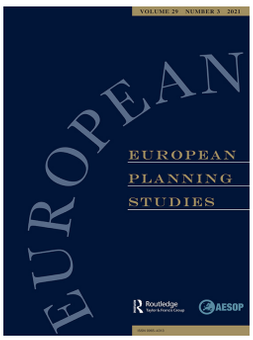

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Exceptional architecture, learning processes, and the contradictory performativity of norms and standards

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ABSTRACT

Large-scale urban projects that make use of exceptional architecture face a number of challenges: namely the scale and complexity of the projects as well as the elevated expectations faced by architectural and engineering firms. Meeting these challenges requires the development and approval of non-standard design and technical solutions. Based on the analysis of four case studies in the German context, we show how the creation of exceptional architecture requires that built environment professionals actively negotiate with established norms and standards in various ways. The learning processes thus enabled are contradictory. On the one hand, knowledge gained in the process of developing innovative solutions remains exclusive and, often, codification and standardization do not occur. On the other hand, in some instances, standards and norms are adapted to inform and guide other projects. In conclusion, this paper argues, norms and standards constitute a contested terrain and are characterized by a contradictory performativity. This paper thus advances wider debates on innovation in the building industry by highlighting the extreme tensions and ambivalent trade-offs that exist between the development of unique and tailor-made solutions for singular buildings and the investment in the standardization of novel products for the built environment.

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Introduction

Exceptional architecture has visibly changed the face of cities around the world in recent decades. Iconic buildings as part of large-scale development projects and culture-led regeneration strategies have attracted public attention and drawn scholarly interest. Research has mainly focused on the impact of such projects in particular realms: aesthetic, socio-economic, and political. Scholars have examined how iconic architecture contributes to cities' efforts of raising their profiles in inter-urban competition (Kaika 2010; Sklair and Gherardi 2012) and securing socio-economic benefits at the city-wide and neighbourhood levels (Plaza 2000; Fuerst, McAllister, and Murray 2011;

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Alaily-Mattar, Dreher, and Thierstein 2018). Research has also provided analysis of how such projects serve to transform public institutions and the wider arena of urban governance (Patterson 2012; Andersen and Røe 2016; Balke, Reuber, and Wood 2017).

Less discussed is how exceptional architecture impacts governance arrangements and the building industry through its *construction processes*. Large-scale urban projects that make use of exceptional architecture to attract attention, to re-shape the built environment and to provide inspiring urban spaces face a number of challenges: the scale and complexity of the projects, their high visibility in the public realm, and the elevated public and professional expectations faced by the architectural and engineering design firms (Flyvbjerg, Bruzelius, and Rothengatter 2003; Broudehoux 2010; Flyvbjerg 2011). To meet these challenges, it is frequently the case that non-standard solutions that have not previously been realized and often exceed existing building regulations have to be developed. In most instances, international celebrity architects are commissioned for such projects. At the same time, the number of firms able to execute such tailor-made solutions is limited due to the specialized expertise and the economic risks involved, which leads to complex contracting and procurement procedures.

This paper explores the agency of built artefacts and their respective construction procedures by analysing the learning processes that occur in the building industry and in local governments when exceptional architecture is realized. We draw on the case studies of four large-scale construction projects in the German context. The construction industry in Germany is characterized by a rigid regulatory framework and an ever-growing number of norms and standards. The case studies analyze how innovation occurred in these large-scale architectural projects and in this specific regulatory context. The empirical analysis of this paper is based on the in-depth examination of 46 interviews. These interviews were conducted with professionals from both the design and execution phases, as well as with representatives of clients, of various public authorities, and of testing and research institutes. The projects selected for analysis in this paper include two high-rise structures (the Elbe Philharmonic Hall in Hamburg and the office tower of the European Bank in Frankfurt) and two hybrid infrastructure projects (the Berlin Central Station and the Wehrhahn underground rapid transit line in Düsseldorf).[1] Here, we examine the learning processes that facilitated the development and implementation of innovative solutions in these projects as well as their wider impact on market structures, regulatory frameworks, and governance arrangements in planning, design and construction. We examine how the challenge of constructing exceptional architectural projects in Germany is related to the performativity of standards and norms and ask what is learned from that analysis in terms of improving standard processes; additionally, we explore norm-making and the interaction between the different actors involved in the exceptional architecture construction process.

Our findings indicate that a key challenge for the respective authorities during project execution was dealing with exceptional circumstances and tailor-made solutions that transgressed established regulations and protocols. This was particularly relevant due to the specificity of the rigid and bureaucratic German regulatory context. For the professionals and subcontracted firms, dealing with restrictive norms and standards is, as we show in this paper, not only a matter of solving technical issues; crucially, it depends on social and collaborative learning processes. We demonstrate how – for the professionals and firms involved – these learning processes included negotiating and weighing

technical matters, economic interests, professional ethos, time constraints, and public expectations against each other; within one and the same project, we found different alliances of project-actors dealing with norms and standards more or less productively. Thus, our main argument contends that norms and standards constitute a contested terrain and are characterized by contradictory performativity which must be carefully taken into account when assessing the transformative effects of exceptional architecture.

