FORGET THE RULES AND INNOVATE: CONTESTING A MYOPIC VIEW ON THE IMPACT OF RULES ON INNOVATION

Léon olde Scholtenhuis[1] and André G. Doree

Department of Construction Management and Engineering, Faculty of Engineering Technology, University of Twente, Drienerlolaan 5 7500 AE Enschede, the Netherlands

A persisting stance in practice is that obliteration of rules creates innovation paradise. Although it seems tempting, this view neglects that regulations may also constructively support innovation adoption processes. To stress these different roles that exist between regulation and innovation, scholars call for a careful empirical analysis of innovation contexts. Recent CM case studies, therefore, explore how standards emerge in new practices. Despite this, however, literature limitedly addresses the dynamic nature of the innovation context itself. This study, therefore, investigates how interactions between regulation contexts and innovation systems change during different innovation adoption phases. We explore this interaction by analysing two innovation trajectories: the Dutch Utility Information Exchange system and the Ground Penetrating Radar. During this desk study, we identified key innovation stages, standards and regulations; categorized these; and, allocated them to different product lifecycle phases. Outcomes reject the 'obliterate rules' stance and confirm the stabilizing role of rules in later innovation stages. To better understand the role and impact of rules on innovation we urge CM researchers to concentrate on the dynamic role that standards and rules have during innovation processes, rather focussing on their static impact only.

Keywords: regulations, rules, standards, innovation, coordination

INTRODUCTION

Promising construction technologies and methods entering the construction arena become embraced by early adopters (Rogers 2010) who aim to improve their work practices. To develop their sector further, these pioneers need to coordinate the behaviour of other stakeholders. Initially, their alignment of ambitions, requirements, and the innovation's performance levels occurs through mutual adjustment (Mintzberg 1979). Stakeholders then directly engage with peers, clients, and end-users without making extensive use of standards and regulations. Such uncertainty reduction processes lose efficiency when innovations become implemented on a grander scale. Standards and regulations then partly replace the existing coordination through mutual adjustment and reshape the institutional context that innovations entered.

The standards and regulations that the institutional landscape comprises of are being contested frequently. Recently, for example, the US-president expressed a desire to 'slash regulations by 75% or more'. This could save paperwork and time, and allow companies to hire more employees, which, in turn, could help spike innovations again. Further, it was argued recently that agencies 'use rules to just protect existing businesses from competition instead of stimulating innovation' (Black 2016). In a more subtle way, also the European Union and Dutch Infrastructure Ministry announced to 'address regulatory

[1] l.l.oldescholtenhuis@utwente.nl

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barriers' to boost green building initiatives. The prevailing thought in these narratives is that rule abolishment creates an innovation paradise. This study challenges this view. We therefore explain, based on two cases, how the impact of standards and rules changed while innovations passed through different product lifecycle phases. Rather than supporting or contesting the positive impact of regulation on innovation, we identify the role of rules during the uptake of two systems: the 'KLIC utility register' and the 'Ground Penetrating Radar'.

The remainder of this article first synthesizes seminal literature and elaborates how we used a product lifecycle perspective to study innovation and regulation. Next, we present results and conclude that the call to 'reduce rules to stimulate innovation' does not simply hold in any context. Finally, we propose hypotheses about what impact different rules and standards have during distinct product lifecycle stages.

REGULATIONS, STANDARDS, AND INNOVATION

Innovating involves the implementation of an idea or improvement into a new process, product, or system that is novel to the institution developing it (Slaughter 1998, Shilling 2010). Innovations land within an existing institutional setting where regulations and standards shape interactions between regulators, the market, and innovation systems (Lyytinen and King 2002). This interaction is very apparent in sectors that integrate multiple complex subsystems and technologies into specialized one-off products. In such regulated industries, authorities and companies dictate standards to shape collaborative innovation paths (Yoo *et al*. 2005, Dedehayir *et al* 2014).

Blayse and Manley (2004) found that regulations and standards are one of the six 'main factors driving or hindering construction innovation'. Initially, innovation studies mostly focused on the restrictive influence that standards have (Gann, Wang, and Hawkins 1998). Such research stressed that regulations impose a cost burden on firms that reallocate spending away from investments in innovation (Stewart 2010). Consequently, the argument resulted that rules should be abolished to let innovations flourish. Later, this debate turned toward the enabling role of regulations with respect to stimulating innovations (e.g. Pries and Dorée 2005; Koch and Jacobsen 2014).

