Beyond the iron law? Large-scale construction projects as drivers of innovation

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Paper presented at the 34th EGOS Colloquium | 5-7, 2018 | Tallinn, Estonia
Sub-theme 52 | Projects for Innovation: Managing Novelty and Uncertainty

1. Introduction

Large construction projects as drivers of innovation? This conjunction appears counterintuitive, at least in two respects: For one thing, the recent record of large projects worldwide is anything but a success story (e.g. Flyvbjerg et al., 2003; Flyvbjerg, 2011, 2014). According to Flyvbjerg (2011), mega-projects are subject to an “iron law” of chronic underestimation of costs and overestimation of benefits. Big, it seems, is rather associated with “fragility” (Ansar et al., 2017) than with novelty.

For another thing, a lack of innovativeness similarly holds for the construction industry in general. Construction firms perform poorly in an inter-industry comparison, and according to classic innovation indicators (e.g. Reichstein et al., 2005; Butzin/Rehfeld, 2009, 2013; “Least improved”, 2017). The relevant literatures on innovation, in fact, simply tend to ignore the construction business as field of inquiry.

And yet, this is not to say, the “design and production of buildings” is purely based on the repetitive application of “well-tried technical solutions” (Groák, 1992: 6). Throughout its history, the construction industry has regularly introduced new technologies and processes (e.g. Ågren/Wing, 2014). And, at present, it is confronted with pressing needs to change, such as new technological requirements and affordances as well as the internationalization of the entire value chain.

What is more, when looking at the history of construction in more detail, large-scale projects have regularly leveraged novel technologies and engineering solutions. Crystal Palace, the Eiffel Tower and St. Pancras Station, to name but a few prominent instances, are regarded as milestones in the implementation of steel structures and prefabrication techniques (Ågren/Wing, 2014). And even the Sydney

Opera House is less famous as the “great planning disaster” that it in fact was (Hall, 1982) than for its innovative concrete shells and the image as one of the architectural icons of the 20th century (e.g. Groák, 1992).

A systematic exploration of large-scale projects as innovation vehicles in construction requires to venture into uncharted conceptual terrain. With this paper, we seek to take first steps into this terrain, both conceptually and empirically. In section 2 we discuss two approaches to conceiving of innovation in construction, one rooted in project and construction management literature (2.1) and another one arising from recent work in ‘classic’ innovation research (2.2). Through a synthesis of both strands of inquiry (2.3) we seek to build a framework for the case studies (3) of two recent large-scale architectural projects in Germany: the new premises of the European Central Bank in Frankfurt and the new concert hall (Elbphilharmonie) in Hamburg. Despite their similarities as iconic architectural emblems for the cities in which they have been built, they exhibit profoundly diverging processes of planning and construction which are also reflected in the novel technologies, strategies and practices that they generate.

Section 4, by way of conclusion, provides an interpretation of how diverging project trajectories shape innovation processes in large construction projects and seeks to open some avenues for future research from there.

2. Perspectives on innovation in construction

2.1 The construction literature perspective

Notwithstanding the general neglect of construction in the mainstream innovation literature, a rich body of research has been produced over the last decades, mainly in the international project management literature (e.g. Winch, 1998; Slaughter, 2000; Gann/Salter, 2000; Dubois/Gadde, 2002; Harty, 2008; Brady/Davies, 2014; Clegg/Kreiner, 2014; Davies et al., 2017), but also in regional studies and economic geography (Butzin/Rehfeld, 2009, 2013; Rehfeld, 2012). This work particularly focuses on one aspect that essentially frames innovation activities in the construction industry, albeit with an ambivalent outcome: construction is a project-based industry.

Two features exemplify the project-based character in particular: complexity and singularity. Every building is an assemblage of numerous and diverse components

that are both placed into a new context and orchestrated by a large and diverse spectrum of players from the construction value chain (Gidado, 1996; Dubois/Gadde, 2002). Construction projects, in addition to this “structural complexity” (Brady and Davies, 2014: 24), also exhibit „dynamic complexity“ (ibid.), as they change over time. At the same time, buildings are one-offs, and they are produced by “temporary organizations” (Lundin/Söderholm, 1995; Turner/Müller, 2003) that are established as „quasi-firms“ (Eccles, 1981) for every single project.