The analysis has significant implications beyond the German context. Our findings can be conceptualized as lessons for built environment professionals, as well as for public authorities, when facing the challenges of developing and constructing exceptional architectural projects. Moreover, the building industry is challenged, more generally, to develop innovative solutions and conceive of novel strategies to reduce carbon emissions, energy consumption and resource use related to the urban built environment in the face of climate change. This raises pertinent questions around the ways in which building norms and standards either allow for change and innovation or restrict it (Cass and Shove 2018; Shove 2018; O'Neill and Gibbs 2020). This paper advances the debate by highlighting the extreme tensions and ambivalent trade-offs existing between the development of unique and tailor-made solutions for singular buildings on the one hand, and investment in the standardization of novel products for the built environment on the other.

Thus, the first section of this paper discusses the role of norms and standards from a social science perspective and provides a conceptual framework for analyzing learning processes in design and construction. The second section contains two parts: the first discusses the productive potentials of building norms in generating and fostering innovation, while the second part focuses on the related adverse effects. The third section analyzes the resulting contradictory learning processes through the discussion of micro-moments of learning and unlearning. The conclusion highlights the wider implications for both the building industry and for urban societies at large.

Norms and standards in the production and governance of urban space

Standards and norms as regulatory tools have been much discussed in academic discourse (Bowker and Star 2000; Ponte, Gibbon, and Vestergaard 2011). Historically, standardization was constitutive of the emergence of modern statecraft; thus state projects aimed for legibility and simplification to bring order to nature, space and society (Scott 1998). Today, we find complex processes of re-regulation, in which national legally binding norms and standards are integrated within a wider body of transnational regulatory mechanisms (Djelic and Sahlin-Andersson 2006; Loconto and Busch 2010). The latter are particularly related to sustainability certification and green standards (Dingwerth and Pattberg 2009; Ponte and Cheyns 2013). Scholars have emphasized that, most fundamentally, norms and standards are characterized by their 'capacity to enhance coordination' (Botzem and Dobusch 2012, 737). Norms and standards thus create common frames of reference for firms and interpersonal networks of professionals. Yet scholars have also highlighted that norms and standards are power-laden vehicles of governance. Political choices will inevitably become inscribed into standard practices, 'embedding and concealing the politics in the process' (Fortin 2018, 809). This allows insiders to gain strategic advantages, as a standard 'valorizes some point of

view and silences another' (Bowker and Star 2000, 5). This selectivity, however, frequently remains opaque, as standards rely on objectifying and normalizing the regulatory requirements that are inscribed into them.

Today, the production and governance of urban space is increasingly influenced by various forms of more or less-binding regulations. This is complemented by the expansion of contractual forms of governance, particularly through procurement strategies for project delivery in urban development (Raco 2014; Grubbauer and Čamprag 2018). Standards and norms play a central role in these developments. Alongside recognized norms with legal status, such as the German DIN (German Institute for Standardization), the British BSI (British Standards Institution) or the international ISO (International Organization for Standardization), a growing number of non-binding market standards, such as BREEAM, LEED, or DGNB, work as potent mechanisms of transnational, private regulation (Schweber 2013; Faulconbridge and Yalciner 2015). These voluntary certification systems both facilitate global investment by fostering market transparency and help to involve private corporate actors in the governance of urban space. However, also the legally-binding norms such as the German DIN are decisively shaped by market actors' economic interests as well as by alliances between industry and political actors. Industry has a vital interest in securing the growth of its markets by influencing standards and norms through standard-setting and various lobby organizations (Grubbauer 2015). The specificity of standards and norms related to urban space and construction processes lies in the fact that the product (in terms of the built object or structure) will always be unique, localized, and immobile (Ben-Joseph 2005; Imrie and Street 2009); this is even more crucial in the case of exceptional and ambitious architecture projects: these seek to distinguish themselves through innovative solutions which tend to transgress established norms and standards.

To conceptualize the learning processes involved in negotiating standards and norms in the production of the built environment, we rely on two strands of work. The first is work within the field of economic geography and organization studies that has emphasized the experiential dimension of knowledge and learning, in contrast to codified forms of knowledge (Lundvall 1996; Gertler 2003). We follow arguments for practice-based understanding of knowledge, which emphasizes know-how and learning-by-doing based on embodiment, practical action, and social interaction (Amin and Cohendet 2004; Martin and Moodysson 2011; Vallance 2011). This focus on learning as a socially embedded process, often organized in 'communities of practice' (Wenger 1998), has particularly advanced the understanding of the social interaction of built environment professionals and the crucial role of transnational professional networks (Heeg and Bitterer 2015). Even though proximity and access to the building site inevitably define the working practices in the building industry, built environment professionals have developed various methods to enable working across distances and beyond local communities of practice, particularly through 'models, texts, and photographs, alongside travel that allows architects themselves to circulate, perforate scales, and learn from nonhumans' (Faulconbridge 2010, 2855).