Rules may support innovation because they provide structure. They stabilize market situations, provide the technical infrastructure that facilitates diffusion (van Waarden 1996), and create competitive advantages for nations as a whole (Porter 1990). Furthermore, progressive rules create incentives to innovate (van Waarden 1996, Stewart 2010). Regulations about safety, competition, and sustainability, for example, triggered innovations in Formula 1 technology (Jenkins 2010), and automotive industry (Huber 2012). Similarly, innovations are stimulated through tight environmental regulations and green building standards (Porter and Van der Linde 1995, Monahan Coates and Clarke-Hagan 2014). These regulations shape conditions that re-allocate corporate investments toward environmental R&D (Brunnermeier and Cohen 2003, Kneller and Manderson 2012).

Overall, the structure and incentives that regulations provide create a minimum threshold for performance and may stimulate innovation. This needs to be balanced by 'dangers of over-regulation' (Loosemore and Holliday 2012).

Standards and innovation have a symbiotic relation: standards can be derived from an innovative technology, and alternatively, innovations can be spurred from standards too (Allen and Sriram 2000). Mainly three different ways for standards acceptance exist: industry accepts them de facto (such as a QWERTY-keyboard); authorities approve them (regulatory standards) or professional associations reach consensus to use them (Allen and Sriram 2000). The effectiveness of rules on the adoption of an innovation depends both on the type of regulations as well as on the local external context in which innovations emerge (Hartmann 2006). Careful empirical studies of the social and material aspects that altogether define the non-linear relation between innovation and different standards are therefore needed (Timmermans and Epstein 2010, Koch and Chan 2013, Koch and Beemsterboer 2017, Yoo *et al.*, 2005).

Despite this call for contextualized empirical studies, however, the different types and impacts that standards can have - depending on the innovation context - are often lumped together as if the standards-regulation-innovation relation is static and unambiguous. Although scholars often acknowledge that rules and innovations 'have a complex relation' it remains unclear how this relation should be conceptualized. Blind (2012) already distinguished between the short-term compliance costs and long-term positive effects that various rules can have on innovation. We contribute to this by hypothesizing that regulation, standards, and innovations interact differently during four stages of product adoption. These stages are called product lifecycle stages and include the following phases: introduction, growth, maturity, and decline. The aim of this study is to explore how the role of regulations and standards evolves during these distinctive stages.

METHOD

This study focused on the adoption of the KLIC system as well as the adoption of the ground penetrating radar device for utility mapping. Both systems were confronted with rules and standards. Besides choosing these innovations because they lie within the domain of expertise of the authors, we also selected them because they contributed significantly to the reliability of existing construction management practices. The KLIC system and ground penetrating radar enrich practice by providing information about underground project conditions. This helps project managers reducing the risk that excavation incidents occur. To analyze the uptake of both systems, we first conducted a desk study to backtrack the key activities during their adoption.

Moreover, the authors' involvement in industry meetings and innovation initiatives allowed them to identify the main documents related to the adoption of KLIC and the GPR. We used these to identify the key events, standards, and rules that shaped the two innovation trajectories. As a next step, we used the taxonomy of Allen and Sriram (2000) to analyze what type of standards (de facto, regulatory or consensus) applied to each of the product lifecycle phases. Similarly, we used the terms from van Waarden (1998) to denote whether regulations were structural or used as an incentive. This finally allowed us to create an overview that categorizes the regulations, standards and their functional role during different product lifecycle stages.

RESULTS: TWO INNOVATION NARRATIVES

This section describes how regulations impacted two innovation trajectories. The first innovation trajectory we describe is the Dutch system for utility plan exchange - KLIC ('Kabels en Leiding Informatie Centrum'). KLIC stores and exchanges maps containing the geographical location of utility owners' networks. The second trajectory focuses on the adoption of the ground penetrating radar as a technology for surveying buried infrastructure.

Trajectory 1 - The Adoption of the KLIC System

The utilities' sector in the Netherlands became largely privatized in the 1990s. Back then, ownership and control over the utility networks migrated from a few government organizations to myriads of private and semi-private utility operators. The privatization involved a transfer of ownership over physical infrastructure. The new owners became responsible for the accurate registration of the location and status of their own assets. This information, in turn, supported construction planning and utility strike avoidance.