The complexity and singularity of construction projects both support and hamper innovation. Complexity and changing constellations and tasks both create opportunities (e.g. Dubois/Gadde, 2002) as well as pressures (e.g. Slaughter, 2000) to develop novel solutions. However, the complexity also entails risks of uncontrollable feedback dynamics. Managers therefore tend to minimize these risks by giving preference to tried and tested practices (van Marrewijk et al., 2008; Lenfle/Loch, 2010; Davies et al., 2014).

When it comes to the diffusion of innovations across the value chain, the project nature of construction is a real obstacle. Due to the difficult transfer of single components between different complex systems (Harty, 2008) the involved firms have difficulties drawing long-term profits from once-only technologies or practices. More importantly, temporary organizations essentially suffer from „organizational amnesia“ (Grabher, 2004: 1492): projects are confronted with the challenge of how to store learning progress once a project is completed and the project ecology is dissolved.

Within the complex organizational ecology of construction projects, the literature considers one group as particularly relevant for innovation: the clients, or project owners, respectively (e.g. Nam/Tatum, 1997; Gann/Salter, 2000; Slaughter, 2000). Winch (1998) refers to the „large sophisticated business user“ (Miller et al., 1995: 365) particularly in „complex product systems“ (Miller et al., 1995), such as flight simulators, military systems or aircrafts, as a benchmark for a committed and demanding client that operates in a framework similar to construction. He argues, however, that construction clients in general are not such sophisticated users, as they tend to outsource responsibility for the accomplishment of their demands to architects and engineers (Winch, 1998: 276). What is more, the dominant client in the construction business is the public sector, and state bureaucracies in general have a

notoriously bad reputation when it comes to their capacity to support novelty (Siebel et al., 2001). However, recent work on UK projects shows that a systematic upgrading of public sector agencies to best practice clients in construction projects can induce far-reaching innovations (Davies/Mackenzie, 2014; Davies et al., 2014; Brady/Davies, 2014).

2.2 The innovation literature perspective

What does innovation actually involve? Within the pertinent literature there is a widespread agreement that it entails more than the mere creation of novelty (e.g. Brady/Hobday, 2011). An invention, such as a new idea, technique or product, is only considered innovative when it comes with a certain degree of acceptance, or even economic success. In a simple equation, this looks as follows:

Innovation=Invention + X

the X representing “exploitation” (Roberts, 1988); “value” (Amabile, 1996) or “success” (Brady/Hobday, 2011), for example.

Given the singularity and complexity of construction, the accomplishment of X in the construction value chain is anything but a trivial task. As a (singular) one-off, every new building by definition is an invention. But can it also be qualified as an innovation once it has been built? As a (complex) system assembled from myriads of components, put together by a diverse range of players, a building exhibits novelty not as a discrete whole. In construction projects, innovation is diffuse and interdependent. How, then, should it be grasped at all?

We suggest approaching this challenge by proceeding in two steps that simultaneously broaden and narrow the understanding of innovation. For the first step, we draw on recent work that seeks to examine innovation as a “pervasive social phenomenon” rather than as a process “restricted to the labs of scientists and engineers, R&D departments in the private economy and […] artist’s studios” (Hutter et al., 2015: 33). Hutter et al. (2015: 37) distinguish three different “observation forms” of innovation: “semantics, pragmatics and grammar”. Based on this differentiation, we can specify the X that transforms an invention into an innovation on three different levels. A new idea, practice or artefact would be an innovation (a) by being acknowledged in a professional or public *discourse* (semantics); (b) by

proving as a solution for a problem that comes up in *practice* (pragmatics); and (c) by having an impact on the "systems of *rules*" (ibid.) that constitute the institutional framework for professional practice (grammar). The three levels are not independent from each other: Discourses and rules, for instance, influence practical solutions and vice-versa (ibid.: 38). Through the emphasis on rules and discourses we can also grasp the soft (e.g. aesthetic) aspects of innovation in construction.