The second body of work that we draw on concerns innovation in construction from a social science perspective. Traditionally, the construction industry has been considered to hold little insight for innovation research due to its alleged lack of innovativeness (Reichstein, Salter, and Gann 2005; Butzin and Rehfeld 2013). Yet social science studies have also shown that design and construction are strongly characterized by

inter-organizational collaboration and distributed innovations (Harty 2005; Whyte and Sexton 2011). This has led to claims about rethinking 'common assumptions that innovation always takes place within coherent and unilateral landscapes' (Harty 2008, 1032). More recently, the construction industry's capacity to generate novelty has been discussed in 'a more comprehensive and pluralistic fashion' (Thiel, Dimitrova, and Ruge 2021, 11). Similarly, Ingemansson Havenvid et al. suggest that innovation in construction is situated 'across *an inter-organisational landscape* that includes *interaction* processes within and between both permanent (i.e. firms) and temporary organizations (i.e. projects)' (2019b, 5, emphasis in original). This has significant impact on learning processes and leads to the generation of highly diverse types of knowledge, including technical, social, and aesthetic (ibid.). Moreover, what is specific is that the generated knowledge is often bound up with material artefacts that allow professionals across disciplines and sectors shared understanding and collaborative problem solving (Ewenstein and Whyte 2009).

In summation, social science debates have put emphasis on the organizational and political dimensions of norms and standards. They provide valuable insights into the deeply political character of norms and standards, their selectivity and their implicit mode of regulating professional practice in different fields. However, Botzem and Dobusch note that standards 'only become authoritative rules under certain conditions that need further specification' (2012, 738). Specifically for the production of the built environment, we lack an in-depth understanding of the performativity of norms and standards as well as evidence of how standards and norms as codified rules either foster innovative solutions or constrain them. Recent research into the growing field of sustainability-related norms and standards in the building industry reveals how their effects have, up to now, been very mixed and can even lead to higher energy demands (Faulconbridge, Cass, and Connaughton 2018; Shove 2018; O'Neill and Gibbs 2020). In the case of speculative office developments, Cass and Shove (2018) show how market standards limit professional activity and rule out more sustainable alternatives through 'over' specification. They argue that market standards can thus 'impede innovation where 'risk free' and 'tried and tested' strategies are preferred' (2018, 276). Yet apart from these seminal studies, little empirical work is being conducted on the specific ways in which the authority of norms and standards is negotiated in practice or in productive or less productive ways. There is likewise a lack of empirical work on how this in turn shapes professional fields at large and potentially transforms governance arrangements related to the production of urban space (but see Schweber 2013). We provide empirical insights into these issues in the following two sections and discuss the implications in the conclusion.

Productive versus adverse effects of norms and standards in fostering innovation

According to professional discourse, the innovative potential of European architecture has decreased significantly over the last 40 years, not least because of rigid regulations (Sohar and Thill 2020). The growing significance of norms and standards impacts working practices within the building industry, as well as the way tasks, responsibilities and authority are distributed between built environment professionals (Fischer and Guy 2009). In Germany alone, the number of norms has quadrupled since the 1990s (Lütke

Daldrup, Oswalt, and Enders 2018). In the following analysis we examine how this increasing rigidity and growing number of norms and standards impacts professional practice within the construction industry, the interaction and collaboration between the different actors engaging in large scale construction, and subsequently the making of exceptional architecture. We highlight the collaboration between different built environment professionals across phases and disciplines (e.g. architects, structural engineers, builders and subcontractors) as well as between representatives of planning authorities and public administration (often assuming the role of the client).

The productive capacity of restrictive regulatory frameworks

Paradoxically, the restrictive character of building norms that largely defines the German construction industry can be mobilized in a highly creative fashion in the course of making exceptional architecture. The desire to realize architecture characterized by ambitious designs, custom solutions and non-standard elements motivates built environment professionals (across disciplines, project phases and sectors) to search for a way to 'work around' the existing norms, in order to push the 'boundaries of feasibility' *(C1_Arch_1)*. Across the four different case studies, interview partners referred on numerous occasions to some of the 'loopholes' and 'grey zones' inherent to existing regulatory frameworks.