It became more crowded in the Dutch subsurface because more infrastructure - such as telecommunication lines, and fibre optic cables - entered public space since the nineties. The increase and fragmentation of utility information complicated street works. To reconstruct a street, for example, maps from the gas, water, electricity, sewage and telecommunication networks had to be collected from their respective owners. In the beginning, the government formulated no rules as to how the utility information had to be stored and exchanged. Each utility company used different approaches (syntax, symbols, and formats) to map and exchange their asset data. Stakeholders merged this data manually to create a comprehensive overview of all buried utilities on a construction project site. As a result, the integration of the different utility maps was cumbersome and time-consuming.

The Dutch utility sector responded to this information integration and exchange problem by founding the utility information centre, KLIC. Similar to the multiple dial-before-you-dig firms in the UK, project stakeholders contacted KLIC to receive utility plans for a particular area. The system was decentral. This means that utility owners maintained their asset information themselves, while the KLIC system handled the exchange of this information between utility companies and contractors. After implementation of the utility strike avoidance act WION (wet informatie-uitwisseling ondergrondse netten) in 2008, KLIC usage became mandatory for all infrastructure construction projects. The Cadastre became owner and operator of the system. Since that moment, utility owners had the obligation to make available the location data of their main utility lines, and to send this through the KLIC centre on request of a contractor. Together with WION, the national guideline utility strike avoidance (CROW 250) was launched. Nowadays CROW250 is used as a code of conduct that prescribes measures needed to perform careful excavation work.

Since 2010, the technology for digital mapping and exchange of utility plans progressed. The sector demanded from the KLIC system that utilities were mapped and exchanged digitally. These stricter rules become tightened even further in 2016-2018. During this period, the KLIC system will be adapted to the EU INSPIRE directive for public information exchange. This directive even prescribes the digital format and access requirements for public utility data. According to INSPIRE, network owners need to give the Cadastre access to the vector-based location information of their full network by 2017. This network information should not only include the main lines, but also the service lines that connect the main lines with facilities. In the next version of the KLIC system, the Cadastre expects to store all information centrally to provide near-ubiquitous access.

As of 2017, the Dutch KLIC systems is integrated as a public system for quick and low-cost information exchange between contractors and networks owners. In the UK, the regulatory support for this public systems seems not yet to exist. To identify utilities in the UK, private firms perform enquiries through traditional 'dial before you dig' services.

This trajectory shows that utility information exchange was first initiated voluntarily to support asset information exchange. While the sector gradually adopted it, the system passed introduction stages and rules structured behaviour. Later, the rules were sharpened again to provide an incentive for improving utility data exchange. As time passed, complementary standards were developed by the construction sector to elaborate how the rules needed to be applied in a context of excavation work. Incentive rules and consensus standards helped to let the innovation function effectively. Table 1 summarizes the innovation stages, regulations and standards, and regulation types from literature. In contrast with the 'abolish rules' motto, the table shows that rules and standards receive an important role during the innovation adoption.

Table 1: KLIC system product lifecycle, and the corresponding standards and regulations

Period	Event	Related rule/ standard	Type	PLC stage
1990-2008	Unregulated exchange of utilities plans through the KLIC system. Decentral storage of maps	Not applicable		Introduction
2008-2010	Mandatory use of KLIC system for the exchange of data about the location of cables and pipeline mains. Information stored at decentral location	KLIC incorporated in strike avoidance act (WION)	Incentive rule	Introduction
		Industry standard CROW 250 on utility strike avoidance	Consensus standard	
2010-2016	KLIC system exchanges information about the location of cables and pipeline mains digitally. Decentral storage	WION extended to facilitate digital exchange	Structural rule	Growth
		Industry standard CROW 250	Consensus standard	
2016-present	KLIC system as a central system for storage exchange of utility information. Registration of the full network mandatory.	Extended WION (to facilitate digital exchange)	Structural rule	Maturity
		New industry standard CROW 500	Consensus standard	
		EU-INSPIRE directive	Incentive rules	
		Information model IMKL		