In the second step, we turn to what Garud et al. (2016: 456) call a "performative view" of innovation processes. We do not frame innovation in a comprehensive fashion, but follow an approach that "acknowledges the indeterminacy and openness of an ongoing process, and the futility of trying to control it […]" (ibid.). This complex and contingent process is driven through practices of "translation" (Latour, 1986). Rather than "initial force" (ibid.: 267), such as a new idea, new practice or new artefact, that subsequently diffuses through time and space, "the spread […] of anything […] is in the hands of people" (ibid.) who can accept, adopt, modify, transform and/or reject it. This variety of actions adds up to "chains of translations" (Czarniawska/Joerges, 1996) in which actors strategically manipulate relational or temporal settings "by establishing and breaking linkages or by mobilizing events from the past, present and future" (Garud et al., 2016: 456) in order to promote their own projects and initiatives. In contrast to the very broad framework of different observation forms we outlined in the first step, this second step puts the emphasis on the micro-mechanisms inherent in innovation processes. The X here has to be found – if at all – in the complex and contingent chains of translations.

2.3 Large-scale projects and innovation in construction

With these insights from recent innovation research in mind, how can we frame the role of large-scale construction projects within innovation processes? When it comes to the micro-mechanisms, innovations are not necessarily supported in project organizations since the reduction of the complexities and contingencies in which novelty unfolds is a key imperative of project management. Project organizations exemplify what Orlikowski/Yates (2002) label "temporal structuring". They involve a definite beginning and an end, as well as a project cycle that is split into different phases and structured through various milestones within which a defined task has to be accomplished. Activities of project members are entrained according to this time

frame in order to reach predefined targets, rather than to venture into uncharted terrain. Against the backdrop of a process-based approach to innovation, projects and project management, it seems, are simply about delivery (and not about innovation).

That is, confronting construction-related literatures on innovation with recent general innovation literature in our view reveals a paradox inherent in the general debates on the role of projects for innovation. On the one hand, there is a large body of literature that acknowledges the increasing importance of "project-based innovation" (e.g. Boltanski and Chiapello, 2005). Projects as specific organizational forms "which involve(s) […] assembling disparate people for relatively short periods of time" (Obstfeld 2017: 2), it seems, are good at boosting innovative (i.e. non-routine) agency. On the other hand, a growing body of work in project management maintains that the more projects have entered the organizational mainstream, the less innovative they can be (e.g. van Marrewijk et al., 2008; Lenfle/Loch, 2010; Davies et al., 2014) as the increasingly formalized management of projects essentially is about holding down complexity.

Project organizations are likely to propel innovations when projects are a temporary exception in an otherwise stable environment. Under these circumstances, projects interrupt routines and open up previous trajectories of organizations or organizational fields (e.g. Garud et al., 2013). Project organizations may also encourage novelty when they exhibit an extraordinary degree of complexity. Complexity is the basic feature of the archetypes of innovative large-scale ventures, e.g. the Manhattan project and the Apollo-Programme (see Sayles and Chandler, 1971; Davies, 2017), and it is also essential for the large construction projects we are looking at here. Maintaining rather than reducing complexity, in fact, seems to be one of the key requirements as to how large-scale projects can spur innovation (Brady/Davies, 2014; Giezen, 2012; Giezen et al., 2015; Davies et al., 2017).

However, also the delivery-driven part of large-scale projects may decisively shape innovation processes when we consider the three different levels on which innovation may materialize (Hutter et al., 2015) – *discourse, practice* and *rules.* In projects, in a way, a translation between these different forms occurs, in two directions. Given the pressure to deliver a tangible result, ideas that circulate in discourses or are inscribed in rules necessarily have to materialize in projects. Project organizations here afford

what Gibbons et al. (1994) refer to as learning “in the context of application”. Equally, practical problems and possible solutions that come up while projects are executed might be translated into discourses and rules.