The most relevant and frequently enacted mechanism of circumventing norms is the so-called 'individual approval' (German: *Zustimmung im Einzelfall*) which enables the implementation of unique and tailor-made elements and solutions. Yet this type of temporary approval is valid for a mere two years, and only in the specific setting of the respective project. Thus, as described by one of the executing architects representing the main contractor of the Elbe Philharmonic Hall, individual approvals are enacted as 'temporary bridges' between existing and new norms. They potentially facilitate the development and utilization of new products and construction elements until those are officially regulated and thus receive long-term codification.

As argued by some of the subcontracted firms, particularly in the German context, exceptional and design-ambitious architecture can generally only be executed by means of such individual approvals. Professionals in charge of highly complex design solutions (e.g. the curved glass façade of the Elbe Philharmonic Hall, Figure 1) perceived this as a positive development that needs further encouragement from authorities and the construction industry:

> It is a burden, but […] I think for me it is […] the right direction. I think far too little is done for special solutions. […] [I]ndividual approvals are becoming more effective again. [Which] I personally find very good, as I think a lot of problems need a special solution. (C1_Arch_5)

In the process of obtaining individual approvals, the feasibility of innovative solutions and newly developed products needs to be proven by the execution firms, who are supported by architectural and engineering ones. The process requires intensive interaction and collaboration across design and construction phases. In strictly technical terms, proof of feasibility is achieved by conducting numerous tests, trials and experiments, and is inherently interwoven with the material building processes. Yet professionals

Figure 1. The innovative glass panels for the curved façade of the Elbe Philharmonic Hall, which required, among other things, the development of new glass specifications. © Stephan Liebl.

across different case studies have argued that this process also involves discursive strategies of assertion, persuasion and justification, as (especially well-respected and experienced) professionals seek to influence and convince sceptical reviewers and testing engineers:

> And of course the engineers working in the technical department of the [r]ailways are rather conservative, so […] it was extremely difficult to convince them, meaning that [there] also [need to be] extremely elaborate experiments to get something like that through. (C3_Eng_1)

Furthermore, as described by one of the planning engineers specializing in glass façade development, professionals can gain authority over the process of approval by claiming the right to identify and eventually allocate the appropriate expert for the respective reviewing process:

> Yes, I know how you can achieve such approvals, how the whole procedure works. […] you can achieve something like this through the expert reports from […] professors, mostly professors that you know, [who know] how you can achieve something like this, so that it works, and finally that you can support it through tests with building components and then go to the authorities with the results of the component tests. (C1_Eng_5)

Besides the obvious (and clearly defined) way of bypassing regulations via individual approvals, there are also many other smaller productive practices of challenging the objectifying and normalizing power of regulatory frameworks. These build on active engagement with building norms, trying to adapt, adjust and rearrange them and to translate them into new and productive possibilities:

> So that one just follows it and then says, now I reach the boundaries of the regulations and knead those a little bit and change them, so that I can still cope with the design construction and have then a little less comfort within the driving dynamics. (C5_Eng_4)

The constraining capacity of norms and regulations

Any deviation from existing building norms requires demonstrating the technical feasibility and the safety of new and customized building elements and solutions. The experiments, tests, and simulations necessary to deliver the required 'proof of concept' are usually extremely time, cost and effort consuming. Across the different case studies, architects and engineers described this process as 'painstaking' and 'terribly difficult' (C1_Eng_5), as an 'extreme burden' (C1_Arch_4) that could potentially result in 'more costs, maybe also longer planning phases and thus again other costs that otherwise would not have been necessary' (C5_Arch_1). Facing these challenges, risk-averse clients are usually eager to avoid any deviation from standard procedures, despite high aesthetic and technical demands:

> Originally, we were actually […] allowed to work only with regulated building components. This was the vision of the client in the beginning. And then it became very, very quickly clear that this won't work, as we had such high requirements. (C5_Arch_2)

Often, resistance against such lengthy approval processes also comes from the construction industry itself, more specifically from execution firms. Subcontractors are often discouraged by the high levels of economic risk inherent in such processes. Combined with the fear of legal consequences,[2] this discourages many firms from taking on full liability for the execution of custom-made and atypical products and solutions:

> [One must] always negotiate that there could be some irregularities and a [gap] because it deviates from the normal […] guideline in the usual construction. If there is a gap, or unevenness, there is a deduction from the final invoice […]. That is why many companies are afraid [and say], 'We won't do that. We will do it only if it is polished, because only then we can guarantee that everything is smooth [according to the norm].' (C1_Arch_2)

Additionally, the process of obtaining individual approval is often perceived as unrewarding due to the temporary nature of the approval. This implies that approval cannot be transferred to comparable projects. As described by one of the testing engineers, approvals in individual cases are 'strictly speaking not an innovation, as they won't be pursued. It usually stays with this one-time solution, designated for just one specific purpose' (C1_Eng_4). The procedures required to transform these approvals into permanent permissions are equally lengthy and costly, and success is not guaranteed. Also, codification of one-off novel products and solutions is rarely considered sensible, according to the interviewees and especially to those who are main contractors. In their view, buildings, especially those characterized by exceptional design, are always unique and localized items (see Ben-Joseph 2005; Imrie and Street 2009), and thus specific tailor-made solutions must be newly conceived for every project.

