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Impact of changes in regulatory performance standards on innovation: A case of energy performance standards for newly-built houses

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ABSTRACT

This paper explores the impact of changes in prescribed performance standards on innovation in an industry characterised by loosely coupled systems. Using a case of energy performance standards for newly-built houses, it investigates how changes to these standards have affected the innovation of houses, combining qualitative and quantitative data from the Netherlands. The key finding is that standardisation does not only increase the amount of innovation conducted in an industry while achieving societal goals, such as improving energy efficiency. It also triggers different types of innovation. While innovators in the investigated field prefer incremental innovations which can be integrated easily into existing ways of building houses, tightened requirements require systemic innovations, meaning that processes and organisations need to be changed. Additionally, we find that ambitious performance standards can also impact the organisation of an entire sector: they can force integration, the tightening of couplings between firms, in order to achieve systemic innovation.

1. Introduction

Standards may be accused of hindering innovation but literature shows ample evidence of the opposite (e.g., Blind 2013; Swann, 2005). Differences in their impact on innovation may stem from different categories of standards or different forms of innovation. This paper studies a sector known for little innovation, the construction sector. It shows how tightening of a prescribed performance standard in combination with a standard for measuring performance led to several forms of innovation simultaneously. This is an extension of the literature which tends to focus on the impact of one standard or a number of standards in a sector on (an indicator for) innovativeness of that sector.

The paper first addresses the main concepts of standardisation and innovation, and then relates these to the typical characteristics of the construction sector. Next, it describes the approach of our empirical study: the implementation and impact of energy performance standards for newly-built houses in the Netherlands. Finally, we present and discuss our findings.

2. Standardisation and innovation in the construction industry

2.1. Main concepts: standardisation and innovation

Standardisation is the activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context (ISO/IEC, 2004, p. 4). These provisions for common and repeated use have to remain stable until the standard is revised and this stability creates an inherent tension with the newness that is inherent to innovation. Not surprisingly, standardisation has been accused of hindering innovation. However, several studies have suggested a positive correlation between standardisation and innovation, whereas others have reported a mixture of positive and negative effects (Blind, 2003; 2004; 2006; Bodewes, 2000, David and Steinmueller, 1994; Egyedi and Sherif, 2010; Katz and Safranski, 2003; Krechmer, 2004; Mansell, 1995; Shapiro and Varian, 1999; Swann, 2000; 2005; Tassey, 2000). The overall picture (for a recent overview see Blind (2013)) is confusing. The reason seems to be that authors have different categories of standards and different forms of innovation in mind. Therefore, in this chapter, we first address the two concepts standardisation and innovation and how these interrelate (Section 2.1), and we

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then discuss standardisation and innovation and their interrelations in the construction industry.

de Vries (2006) distinguishes three main groups of standards: (1) basic standards (e.g., terminology standards, standards specifying quantities and units), (2) requiring standards (standards that set requirements for entities or relations between entities), and (3) measurement standards (standards that describe a solution for measuring). Requiring standards include performance standards and design-based standards that describe solutions. Performance standards set performance criteria, without prescribing certain solutions. They can include the extent to which deviations from the basic requirements are permissible. Standards may apply to products, services, processes, systems and organisations, and may differ in their degree of obligation (de Vries, 2006). Most standards are voluntary, but market situations may make a standard de facto compulsory, for example, because customers prescribe a certain standard. The same standard can be voluntary for one actor and mandatory for another. Some standards are legally prescribed, but there is often a possibility to conform to the legal requirements in another way than by implementing the standard (Leibrock, 2002).

Innovation is "the commercialisation of all new combinations based upon the application of new materials and components, the introduction of new processes, the opening of new markets, and/or the introduction of new organisational forms" (Schumpeter, 1934). Standardisation and innovation are thus relevant to similar entities. Moreover, according to Schumpeter's definition, innovation is more than an invention: it is a commercialised invention. Whether or not an innovated product or service is commercialised *successfully* can be measured by the rate of diffusion or adoption of that innovation. Henderson and Clark (1990) distinguish between incremental, architectural, platform and radical innovations.