3. Innovation through iconic architecture? Insights into the ECB new premises and Elbphilharmonie case studies

3.1 Data and methods

The evidence presented here is part of an interdisciplinary research project funded by the senator of academic affairs of the City of Hamburg on “Large-scale projects as innovation drivers in the construction industry”[1]. It is a first, and still tentative, analysis of two structural engineering case studies. In total, we intend to look at six cases of recently completed large-scale construction projects in Germany: two structural engineering, two infrastructural engineering and two mixed projects.

The findings presented here draw on an extensive documentary analysis and of 11 transcripts of interviews with management and technical professionals from the core organizations who were involved in planning and construction of the two cases – the new premises of the European Central Bank in Frankfurt and the Elbphilharmonie in Hamburg. Interviewing is still in progress. The interview plan uses the concept of “project ecology” (e.g. Grabher, 2004) as structuring element. The first round is to identify innovations and focuses on the core organizations of the organizational ecology responsible for the management and delivery of a construction project: the project sponsor (client), the architect, the structural engineer, the principal contractor(s), the project management consultant who supports the client. In the second round, we intend to move further into supply chain and the stakeholder environment in order to follow particular “innovation journeys” (Garud et al., 2011).

The material used here shows a state of interviewing at the overlap of the two rounds. We have not fully completed the interviews with core organizations, but are already able to move on into the relational environment.

[1] Project code LFF FV 56

3.2 The cases: similar conditions, contrasting project trajectories

The examined projects are two of the largest and most prominent structural engineering ventures in Germany of the last decades. Both exhibit similarities (see table 1) when it comes to size and scale of investment; the time span between first ideas and completion (15 to 16 years); a close connection with the history of the site and the future of the surrounding areas. Both have been designed by "global architects" (McNeill, 2009), "strong idea firms" (Coxe et al., 1986; Kloostermann, 2010) with a very clear understanding of what they want and a reputation that allows them to push their ideas through. Both buildings are technically sophisticated – e.g. both structural engineers received awards for the innovativeness of the construction. Finally, both projects essentially contribute to the image of the cities in which they have been built. The new ECB premises strengthen Frankfurt's position as the financial centre of continental Europe, also symbolically. Hamburg's new concert hall paradigmatically "reflect(s) the city's desire to play at the forefront of interurban architectural and cultural competition" (Balke et al., 2018: 998).

Table 1: The case studies – basics

	New Premises ECB	**Elbphilharmonie**
Sponsor:	European Central Bank	City of Hamburg
Building Type:	Landmark High-rise office building, integration of listed wholesale market hall	Landmark concert hall (2 halls) with combined use as a hotel and apartments, on top of 1950s warehouse
Location:	Frankfurt/Main	Hamburg
Responsible Architects:	COOP Himmelb(l)au, Vienna	Herzog & De Meuron, Basel
Entire Project Period:	1st quarter 1998 (plot search) until 4th quarter 2014 (completion)	4th quarter 2001 (first project idea) until 4th quarter 2016 (completion)
Construction Period:	2nd quarter 2010 until 4th quarter 2014	2nd quarter 2007 until 4th quarter 2016
Gross Floor Area:	Around 185,000 m²	Around 125,000 m²
Total cost:	Approx. €1.2b	Approx. €870m

Figures from Förster et al., 2017a; Herzog & de Meuron, 2017

Still, ECB and Elbphilharmonie represent different types of buildings that entail fundamentally different technical and institutional requirements: on the one hand, basically an office building with high security standards, on the other, a concert hall in conjunction with a hotel and luxury apartments. More importantly, though, both cases profoundly diverge with regard to the process of planning and implementation and the way how different players behaved – particularly when it comes to how the project sponsors performed their roles as clients. The ECB proved to be very reflexive and organized, able to control the entire project cycle from the decision to build own premises instead of renting office space, through the location search, architectural competition, procurement and construction to the almost frictionless relocation of almost 2,500 workplaces over four weekends (Studener, 2017). While there was a public debate about the project particularly with regard to the architecture and the way how the architects dealt with the historic building of the wholesale market, the ECB succeeded in professionally managing this, in close collaboration with Frankfurt's city administration. In fact, the European Central Bank came close to what Davies and others (e.g. Davies et al. 2014) refer to as best-practice "intelligent clients".