Trajectory 2 - The Adoption of the Ground Penetrating Radar of Utility Mapping

The ground penetrating radar (GPR) was developed in the late 1900s as a technique for geophysicists to explore soil characteristics and identify unknown objects in the subsurface. As antennas and processing software became more reliable, the technology also landed in the civil engineering domain. Array radars helped to sense the composition and the thickness of existing asphalt layers. Additionally, manufacturers and researchers started using the GPR to map buried infrastructure. In the UK, for example, researchers of the mapping the underworld and assessing the underworld programmes, tested and developed utility mapping techniques including the ground radar, electromagnetic locators, and acoustics. They concluded that each of the techniques had different uses and constraints. The ground penetrating radar, for example, could not function properly in wet soil and clay. In addition, the GPR was not able to detect all types of buried material. Although the UK projects terminated in 2015, the technology seemed mature enough for professional use. Industry hence started using GPR to map utilities.

In general, the first practical applications of GPR in utility mapping were disappointing. Either this became because of technology overselling (e.g. a supplier promised that a GPR detected more than it actually could), or because clients had unrealistic expectations of what output a GPR could produce. Dutch clients, for example, often expected that they would receive a map that visualized the locations of all buried infrastructure in the survey area. Surveyors could not live up to this expectation. The UK sector dealt with a similar problem and collectively developed the PAS-128 (entitled: Specification for underground utility detection, verification, and location) to define the different quality levels that utility detection technologies can achieve. Currently, the Dutch also start integrating the GPR-technology into a utility strike avoidance guideline Act (CROW 500) as well as in an equivalent to the PAS-128.

Table 2: GPR for utility detection product lifecycle, and corresponding standards

Period	Event	Related standard	Type	PLC stage
1990s	Ground Penetrating Radar accepted term in science and technology	Not applicable		Introduction
2005-2016	MTU ATU programme	Not applicable		Introduction
2014	Launch of guideline for surveying services launched	PAS128	Consensus standard	Growth
2016	GPR adopted as tool for surveying	CROW 500	Consensus standard	Growth
2015 - present	Dutch PAS-128-NL being explored	PAS128-NL	Consensus standard	Growth

Table 2 describes the adoption process of the GPR. It shows that the early adoption of GPR led to the development of standard processes that prescribe suitable steps and quality levels. These initiatives were industry driven and consensus-based. Standards provided clarity, reshaped the existing institutional environment and eventually contributed positively to the uptake of the innovation. The argument 'that rule abolishment stimulates innovation' was not applicable here.

We allocated the identified regulation and standard types to the distinctive lifecycle stages in Figure 1 to compare the two innovation trajectories. With respect to trajectory 1, the figure shows that innovation growth relates to innovation incentive rules and consensus standards. In trajectory 2, co-ordination of the innovation process took place mainly through mutual adjustment between pioneering stakeholders. The growth and maturity stages of both trajectories were subject to structural rules. It is likely to assume that these rules come into play to stabilize the innovation within an institutional context.

DISCUSSION

All in all, this study shows that the claim that 'rules block innovation' is incomplete and myopic. It does not apply just everywhere and in any innovation context. We show that the regulations and standards have a different impact during each of the innovation stages. We use these findings to define two hypotheses: First, incentive rules, consensus standards, and mutual adjustment are mechanisms to coordinate behaviour in innovation introduction stages. The absence of structural rules and regulatory standards signifies that these rules may not have a positive impact during innovation introduction. Second, incentive rules seem to play no role during the successive stages. We hence hypothesize in relation to innovation growth and maturity stages, that structural rules and regulatory standards become increasingly important to stabilize innovation integration.

Previous studies (c.f. Van Waarden 1996, Gann *et al*., 1998, Allen and Sriram 2000, Timmermans and Epstein 2010, Koch and Beemsterboer 2017, Yoo *et al*., 2005) already highlighted the complex relationship between regulation and innovation. This study conceptualizes this further by using the product lifecycle to map the dynamic interplay between regulations, standards and the innovation system.

