Contributions to Management Science

Co-Evolution of Standards in Innovation Systems

The Dynamics of Voluntary and Legal Building Codes

Bearbeitet von
Stefan N. Grösser

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Preface

Topic. This book addresses the phenomenon of coevolution of standards in residential built environments. It develops a feedback-rich simulation model of the revelatory case of the Swiss residential built environment, first, in order to explain the historical coevolution of standards in this system and, second, to analyze the effects of different administrative polices on energy demand, improvements of energy efficiency in building codes, and estimating reductions in the Swiss greenhouse gas emissions until 2050. Novel to the literature is the conceptualization of the innovation-diffusion-standardization (IDS) cycle, which forms the underlying momentum in this sector of the industry.

Researching this subject has also revealed shortcomings of the methodology which I have applied. The two methodological contributions of this book have emerged at the intersection between a qualitative systems model and the development of a quantitative simulation model. The first concerns the available means for validating simulation models, especially knowing when to use which validation method and when to cease validation efforts. This concerns the requirement of a particular kind of measure for arriving at a model which is capable of capturing delayed and also unintended consequences. The measure that was required allows one to evaluate the degree to which a model has such properties.

Audiences. Three audiences can benefit from the book. The first type of audience is interested in the topic of *sustainable development, energy demand reduction, energy efficiency* in general, and *energy efficiency in the building sector* in particular. The most recent developments regarding energy, especially about the closing of nuclear power plants in Germany or in Switzerland, have fueled existing discussions about reducing energy demand, increasing energy efficiency, and also prioritizing the topic of energy on the political agenda. This book provides a formal behavioral model about the evolution of energy standards for residential buildings, with an estimation of the consequences of their diffusion in terms of likely energy and GHG-emission reductions, and thereby helps to operationalize the long-term energy strategies of administrations. It provides information about the formation of standards, and can stimulate discussions in small, medium, and large businesses as well as among administrative policy makers.

The second type of audience is concerned with the *formation of standards* or *norms*. This book analyzes the development of informal and formal building codes. The informal set of codes could also be described as concerned with *best practices*, while the formal set is concerned with *dominant design* in an industry. The book addresses the case of residential building codes in the built environment and develops a structural simulation model to demonstrate how these codes have evolved over time. Readers may already be interested in this special case. However, most readers will probably be interested in the generalized dynamic model for norm development in the synthesis chapter. This generic model can be transferred to other settings and be used as an initial hypothesis about the coevolution of norms.

The third type of audience is interested in the *application of simulation modeling to the analysis of complex socio-technical systems*. This book is one of the first to provide a formal, behavioral simulation model of a socio-technical system. Existing books and journal articles almost exclusively have used simulation approaches that account only for the technical or economic properties of the system while proceeding on oversimplified assumptions. The material herein is based on an empirically grounded simulation model that begins to account for the bounded rationality of decision makers in the residential built environment with its significant system delays. In addition, it combines the technical, economic, legal, and social perspectives in a simulation model that has a wide model boundary.

Access. How should one read the book? Obviously, this depends on the reader's objective. In principle, each chapter stands on its own, but also offers multiple references to other chapters where certain aspects are treated in more detail. Readers interested in the subject of coevolution of standards and the diffusion of energy-efficient housing should read the book from beginning to end; possibly they might skip the literature review in Chap. 2, since it intensively accounts for existing research in this area. In addition, readers who already know the characteristics of the residential built environment might skip Chap. 4. People who are interested only in the substantive aspects of standard development might concentrate on Chaps. 1, 5, 6, and 9. Readers who are especially interested in simulation modeling in the social and management sciences might concentrate on Chaps. 3, 5, 6, and 9. Someone who is interested in the substantive scientific contributions and policy recommendations might refer to Chaps. 5, 6, 7, and 8, where the individual contributions are generated, and then to the synthesis in Chap. 9. Readers who are interested in advances in simulation methodology should direct their attention to Chaps. 7 and 8.

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Stefan N. Grösser