The City of Hamburg, in complete contrast, rather stumbled into a project that came up through private initiative and gained momentum through the seducing image of a glass structure on top of an old brick warehouse that the Swiss architects Herzog & de Meuron published in 2003. Local politicians and large parts of the city administration almost during the entire project cycle performed in a rather naïve, amateurish and disorganized way. The project produced a comprehensive parliamentary inquiry due to massive cost escalations as well as an almost two-year suspension of construction works. One of the local newspapers accompanied the process as a series – "Insanity, episode 425" (I FHH 1). In fact, the story of Hamburg's new architectural icon very much parallels the "great planning disaster" of Sydney's Opera House that Peter Hall (1982) extensively reports on.

While one could, hence, legitimately describe the planning and implementation process in the ECB-case as client-led, the painful development of Hamburg's new architectural icon was essentially architecture- or design-led, driven by the desire to transform a captivating image into material reality[2]. When it comes to innovations,

[2] see also Tryggestad et al. (2010) for a similar example: Calatrava's turning torso in Malmö that is based on a form orginally designed as a sculpture.

both processes generated novelties that were successfully applied during the realization of the projects and that partly seem to survive after completion – regardless of the fundamental differences in how the processes had evolved. And yet, according to the evidence that we have collected so far, there are some incidences that point to different patterns of innovations depending on how a project was realized.

3.3 ECB new premises: client capabilities, continuity and collaborations

The “best-practice” role of the European Central Bank as project sponsor and construction client was nothing natural. The bank – as a “one-off-project sponsor – strong expertise in monetary policy issues but not in construction” (I ECB1) – had to deliberately build up expertise. The institution mobilized the know-how existing in its existing premises division – previously mainly in charge for refurbishment and management of the rented properties that had accommodated the bank before – and created a ten-people project office outside the bank’s organization matrix. This small core team was supported by an external project management consultancy that employed up to 100 staff in the project (I ECB 2). Membership in the project office remained largely stable over the whole period. The function of the office was essential, not only as it represented the client and user interests in the supply chain. Also, the unit acted like a service provider, catering for the needs of two “clients” (I ECB 1): (a) the ECB and particularly the bank’s decision-making bodies. Here it was decisive “that the bank’s image […] would not be damaged” (I ECB 1) and that decision makers would rely on a sound reporting base; (b) the City of Frankfurt that provided a special permit for a multi-storey building outside the boundaries of the local high-rise plan and that left the listed market hall in the hands of a (public) bank. The city administration therefore had to prove in front of a critical local public that the bank deserved this credit of trust, and the ECB project office – in the bank’s own interest – helped accomplish this task.

Basically, the small ECB-in-house team performed multiple translations within the organizational ecology: e.g. between the construction world and the ECB decision-making bodies; between future users and planning and construction firms; between the involved organizations and the public opinion; between the bank and the

construction supply chain. The project office, it seems, successfully realized these translations mainly for three reasons:

(1) The capabilities of the group members who were selected according to their technical expertise and prior experience in the construction business. Based on these qualifications the group could learn to handle the specific demands of a large-scale endeavour.
(2) The continuity of the team, as well as of other key players in the project ecology. Stability facilitated learning and knowledge management over the entire project cycle.
(3) The collaborative culture among all involved players that both supported mutual learning and facilitated the day-to-day management. This culture was supported by the co-location of nearly all planning functions in a so-called "planners' house" – during the construction period in a container on site (I PM 1; Studener, 2017).

