manufactured offsite, and, due to their lightness, could be craned into place. This meant that laying out floors could be carried out in a swifter, safer, cheaper manner. The first cassettes for The Project were craned into place towards the end of June 2013. Use of the cassettes allowed floors to be laid in shorter cycles, and allowed the simultaneous building of internal walls, leading to the building being completed one month early and with savings on built costs of 25% per apartment. Organization A is currently exploring more widespread use of the cassette in its upcoming projects in other states.

Actor-network theory, data gathering, and data analysis

Interview narratives suggest that the development of the cassette floor system was not a simple, linear process unilaterally executed by a single organization; it was the outcome of interactions among actors linked in complex webs. To understand the context of the cassette's development, it was necessary to map the players involved and their interactions with one another. To accomplish this, we used actor-network theory (ANT), a broad term covering theoretical and methodological approaches that assume that much of social reality is the outcome of actors interacting in heterogeneous networks (Law 1992). We employ ANT here as a methodological approach that provides an analytical toolkit for identifying both human and non-human actors involved in the innovation phenomenon we are seeking to unpack; scrutinizing the interactions that take place among them; and examining the network effects of such interactions.

Our ANT map suggests that Organization A was a central player managing multiple dyadic relationships with an architectural firm, a designer, and a variety of contractors, for example for flooring and framing. At this stage a total of five interviews have been conducted with managers from Organization A as well as two partners. Interviews lasted approximately one hour each, were recorded and then fully transcribed, then analysed thematically. Data was also obtained from document reviews in the form of industry reports, presentations, photographs provided by interviewees, and news articles related to The Project.

FINDINGS

The initial themes that were used for data analysis were drawn from Bourdieu's conceptual apparatus comprising field, habitus, and capital.

Field: Innovation as a gradual "changing the rules of the game"

In understanding the field of housing, we begin with the Bourdivian concept of *doxa*, which in this case sensitizes us to the idea that there are a number of prevailing orthodoxies in the field of Australian housing. Three are noted here: the market's strong inclinations towards large, detached houses (Santow 2009); an industry preference for concrete (Heaton 2015); and the widespread employment of craft-based techniques in construction (Loosemore et al. 2003).

Our preliminary analysis suggests that over the last few decades, Organization A has slowly sought to interrogate and redefine these so-called rules of the game. For more than a decade, Organization A has been making calculated departures from convention. First, it interrogated the "detached housing" rule by diversifying into medium-rise structures. Second, it interrogated the "concrete" rule by making use of timber. Recently, it has begun interrogating the dominance of onsite craft-based approaches by combining onsite techniques with offsite manufacturing.

There are two important things to note about what Bourdieu would call such "heterodoxy". The first point is that Organization A's interrogation of the orthodox involved changes introduced incrementally, and not in sweeping, dramatic ways. One manager described efforts this way:

> I think to get to a lot of people want to go from A to P immediately. I say let's get to B, C, D, E... If you try and jump straight to P you'll fail. Yes we did hybrid which is lightweight timber frame. Okay, the next step for us was, how do we improve? Let's go to five storeys, let's introduce cassettes. All right, fantastic, that's worked. All right, what's the next step?

A second point is that changes introduced are multifaceted. As we will show later, changes introduced by Organization A involved technological innovations tightly coupled social change in the form of new ways of working and managing. The introduction of cassette floorings, then, is just one part (albeit a significant one) of a series of changes that the company has sought to implement in the field.

Our preliminary findings therefore suggest that *innovation in this case is better understood not as the decontextualized introduction of a new technology like a new cassette floor, but as a systematic, multidimensional and gradual changing of the "rules of the game" in a field over time.* This is not to say that innovations are always systematic and gradual, but the incremental, evolutionary approach appears *in this case* to have been favoured by Organization A. It is worth exploring if the success of this incremental approach to innovation is linked to the characteristics of the field of construction, a conservative arena that has historically been linked to low levels of innovation.

Habitus: The need for a prime mover to go beyond habitus/ preservation

In seeking to rewrite (or at least "tweak") the rules in the field of housing and introduce change large-scale change, Organization A can be understood as the *primum movens* or prime mover. ANT uses this term to refer to the main actor that seeks to recruit other actors into a network, triggering a chain of interactions which in turn leads to certain network effects or outcomes (Callon 1999). ANT theorists would

argue that Organization A was a *primum movens* in the sense that, as one manager put it, it "[brought] parties together and…made things happen." However, some ANT proponents would also go further by suggesting that a "prime moving" organization is a collectivity that can be further broken down into even more basic elements, for example individuals (Law 1992). If we drill down more deeply into the dynamics of Organization A, these will reveal that there were key managers within the company who pushed for much of the innovation of the cassette flooring. In particular, multiple interviewees made specific reference to one executive, referred to here Manager 1, who was described as the "key initiator" of the new technology and who mobilized the team to develop the prototype.