Blind and Gauch (2009) relate standards to four phases in the innovation process. Semantic standards reduce information and transaction cost in the phase of basic research. Measurement and testing standards prepare for the next phase of applied research. Interface standards provide interoperability between components and reduce adaption costs to allow experimental developments. Compatibility standards, quality standards and variety reducing standards increase quality, reduce risks, build critical mass, and achieve economies of scale and network externalities and enable interoperability among products during the last phase of diffusion. Standards can support innovation but also hinder it. If a certain solution is "frozen", it can hinder its further improvement. This is referred to as "lock-in" and can result from standards imposed by authorities, standards developed in committees of stakeholders, as well as de-facto standards that emerge in the market. A classic example is the QWERTY de-facto standard (Arthur, 1989; David, 1985). However, even in this case, lock-in may be disputed (Kay, 2013). Changing a standard makes sense if the advantages of the new one compared to the old one outweigh the cost of conversion, and then other factors determine whether this change is feasible or not (de Vries et al., 2011; van de Kaa et al., 2011).

Egyedi and Sherif (2010) relate standards to the technology life cycle: emergence, improvement, maturity, and obsolescence. Traditionally, standardisation takes place during the first three stages, and is anticipatory (a forward-looking answer to expected problems), enabling (standards proceed in parallel with market growth and enhancements to the technology and products), or responsive (reactive to improve efficiencies or reduce market uncertainties). Using the case of Ethernet networks, Egyedi and Sherif conclude that standards co-evolve with technology innovation. So standards can indeed freeze solutions, but they can also be changed during their maintenance (amendments, corrigenda, or new versions) or succession (next generation) (Egyedi and Blind, 2008). There is hardly any literature on this topic, the main exception being "The Dynamics of Standards" (Egyedi and Blind, 2008). van den Ende et al. (2012) show how the dynamic relationship between modifications of a standard and the size and diversity of the network of stakeholders involved in setting these standards influences the outcome of battles between competing standards, and thus the success of innovation. The empirical data in these studies are from the ICT and telecommunications industries, and in these fields most standards are related to interoperability. Therefore, new research is needed to study the interrelation between standards and innovation in other fields. In this paper, we study standards that differ in several dimensions: sector (construction industry), category (environmental performance and measurement standards), and level of obligation (compulsory).

Because of these characteristics, there is a parallel to studies on the impact of environmental regulations on innovation. Porter and van der Linde (1995) have argued that regulatory environmental performance requirements stimulate innovation. This has been confirmed at a macro-economic level (Blind, 2012), and at sector level (Lee et al., 2011; Popp et al., 2011; Testa et al., 2011). Jaffe and Palmer (1997), however, did not find any statistically significant effects – R&D expenditures slightly increased while the number of patents slightly decreased. Apparently, stricter requirements may trigger innovation to meet the requirements but this advantage has to be balanced with the cost of convergence and compliance.

Standards may impact innovation but innovation may also impact standards. Standards may be needed to ensure an innovative product is fit for use, or safe. A recognised testing method can give evidence of performance (which may be a necessary condition to enter the market). Interface standards may be needed to ensure interoperability. An innovative solution brought to the market may become a de-facto standard, whether or not after a battle with one or more other solutions. Van de Kaa et al. (2011) provide an overview of the literature and show which factors contribute to success in standards battles.

2.2. Standardisation and innovation in the construction sector

Construction standards cover the buildings or the infrastructure to be constructed and the products used. Many of these are voluntary standards which are developed in committees in which different stakeholders are represented. Most countries have housing regulations and standards may be related to this legislation. Most standards provide requirements for quality and safety, other standards are related to, for example, information exchange (e.g., technical drawings) and methods of working. This entire set of regulations and standards provides a common body of knowledge which makes it easier for different actors to cooperate (Dubois and Gadde, 2002). In the construction industry, design and the construction processes are often separated: the architect designs the building and then construction companies build it. Sometimes more detailed elements of the design are left to construction companies. Standards provide the common language to ensure that the building is constructed according to the design. Moreover, standards provide testing and inspection methods to ensure the building and its components conform to the requirements. The building process requires the services of several specialist sub-contractors such as plumbers, electricians and carpenters, coordinated by one main contractor. Standards can be used to specify the work to be performed.

The construction industry is a typical project-based sector with different firms working in cooperation per project. It is therefore considered as a "loosely coupled system" (Dorée and Holmen, 2004; Dubois and Gadde, 2002; Weick, 1976). However, within a project, the organisation and technical structures are more tightly coupled. In a tightly-coupled system, a change in one activity impacts another activity, whereas in a loose coupling, changes can be made independently without impacting other activities (Orton

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