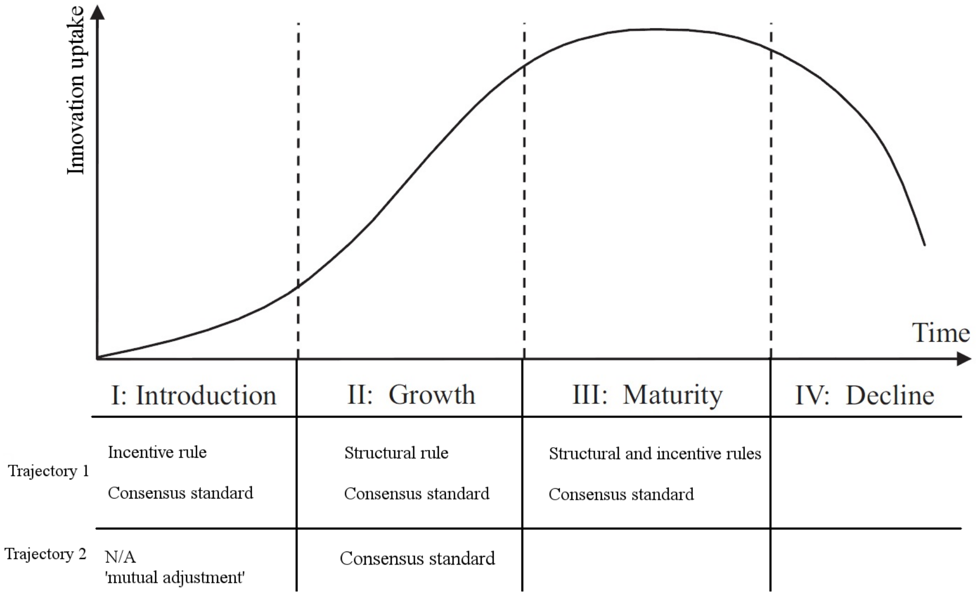

Figure 1: allocation of the identified regulation and standard types and their relation to different product lifecycle phases

Our findings fit within ongoing regulation-innovation debates. The changing role of regulations is, for example, also addressed by Blind (2012) who argues that the short-term impact of regulations may be negative, while on the longer term regulations encourage adoption, accelerate uptake, and create spillover benefits. Additionally, Shen *et al*., (2013) confirm our observation of a dynamic innovation context by claiming that hybrid standards may emerge from a combination of existing and new standards. Finally, our observation that mutual adjustment first coordinates innovation processes before structuring regulations come into play is in line with Van Waarden (1996). He argues that a pragmatic and flexible regulatory approach, where rules are implemented in close collaboration with industry, helps to shape a protective and innovative atmosphere where rules are challenged less frequently.

We suggest various steps for future research. First, this study contains only a first exploration of the innovation trajectories of the KLIC-system and GPR. Additional research could focus on mapping this interaction in greater detail. Such a study can then also take into account the various impacts that rules have on an innovation. Koch *et al*., (2014) give examples of such impacts by stating that standards: improve interoperability, enable efficient repetition in product development, stabilize volatile processes, and enable entry of products into new markets. Furthermore, additional studies of other innovation trajectories in different contexts would help explain whether cultural factors (such as regulator's flexibility and adversarial behaviour) also influence the emergence and effectivity of standards and regulations. Van Waarden (1998) advocated the point earlier but we did not yet consider it in our study.

CONCLUSIONS

This study explored the changing role of regulations and standards during the adoption of the Dutch KLIC-system and the utilities GPR. We outlined the key activities that influenced the adoption trajectory and used taxonomies of Allan Sriram (2000) and Van Waarden (1998) to categorize the relevant standards and regulations. Next, we developed an overview of the functional standards and rules during each of the adoption stages. Our comparison of the two cases from the utility construction domain demonstrates that the prevailing motto 'forget the rules and innovate' is unrealistic and short-sighted when considering the innovation lifecycle for analysis. We argue that, although freedom enhances design and innovation space, the reduction of rules is not the necessary solution for smoothening innovation adoption processes.

A closer look at the adoption of the KLIC system shows that different rules and standards influence distinctive phases of the product lifecycle. In this case, mutual adjustment first coordinated the behaviour of the stakeholders. Regulations and standards only emerged after the industry adopted the system on a larger scale. In both cases, the initiative to implement standards and rules originated from the sector itself, rather than from regulators.

This study contributes to practice by describing a more nuanced innovation context, and by explaining how the shape and impact of rules change along the product lifecycle stages. Furthermore, we refine the research concepts by adding the product lifecycle view to innovation-rules debates. This provides a more holistic and realistic frame of reference for future studies. Finally, we recommend practitioners to take into account the product lifecycle stage, as well as the regulation and standardization types before considering that construction industry should 'forget the rules and innovate'.

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