Such rigidities, hurdles, and strains make the processes of obtaining individual approvals and of working around norms highly restrictive and exclusive. Such processes need to be actively pushed for by (a broad network of) actors, who have incentive (often an economic interest and/or the ambition to receive symbolic recognition) for delivering high-quality design and technical solutions. Yet few architectural, engineering and executing firms have the capacity to engage with the related challenges (described by one engineer as 'battle') that occur when 'one deviates from the usual path' (C2_Eng_4). The reputation and authority of the architects often play central roles in

initiating, building support and pushing for novel solutions and products. However, the subcontracted firms, with their highly specialized knowledge and skills, can also make decisive contributions. Project architects often associated these subcontractors' capabilities with a specific mind-set comprised of grit and willingness to face risks, or, as described by one interviewee, the motivation to 'solve a small riddle or to develop a complicated thing […] and not only standard projects on a square meter basis' (C1_Arch_1). Thus, to overcome the constraining capacities of building norms and regulatory frameworks, a broad range of resources (financial among them) need to be mobilized to allow firms and professionals to invest time and effort in such processes.

Ambiguous learning processes

As shown in the previous section, norms and standards are characterized by a contradictory performativity – on the one hand, they decisively restrict the scope of action taken by architects, engineers and subcontractors; on the other hand, these norms and standards provide loopholes and can motivate firms and professionals to work around or even bypass rigid regulatory frameworks. In both cases, we find learning processes that stretch across sectors, disciplines and, potentially, beyond any single given project. This confirms recent discourse surrounding the connectivity of construction actors and the collaborative character of work for understanding how innovation takes place in construction (Whyte and Sexton 2011; Ingemansson Havenvid et al. 2019a).

Facilitating learning in the industry and in public authorities as clients

The development and actual execution of exceptional architecture, as defined by innovative design and engineering solutions, was perceived by numerous interview partners across disciplines as an important contribution to the existing built environment. In the opinion of these actors, dealing with the restrictions and challenges posed by a rigid regulatory framework played a key role in the process of creating new references and initiating learning processes with the potential to re-shape the construction industry's routinized ways (Table 1).

First, learning occurred through collaboratively delivering haptic objects that testified to the feasibility of novel solutions. These objects included various kinds of models, test products, prototypes and mock-ups (Figure 2). Such material artefacts serve as proven references and enable professionals and firms to scrutinize and potentially achieve a long-term adaptation of existing norms (Figure 3), for instance by the issuance of permanent permissions:

> That is why new references are needed every now and then to shape a context in which one can make certain judgements or certain decisions. That means, probably, in ten years, there will be a guideline for assessing the visual quality of double-glazed, multi-printed, spherically curved panes. Maybe? (C1_Eng_6)

Considering that knowledge is based on embodiment and practical action (Amin and Cohendet 2004), the actual making of new products and solutions can support professionals and firms in learning how to undertake and execute more ambitious tasks.

Table 1. (Micro-)moments of facilitating learning.

Type of project	*Challenge*	*Means*	*Collaborations*	*Geography*	*Outcomes/Learning processes*
High-rise structure	***Lack of standardization and specifications*** for a curved glass façade (materials and products that still have not been developed/ are not certified for the market) (see Figure 1)	Embodied process, relying on a variety of artefacts; subcontractors need to acquire new tools (e.g. furnace) as well conduct a set of experiments and simulations at different locations; initiation of numerous individual approvals	Industry (a wide range of subcontractors, specializing in glass production) – façade engineers (as planners) – architects (design) – universities /research institutes	Spanning between the architects' office, research laboratory, workshop/atelier of the subcontractor and the construction site	Knowledge is generated amongst a wide range of specialized executing firms; not yet integrated in norms but can be utilized in future projects and for development of new norms and glass specifications
Infrastructural project	Identifying the best qualified project partners due to the restrictive ***allocating and bidding processes*** (see Figure 2)	Developing and building samples and mock-ups in advance, before the official commissioning of subcontractors, and presenting those to the client (in secrecy, without public announcement)	Planners (architects, engineers, artists etc.) – sub/contractors – clients (e.g. public administration)	Spanning between different artists' ateliers, firms' workshops and construction site (where results were presented)	Planning and executing firms: learning through the making of mock-ups; gaining crucial knowledge for the actual execution of the project Public administration: adapting existing procurement processes; setting focus on quality instead of cost efficiency in the commissioning
Infrastructural project	***Lack of regulatory framework*** for the execution of vertical and overhead glazing (see Figure 4)	Developing and conducting a number of specific experiments; considering numerous factors, including the probability of the glass breaking or failing, as well as how to clean and maintain the glass surfaces and how to integrate photovoltaic cells	Test engineers and surveyors, on behalf of the federal (e.g. railway) authorities	Research laboratories and workshops	Nowadays vertical and overhead glazing are standard products based on specific norms, as are the different testing methods used
High-rise structure	***Developing wall cladding*** with high acoustic qualities that conforms to safety regulations for public buildings (see Figure 3)	Conducting tests and simulations; developing new types of plaster; acquiring new digital tools (to programme algorithms) and machines (CNC cutter); building a 1:10 model to test acoustic qualities	Industry (manufacturers, large and middle-sized firms) – acoustic engineers and architects	Various workshops	A new material has been integrated in the product catalogue of one of the firms