Innovations that took place in such state-of-the-art governance and management context largely revolved around that culture of learning and collaboration and the translations that happened between the different worlds involved: e.g. an exemplary public information strategy in which the ECB transferred its competencies as an institution under permanent public scrutiny into the world of construction (I ECB 1, I PM 1) or an innovative strategy to tackle claim management problems – by postponing conflict solutions to the period after project completion (I PM 1). Thereby suspension of construction works could be avoided and issues were solved with some temporal distance from the actual problem and, hence, in a more tranquil atmosphere. Also technical innovations arose from close collaborations – e.g. between architects and engineers, when the latter deployed parametric design tools to arrange the connecting trusses between the two parts of the high-rise tower (Förster et al., 2017b).

3.4 Elbphilharmonie: challenging geometries and experimentation

While we can describe the ECB project ecology with some justification as essentially based on collaboration and continuity, the opposite is actually the case when it comes to the process of planning and assembling Hamburg's new concert hall. Basically, the realization of the Elbphilharmonie implies an uncompromising

implementation of the radical “design vision” (Boland et al., 2007) that the architects developed. Herzog and de Meuron were asked by a Hamburg-based private developer, a former fellow student, in 2001 whether they would like to design a concert hall within a 1950s warehouse at a prime location within the HafenCity development area. The original plan was a private investment in which luxury private uses (a hotel and apartments) were to subsidize the cultural heart of the building. The architects accepted but suggested to top “the massive brick warehouse […] (with) a crystalline glass structure of similarly block-like density” (Herzog & de Meuron, 2017: 42) that was to accommodate the main functions, and to design a public square in between the two structures, on the roof of the old warehouse.

That was the vision that has eventually been built – as a fully publicly funded and controlled project, though. However, the architects in the beginning did not have a detailed plan about how such a building should materialize. On the contrary, “they set things in motion […] of which they did not know how they would resolve them. […] they had the plan to resolve them […] they had the idea to resolve them” (I FHH 1). It is this learning process sparked by a unique design and driven by the architects’ persistence and determination to build what they had drafted that has been the main source of innovations in the project.

The process resembles what Boland et al. (2007) refer to as “wakes of innovations” that flow through complex project networks triggered by a central force – in the author’s case study this is a combination of Frank Gehry’s “challenging geometries” (ibid.: 643) and the introduction of 3-D digital representation technologies in the architect’s office. In our Elbphilharmonie case these wakes of innovation exhibit three key elements:

(1) “Trials of strength” (Tryggestad et al., 2010) between the architects and those who had to implement their proposals. Generally, the architects had the “burden of proof […] If it’s not the product from the standard catalogue, the initial answer is always: it does not work. And then you have to invest a lot to prove that it does work” (I ARC 1).
(2) Close and direct collaborations between junior architects and specialized subcontractor or material supplier firms. The implementation of non-standard solutions in most cases circumvented the main contractor, looking for “firms

that have an own interest to experiment […] that try hard – with interest and passion – to manage that" (I ARC 2).

(3) Material and virtual objects – e.g. mock-ups, patterns or 3-D models as "trading zones" (Boland et al., 2007), or "boundary objects" (Star and Griesemer, 1989) – that facilitate and structure the "trials of strength" and processes of collaboration and help develop and illustrate possible solutions.

Many of the particular qualities that are now praised as extraordinary achievements of the Elbphilharmonie project – e.g. the spherically curved glass elements in the façade; the inner covering of the main hall made from individually milled and cut high-density gypsum fiberboard slabs – are based on such a "centralized push" (Boland et al., 2007: 643) by Herzog & de Meuron's challenging design and the following experimental process of implementation. The whole construction site resembled an "experimental workshop" with young and ambitious architects closely working with construction firms on how to make this singular piece of architecture become reality (I FHH 1).