Manager 1 was described as having "insurmountable credentials" and a "reputation within the organization for getting the job done". An interviewee offered the opinion that the chain of events resulting from the cassette floor innovation would have taken place without this individual. The interviewee said,

> *He is a director himself but the general managers and the executive general managers of that level have that trust in him to say, right [Manager 1], if you think if you have bit of an inkling that this will work let's explore it.*

The so-called "power" of Manager 1 to initiate (though not singlehandedly bring about) innovation can be accounted for in a number of ways. One possibility that we explore here is this person's so-called habitus. Habitus and field are linked in the sense that objective structures in a field tend to be subconsciously internalized by actors, and are often (not always) reproduced. Habitus thus has some structuring effects over individual actions (because of habitus, some possible actions are automatically left out), but these effects are by no means deterministic (Mahar et al. 1990). In the case of Manager 1, it is clear that he was all too aware of prevailing practices in the field of housing, practices that could for example erode the collaboration necessary for an initiative as complex as the cassette flooring. He stated,

> *I think we're in a very male dominated environment. I think because we've got such a high dominance of the male thinking, testosterone, the male thinking pattern which is very - I need to be disengaged from you because if emotionally I get too close it starts - that's vulnerability and all that sort of thing and I don't think there's an understanding that you can get actually close to someone and you don't need to be vulnerable to them.*

A less reflective agent would internalize these rules then reproduce this tendency in work practices, perpetuating an arrangement where housing actors remain detached and aloof from one another. In this case, though, Manager 1 made an intentional decision *not* to adopt prevailing practices, and instead took on a very specific posture that carved out a space for trust and collaboration (social capital, discussed later), while still maintaining a significant level of accountability and task orientation:

> *I've got one of our external builders right now… he has fallen off the track and I noticed he was coming off the track. We went and had a talk to him. The general foreman's wife walked out on him... they didn't want to come and tell us. They were scared to come and tell us about it. [W] e're both commercial entities and we've both got outcomes we have to achieve. So that will come into it at some stage. But at this point in time they're not the place I want to be. Right now I want to work out how can we get you back on track, because if I can get you back on track I'm going to win, you're going to win and everyone is going to look good.*

This is consistent with Bourdieu's argument that agents occupying positions in fields can, despite predispositions of habitus, mobilize a number of postures in non-deterministic ways (Mahar et al. 1990). At times this leads to fields being transformed.

An important lesson from this preliminary analysis, then, is that *innovation (in varying degrees) can only take place if led by an initiator who is reflexive enough to move beyond "preservation strategies" that simply defend the orthodoxy of a field.* In this case, we see that Manager 1 and Organization A mobilized what Bourdieu (1984) calls *transformation* strategies. This is interesting because it contradicts one of Bourdieu's (1984) arguments: that preservation strategies are usually mobilized by actors in dominant positions, while transformation strategies are usually mobilized by actors in dominated ones. In this case, Manager 1 (rich in credentials and expertise) and Organization A (rich in reputation and economic capital) were actors in powerful positions, yet they were mobilizing strategies of transformation. While this may initially seem like an outright contradiction, a more nuanced explanation that can be explored in future work is that both were mobilizing another type of strategy: navigating the fine line between "tradition and tempered innovation" (Bourdieu 1984, p. 15). This is a strategy often attributed to actors linked to the function of education in a field.

Capital: A successful pathway of capital conversion in the construction industry

Another important finding at this stage is that Organization A's ability to change the rules of the game (incrementally) while maintaining its position of power was due not only to its incremental approach, but also due to its ability to execute a series of capital conversions. As Organization A rewrote the rules of the game, it did so in ways that allowed itself to create and convert capital, ending in a state where it had more. Our findings suggest that the company employed a specific pathway of capital conversions, depicted below:

Figure 1: Organization A's pathway of capital conversion.
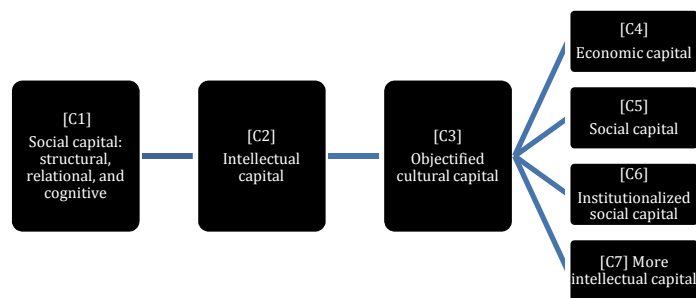
The intentional and deliberate creation of social capital appears to be the critical starting point for introducing changes in the field related to the cassette flooring. Using Nahapiet and Ghoshals' (1998) definition, we see evidence of structural, relational, and cognitive dimensions of social capital being managed. Efforts to develop the cassette flooring began by building the *structure*:

> *… we knew who our core subcontractors and suppliers needed to be. And in doing so we had to research on that company and make sure they were capable of doing what we needed as well. So we went out to the largest frame and truss manufacturers who had the best detailers in their, I guess, pool of employees. We went to a flooring company who had the ability and cashed up to be able to do all the independent testings that we wanted to be done. And*

we had the best engineers on board. All those things all clicked, that's all. So we knew who we needed to make it to work.