Figure 2. Developing mock-ups in advance for the new underground rapid transit line in Düsseldorf, which served to identify the best qualified project partners. © Ingo Lammert.

Figure 3. First time execution of vertical and overhead glazing in Germany at Berlin Central Station, which presupposed the development of new regulatory frameworks. © schlaich bergermann partner.

Moreover, project architects emphasized the capacity of exceptional architecture in its role as a reference for advancing 'building culture' as a whole. In this context, material artefacts can serve as proofs for 'what it needs so that something special can come out of it' (C1_Arch_2). Such novel solutions, whether temporal or codified, are often testbeds for future development and thus facilitate learning processes independently from the

respective projects. For instance, in the case of the new underground rapid transit line in Düsseldorf, ambitious design visions and aesthetic requirements led to the development of a new type of translucent concrete. In the case of the Elbe Philharmonic Hall, a new type of plasterboard with high acoustic qualities was developed for the wall cladding (Figure 4) and is now offered as a standard product.[3]

Second, productive learning occurs when the knowledge and experience gained are translated into standardized products. In this process, the subcontracted execution firms especially developed a wide range of new skills and expertise (often concerning work with digital tools, software programmes and 3D models), acquired new machines (e.g. furnaces for glass bending and CNC machines), and revised and adapted their working routines as a result. For some of these highly specialized firms – usually family-owned, medium-sized, and situated in Southern Germany – the knowledge gained secured them competitive advantages. To secure long-term benefits from one-off investments, these firms were often willing to standardize or patent one-off solutions:

> I take the risk. […] And now I can offer something completely different [in bidding processes]. That is the case. There are now standard construction projects […] in which I can participate for a reasonable cost. And then I can […] provide very complicated solutions for very low process. (C2_Supp_2)

Third, learning processes in the making of exceptional architecture also extend to the client. As emphasized by professionals across disciplines and sectors, the complex processes involved in developing novel design and engineering solutions require a very specific setting that usually can be shaped in a productive manner by the client. This relies crucially on the client's willingness to provide planners and builders with sufficient resources as well as scope of action for conducting elaborate detail and execution planning, tests, trials and experiments:

Figure 4. The processing of the innovative acoustic panels for the Elbe Philharmonic Hall, for which Hasenkopf Industrie Manufaktur GmbH was commissioned. © Christian Höhn | www.hasenkopf.de.

> Creativity and innovation, for that I have to have the freedom to think and for that I simply need the boundary conditions […] also with the client; we are not supposed to be against each other. If that is the case, then I'm not creative. (C5_Eng_1)

A crucial factor in helping clients create a productive setting for novel solutions involves existing protocols in project management, most prominently including eligibility criteria in tender and allocation processes. For instance, learning from (negative) experiences during the development of a new underground rapid transit line, the City of Düsseldorf adapted allocation regulations to prioritize the consideration of qualitative parameters beyond mere costs, such as firms' qualifications, references and proposed concepts. Another factor that clients can influence relates to the division of tasks between planning and executing firms. Most clearly visible in the cases of Düsseldorf and Hamburg, consultation with experts about the feasibility of potential solutions needed to take place before the official allocation of the respective executions firms. This contradicts procurement regulations, yet is essential for securing high quality execution:

> There are no such materials, no such colors, no such constructions. […] So that we don't fail at the end […] we first built samples, mock-ups, one-to-one in a disused subway tunnel. […] [All] the […] samples [costed] €3,000. A lot of money. But as I said, this knowledge advantage that we had achieved three years earlier […] was ultimately what saved the execution phase. (C5_Eng_2)

In summation, creatively tackling the challenges posed by regulatory frameworks: generates expertise within firms and is bound up with the involved professionals; provides important references to the whole industry; and allows, particularly, clients who are public authorities to gain experience in productively organizing collaboration and interaction between built environment professionals.