That this spirit of experimentation and innovation could be kept up was also owing to a positive contribution of the otherwise disorganized project owner, Hamburg's city administration: a commitment to quality. Basically, this was due to the failure in the other classic project performance indicators: "I always said: we have exceeded cost and time so tremendously that we must not give up our quality ambitions. This was our mantra […] that in the end people say: 'Okay we know where all the money has gone'" (I FHH 1).

3.5 Lesson drawing: project owners vs project based firms

Regardless of the profoundly divergent patterns of management and governance both ECB new premises and Elbphilharmonie produced non-standard solutions for problems that were coming up during the process of planning and construction. Referring to the three "observation forms" (Hutter et al., 2015) of innovation outlined above both projects generated innovations on the level of "pragmatics". But how about the more enduring effects, the lessons that could be transferred to other projects and the repercussion of novelties in the "semantics" and the "grammar" (ibid.) of the construction business? There is plenty of evidence about how the major technical achievements of the Elbphilharmonie project were taken up and praised in

both public and professional discourses. In addition, the structural engineers of both buildings have received awards[3] for the structural design and the buildings were listed among the best architectures in Germany for the respective completion years[4]. That is, an innovative contribution is quite obvious for both projects when it comes to "semantics".

However, a sustainable impact with regard to rule changes and specific lessons that could be transferred into future construction projects is more difficult to assess. Also, the patterns of transfer differ, depending on which of Winch's (2014) three "domains of project organizing" is affected. Given that the project organization itself breaks up after completion, only the permanent domains – *project owners* and *project based firms* – can carry lessons into the post-project period. In our two cases, while both owners had a steep learning curve over the project cycle, their ability to pass experiences on for future projects is limited. For the ECB the construction of new premises was a pure one-off venture. The in-house project office was disbanded – some members returned into the premises division – others retired or went on to do completely different things. None of them capitalized on the expertise obtained in large-scale project management (I ECB 1). The 12 years "50-60 weekly hours" effort not only has been a "once-in-a-lifetime opportunity" to learn and to contribute to a particularly important venture, but also a singular "physical" exertion that is difficult to repeat (I ECB 1). Transfer of experiences happens informally within the professional community, via guided tours through the building that are mainly for professionals, and are carried out by the former heads of the project office, and through a comprehensive publication supported by the ECB, in which the bank's contribution only comprises two out of 40 chapters (Förster et al., 2017a).

The Elbphilharmonie case is on the one hand similar, as the project team in the department of cultural affairs was broken up and spread over the city administration. On the other hand, there was a huge impact precisely through the negative experiences the City of Hamburg had made in terms of cost escalations, suspension of construction works and a six years delay. The interviewees (I PM 2; I FHH 1; I FHH 2) unanimously confirmed that from the project owner perspective there is nothing to learn from the Elbphilharmonie, except that one should act differently in

[3] http://www.building-award.ch/cont/gewinner_buildingaward_2017.html - accessed 14.06.18; https://www.bmu.de/pressemitteilung/deutscher-ingenieurbaupreis-2016-geht-an-das-sturmflutsperrwerk-greifswald-wieck/ - accessed 14.06.18

[4] http://www.dam-online.de/portal/de/Architekturpreise/ - accessed 14.06.18

future projects. Precisely this aspect was taken seriously in the political realm of Hamburg. Parallel to the parliamentary inquiry the city administration developed new guidelines for cost stability in public construction projects (Bürgerschaft 2012) that have been applied since then.

The capacity of the involved project based firms to transfer lessons into follow-up projects is higher, for obvious reasons. However, it seems, there are differences between the architecture firms and other service providers, e.g. structural engineers or project management consultancies. As the "strong-idea firms are defined by their drive to define an innovative architectural design" (Kloostermann, 2010: 68) their learning strategies correspond rather to what Grabher (2004) refers to as a "disruptive learning mode". The architects strive for uniqueness which can by definition not be repeated. "[…] it's important to start new things […] with openness, but also with a certain naivety […]. While experiences are important […] at some point they are also a limitation" (I ARC 2). That is, the lessons drawn in the architects' core business mostly apply to an attitude of curiosity that one should maintain.