As work on the cassette floor progressed, the *cognitive* dimension of social capital emerged in the form of shared thinking and discourses:

…it's a momentum. It just builds moment and momentum and people catch on...Yeah, the positivity just really catches on. And people start becoming like-minded when you put that group together.

…everyone was very narrow-minded but by the time you finished with the group after six months, everyone knew, okay, if I put this floor joist here it will do this to acoustic, it will do this to fire. Everyone becomes a little bit more understanding of how each other thinks.

The *relational* dimension was also evident:

…you've got to make the site fun. You've got to take them out for lunches. People in here are going out for lunches all the time. Get the guys off site, shut the site down for half a day and take them out for lunch and say to them, "Thanks, you're doing a great job."

Consistent with the proposition of Nahapiet and Ghoshal (1998), our findings highlight the close link between social capital and intellectual capital. The creation of a network of like-minded actors working in close proximity appears to have led to knowledge creation, or intellectual capital:

By us having everyone there at the table once we hit an issue we can ask that discipline, how do we get around it, what are my options, bang. Decision is made right there and then, you move on... that's why we have people around the table because I know I don't know engineering to the nth degree but I've got a fairly good understanding of it from a frame and truss point of view. But to draw on knowledge from these guys has given me a bit more confidence in making decisions in big meetings to say, guys I think we can do this.

There are three observations to make about this pathway of capital conversion. The first is that *social capital appears to be an important foundation for capital accumulation, possibly because it addresses the fundamental problem of fragmentation in the construction field.* A single *primum movens,* no matter how strong, thus appears to be a necessary but not sufficient condition for successful innovation.

A second point is that *intellectual capital is not an automatic, unproblematic outcome of social capital – good networks can create invalid knowledge.* One manager from Organization A discussed the case of a competitor company forming its own network with the aim of creating similar innovations for timber buildings. A network of partners was built up (good social capital); however, the effort was deemed a failure because the knowledge that was created had a misdirected focus on building around concrete standards, instead of on timber standards required to support the innovation.

A third observation is that in the case of the construction industry, it seems necessary to convert intellectual created into tangible forms in order to maximize its value, thus *it is important in an industry dealing with tangible assets to convert intellectual capital into objectified cultural capital.* In this case, brainstorming, discussing ideas about a cassette flooring prototype, and writing reports were important. However, it was not plans on paper that led to the creation of more capital; it was completed

buildings showcasing the robustness of the cassette flooring that proved to be invaluable in the creation of more capital. Three interviewees repeatedly mentioned the importance of bringing doubtful partners to the completed project site, in order for them to "jump up and down" in the completed building to demonstrate how the timber flooring felt as strong as concrete. One interviewee mentioned that the walk-through strategy was being considered for doubting customers as well. Another also mentioned that very people who had designed the cassette came to appreciate their "intellectual capital" most fully only when they saw it in embodied form:

> *… on the very last day of lifting …we took the fabrication team to the site and it wasn't until then that they realised…how critical it was to fit.*

Objectified cultural capital thus appears to be a particularly potent and versatile capital base in the housing field. This is an important consideration given widespread discourses regarding economies being increasingly driven by "intangible" knowledge. Our findings suggest that it was objectified cultural capital that has led to the creation of at least four new forms of new capital. The cassette has led to (1) more economic capital:

> *Cassettes are a component of what we do. But yeah, the idea is strong. The momentum is still there and I guess the outcomes from it, from a financial timing, design and everything and meeting market expectations are all there. So…we've hit a lot of milestones and the rest of the business units have seen how this can work so it's spruiking a lot of interest in our other states.*

It has also been linked to (2) more social capital, as contractors who formerly doubted the viability of the cassette flooring are now coming on board:

> *…in particular the sales and marketing manager, cause he was the one who I was going, oh guys be very careful, blah, blah, blah. He was the one, he's jumping up and down [on the cassette, to test it] going wow, I get this now.*

It has also led to the creation of (3) institutional cultural capital, as the organizations involved in developing the cassette have recently received an industry award for innovation, and to (4) intellectual capital, as intellectual property in at least two forms has emerged and is now shared by three of the partners.

CONCLUSIONS

In this study, we have shown through our preliminary findings how the concepts of field, habitus, and capital can shed light on the process of innovation in the field of housing. Innovation is in this case is an incremental, socio-technical process of rewriting the "rules of the game", often led (but not completely controlled) by a prime mover who is reflexive enough to question a field's orthodoxy, and facilitated by strategic conversions of capital, with social and embodied cultural capital appearing critical in the field of housing and construction.

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