Hindering learning and knowledge transfer beyond individual projects

The rigidity of regulatory frameworks and the complexity of approval and issuing processes can, however, also restrain learning processes and hamper the transfer of the knowledge and expertise gained. Most importantly, regulatory frameworks strictly predefine the scope of actions that can be taken by planners and subcontractors, including their methods, practices and working approaches, as well as the choice of possible materials, products and building elements. Learning processes are thus hindered in several ways (see also Table 2).

First, the time-consuming and costly processes of gaining individual approval and permanent codification favour large and renowned firms. Hereby, when the codification of novel solutions is not pursued, the generated knowledge often remains within the scope of certain actors, thus hampering learning processes. As a result, a small number of firms worldwide have gained oligopoly over certain fields and domains of construction, most prominently in the glass façade industry:

> Yes, I mean the firm […] today has more knowledge about curved glass […] than what others can get from the specialized literature. And it is the same with the façade firms that produced the glass. […] But we are the contractor, we get the knowledge. What happened where? […] That means we followed very meticulously all the processes in all the subcontracted firms. Also, in the administration offices, in the engineering firms, and so on. (C1_Supp_1)

Table 2. (Micro-)moments of hindering learning.

Type of project	*Challenge*	*Means*	*Outcomes/Learning processes*
High-rise structure	***Identifying potential firms*** willing to execute the curved glass façade	Two firms proved unwilling to take on the challenge of developing non-standardized glass products, considering the task too risky, as well as due to the rigidity of regulatory frameworks – in result, unwilling to acquire the needed equipment and adopt the respective skills	Specialized knowledge in glass making is concentrated in a small number of firms; Long-term impact on the professional culture and working practices of certain firms (risk-averse), and thus on the built and urban environment
Infrastructural project	***Transferring specific solutions*** to new projects – individual approvals are property of the respective client/project owner	Built solutions that have yet not been standardized cannot be used as a reference/proof of feasibility for future projects	Experiments and tests need to be conducted anew, which is time-, cost- and effort-consuming

Such firms gain even more authority and visibility in the context of exceptional architectural projects, as they enter partnerships with leading architects and engineers who can potentially influence allocating processes. The restrictive and exclusive character of norms and standards can thus, paradoxically, generate new forms of intra- and trans-organizational interaction between built environment professionals (Harty 2005). This potentially re-shapes how communities of practice are organized and enacted within construction projects.

The codification of novel products and technologies does not necessarily guarantee their uptake by the wider industry. The issuing of patents and the standardization of solutions can potentially reinforce the authority and exclusive control of certain actors over specialized fields of expertise. As argued by one of the interviewed planning engineers, when one 'patents stuff […] then it will never be built again. And that is not the point' (C2_Eng_4). Yet paradoxically, taking control of regulation processes can also be highly rewarding for firms and organizations. Large, international planning and execution firms often engage in the development of new norms and standards themselves to secure competitive advantages:

> The problem, that one does not expect, is that these big firms are hiring people that take care only of standardization, especially in the UK. […] That means [they] promote increasingly complicated norms. And that's how they get rid of the small offices. (C1_Eng_4)

A second factor that hampers learning processes is that specific one-time solutions in the form of individual approvals are property not of the firms that issued and obtained the respective approval but of the client who authorized the process. Thus, besides the construction industry and standards-setting institutes, public authorities and state-owned organizations as clients participate actively in the re-shaping and adjustment of regulatory frameworks. As evident, for instance, in the case of the Berlin Central Station, this can potentially hamper knowledge transfer and learning processes due to these actors having little interest in sharing their knowledge:

> If the German [r]ailways obtain an approval in [an] individual case, then [it] is property of the German [r]ailways. Even if I have been involved as a planner, I cannot go to the client and [tell] them, 'Look here, take this for instance, then you have it easier.' (C3_Eng_2)

This suggests that the norms and standards that impact the making of the built environment vary in scope and scale – building norms and regulations can be defined and altered not only by public authorities and standard-setting institutes but also by public institutions and private firms as clients.

Third, learning processes are undermined more broadly as firms seek to evade the rigidity and restrictive character of building regulations in Germany by shifting their activities to international markets. This has, to a certain extent, redefined the landscape of firms within Germany, especially regarding specialized executing firms and most clearly in the glass industry. Ambitious firms, willing to distinguish themselves through innovative solutions, can explore experiments with exceptional architecture much more easily when operating internationally (mainly in the USA and Asia):

> In construction […] the way of thinking is simply different. [I]n Germany it's [still] not [even] possible today to use glued glass panels. Which […] in Japan, Hong Kong is not a problem. And a lot is happening there. Firms like X […] or the firm X, they certainly

> always push the market, but that has a lot to do with what responsibilities they have. (C1_Arch_5)

Thus, as is emphasized by structural and executing engineers, the decreasing interest in ambitious, innovative and yet expensive buildings has led to the shrinking of executing firms specializing in complex engineering solutions, and potentially to the loss of a culture of innovation in the German context. Yet not only firms but also nation states, cities and public administrations in their role as clients and owners lack this kind of *know-how*. This means they are required to deal productively with building regulations and handle the challenges that emerge throughout ambitious projects. Across the case studies, project actors emphasized that such ambitious endeavours need 'strong clients', who are willing to acquire, provide and secure the needed expertise for undertaking such challenges.