This is completely different for those consultants who follow a "cumulative learning mode […] (where) (p)roject organizing is geared towards moving from the singular one-off venture to repeatable solutions" (Grabher, 2004: 1493). Most obviously, this applies to the external project management consultancies. In both cases these firms could draw new products (e.g. a "lean construction management" package (I PM 1)) and new management tools from the projects. In addition, prominent large-scale projects serve well as references for internal training programmes, even (or particularly) when lots of things have gone wrong (I PM 2). In the ECB case, also the structural engineering consultants could follow such a repetitive learning logic. The parametric design for the office tower was further developed into a software package embedded in standard 3-D design software that can be used in future projects (Förster et al., 2017b).

4. Conclusion

The present paper has two starting points: The first is what Ekstedt et al. (1999: 7) call the "renewal paradox" of the construction industry. Construction is a project based business *avant la lettre.* That is, while one of the most traditional industries, it is, in a way, a role model for "neo-industrial organizing". However, unlike it should be

expected for this kind of organizing, construction is not known for a particular innovativeness. On the contrary: “the general circumstances that surround construction activities should make the companies innovative, but the fact is that they are not” (ibid.: 8).

The second starting point is about large-scale construction projects and their potential role in propelling innovation. Looking at recent innovation literatures we have found two conceivable driving forces of innovation inherent in large projects. For one thing, large projects afford the necessary adaptive, relational and temporal complexities (Garud et al., 2016) in which processes of novelty generation and implementation are likely to unfold. For another, large-scale projects exhibit the sufficient size and prominence in order to induce translations of novelty between different levels on which innovation may materialize (Hutter et al., 2015): practice, discourse or rules. New solutions (*practice*) might be acknowledged in the professional *discourse* or change regulations (*rules*). In turn, problems and possible solutions circulating in professional discourses might be implemented in large and prominent projects.

The preliminary findings from the in-depth investigation of two recently built architectural icons in Germany point to a further development of these argumentative starting points, in three directions:

First, it seems, it is not simply size, complexity and prominence that influence innovation processes but also the patterns of collaboration within the project coalitions (and the wider project ecology) responsible for the realization of each building. Our case studies represent fundamentally different coalition patterns: one based on collaboration among equal partners, led by a reflexive and organized client; another one based on a central force that – in a rather uncompromising way – pushes a design vision through, facing a client completely overwhelmed by this force. While both patterns do generate innovations, the nature of these innovations and the process of their generation seems to be noticeably different. It would be worthwhile to follow this line of thinking in further work in order to both corroborate the differences empirically and frame them conceptually more clearly.

Second, particularly the Hamburg case challenges the alleged importance of the client – the “sophisticated business user” (Miller et al., 1995; Winch, 1998) – as driving force of construction innovation. In part, it was precisely the clients’

disorganization that supported – in a non-intended fashion – innovative ideas to be resolutely implemented. It seems, that here Hirschmann's (1967) "principle of the hiding hand" applied, notwithstanding the literally high price the City of Hamburg had to pay. While Hirschmann's arguments are massively under fire in current mega-project research (see Flyvbjerg 2017) it could nevertheless have some value looking at innovation in large-scale projects from his angle.

Third, the dynamics of translation between Hutter et al.'s (2015) different dimensions of innovation is closely connected with the roles of different players in the project ecology and the relational contexts in which they are embedded. Clients – or project owners – at least as long as they do not regularly embark on large-scale construction ventures, only have limited capacities to push innovations beyond the single project. In our cases project based firms are clearly the main vehicles of moving novel solutions to other levels. The way, in which they do this, very much depends on the specific learning modes (Grabher, 2004). The reverse direction, however, also works for client organizations, as they can transfer public discourses – e.g. about cost escalations in large projects – into real-world implementations. Specifying the translation dynamics, then, with regard to different involved players will also be a reasonable undertaking in our future work.

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