Conclusion

In the German context, the processes of executing large-scale projects that incorporate exceptional architectural objects are crucially defined by the contradiction between the restrictive nature of regulatory frameworks and strategies for minimizing economic risks on the one side, and, on the other side, by the ambition to transgress established norms and standards and receive recognition for symbolic and aesthetic value. Yet, actively negotiating building norms and regulatory frameworks is usually a highly time- and effort-consuming endeavour for all actors involved, and thus can contribute to significant cost increases. The resulting solutions and the knowledge generated in this process, however, are often limited to application on one specific project and not replicable. Additionally, professionals need a project setting that not only enables collaboration between different professional cultures but also provides for enlarged scope of action based on client willingness to deal creatively with allocation, procurement and project management.

Our findings reveal that in the German context the learning processes in the execution of exceptional architecture are crucially shaped by the active negotiation of restrictions and constraints posed by building norms and other regulatory mechanisms. While the general assumption is that global markets rely on norms and standards to 'specify and justify […] how those involved in the network should operate' (Bartley and Smith, 2010, 348), a contrasting picture emerges in our case. The actors involved are challenged to channel their investment incentives and resources into *working around* norms and standards and into developing one-off solutions. This is enabled by social interaction and physical working presence at construction sites and in workshops, and based on active engagement with material artefacts. This focus on work-arounds results in creative ways of overcoming, circumventing or even bypassing particular norms, standards and established procedures. Such a way of working fundamentally differs from standard processes with regard to other spheres of production and consumption in which products and services are made to be comparable and, to a certain extent, also interchangeable (Lampland and Star 2009; Thévenot 2009).

The resulting learning processes are thus highly contradictory. First, this contradiction relates to the profits and the actual knowledge gained from the development of new products: these remain highly exclusive and allow key actors to gain a monopoly on certain products; while at the same time this profit and knowledge seem to remain underused

and do not receive recognition or acceptance because of the lengthy and costly processes of certification and standardization. Second, contradictory learning processes also become visible in the relationships between general contractors and subcontractors. Standardization has a greater advantage for more specialized firms, who gain specific knowledge of the product development processes. In contrast, main contractors are less likely to secure this advantage and will tend to be risk-averse, as they carry the full legal liability for the projects. Finally, differentiated learning processes also shape relations between the celebrity architects and their local partners who assume legal responsibility but remain mostly invisible to the public (Faulconbridge 2009). Despite their prestige, celebrity architects lack crucial knowledge about local contexts, and thus cannot 'design an architecturally conceived totality' (Ahuja, Nikolova, and Clegg 2017, 5). There appears to be a growing dependence upon local architects, who, due to their intimate knowledge of local regulatory frameworks, play a key role in opening loopholes, working around norms and achieving building approval.

In summation, norms and standards play a deeply ambivalent role in the processes of executing exceptional architecture: on the one hand, they foster creative practices and a productive learning-by-doing environment as well as encourage the exploration of hidden loopholes with the potential to generate novelty. On the other hand, norms and standards in the German context clearly constrain the creativity of architects and engineers and serve to make innovative solutions highly exclusive. In fact, interviewees held the view that one-off solutions would often be *too* specific to be worth codifying. This ambivalent assessment reflects the unique nature of the construction industry and bolsters the critique of simplistic accounts of innovation and technology uptake in construction that assume innovation will automatically lead to codification, and codification to standardization (see also Cass and Shove 2018). We have shown in this paper that the objectives behind the *setting* of norms and standards, the *negotiation* of norms and standards in professional practices, and ensuing processes of *standardization* need not be aligned and can have contradictory effects in guiding the decision-making of built environment professionals. As the construction industry is urgently challenged to respond to climate change and sustainability issues with novel solutions, further research, which engages conceptually and empirically with these contradictions and scrutinizes the ambivalent role of norms and standards in generating and distributing innovation in the production of the built environment, is needed.

Notes

1. The case studies have been conducted as a part of a large interdisciplinary research project on 'Large-scale projects as innovation drivers in the construction industry', funded by the City of Hamburg over a period of 3.5 years.
2. Interview partners emphasized the growing influence of legal aspects in construction projects, as well as the increasing presence of lawyers in project meetings between clients, architects, engineers and subcontractors.
3. The processing of this new type of plasterboard into acoustic panels proved challenging. It was conducted by the middle-sized family company *Hasenkopf Industrie Manufaktur* based in Southern Germany, specializing in the processing of innovative building materials and with more than 55 years of expertise in the making of unique elements as well as series production.

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