1. Introduction: unravelling the relationship between standards and innovation

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1.1 INTRODUCTION

At first glance, standards and innovation might seem to be opposing forces. By definition, standardization is about doing things the same way, whereas innovation is about doing things differently. In practice, however, the two are often closely related, both in terms of how their functions, dynamics and organization affect industrial practice and economic growth, and in terms of the conceptual and analytical apparatus that has grown up around them. Just how this nexus between standards and innovation works out in theory and practice is broadly the subject of this volume.

Most current theory as to how standards function in modern industrial economies, along with the general logic pertaining to their development and application, has firm roots in much the same tradition of heterodox or evolutionary economics that has also contributed many of the key insights into innovation phenomena, along with most of the empirical evidence.

This has not meant, however, that the standards–innovation nexus has yet generated a fully coherent or distinctive literature. There is still more cross-fertilization of ideas drawn from several literatures than there is anything like a fully formed synthesis, much less a dominant theory. It is still mostly the case that some innovation scholars also write about standards, and some standards scholars also write about innovation. Nevertheless, elements of a more coherent synthesis have been accumulating for some time, indicating that the climate was opportune to begin weaving some threads together in a collection of chapters from some of the many scholars who have been investigating different aspects of this theme in various contexts.

The *Handbook of Innovation and Standards* represents the first explicit attempt to sound out the current state of theory, evidence, opinion and experience specifically with respect to this relationship. The aims of the editors were to establish a kind of knowledge baseline that would document and summarize the origins and directions of existing work, stimulate new research and suggest productive new links between scholarship, policy and practice.

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However, as the editors reviewed and discussed the evolution of scholarly work in this field, it became clear that the state of the art was still very fluid. Adopting a purely topical or subject orientation proved to be problematical. Most core themes and issues in the extant literature permeated topic and subject boundaries. Much of the literature also tends to be interdisciplinary, making it difficult to separate contributions according to distinct schools of thought, or methodological approaches. Another issue concerned scope. For example, a significant part of the current literature on standards and standardization focuses mainly on practical matters of implementation or certification. Although sometimes also based in the social sciences, references to innovation in this literature are mostly tangential, and geared mainly to the practice of engineering.

So the decision was made to focus the *Handbook* on conceptual, analytical and empirical work that draws primarily on the core literatures associated with innovation studies on the one hand, and with the economic, social and political dimensions of standards on the other. An effort was also made to achieve a reasonable balance between theoretical and empirical contributions. And to provide a reality check, a group of chapters was included that reflects the practitioner perspective. Fortunately, we could draw here upon a pool of highly experienced practitioners who are also academics, or who otherwise have made significant contributions to the scholarly literature on standards.

Taking all of this into account, it was decided that the best approach to covering as many of the key issues and schools of thought as practical in one volume was to assemble a reasonably representative group of scholars who have been contributing to knowledge about standardization and innovation in some form or context, in some cases over many years, and to let the authors decide how best to reflect what they considered to be significant insights, from their own work and from that of others, for understanding the dynamics of this relationship. The result is a structure that is more thematic than topical, themes being derived from the synergies and linkages that became apparent as the contributions were assembled.

The first part of this collection, 'History, Theory and Evidence', covers some of the more high-level issues related to history, practice and policy in terms of how the relationship between standards and innovation can be conceptualized theoretically, and then defined, mapped and monitored in terms of the implications for innovation. The second part, 'Standards, Innovation and Industry', focuses on the significance of the standards–innovation nexus for industrial development, research and development (R&D) strategies and intellectual property. The third part, 'Standards, Innovation and Markets', adopts more of a case example

approach oriented to explaining how firms and institutions utilize and leverage standards in ways that are relevant for innovation within specific technological, institutional, or product and service environments. The chapters in the fourth part, 'Strategies, Standards and Innovation: A Practitioner Perspective', round out the volume with a view from the coal face, provided by contributors with extensive backgrounds in standards development, implementation, strategy and management.

1.2 DEFINITIONS AND BACKGROUND

Before guiding the reader through the contributions in terms of the key arguments, insights and questions, some overall background to the subject is required, especially as we can anticipate that the typical reader is likely to be more familiar with the subject of innovation, which is widely discussed, than with standardization, which remains situated within a much smaller and more specialized group of scholars.

Defining Standards and Standardization

Defining standards and standardization is both simple and complicated. To readers less familiar with the specific literature on standards, the conventional taxonomical and definitional distinctions can seem somewhat confusing, even more so as the international standards system to which many of these definitions are linked has undergone significant evolution over the past 30 years.

At the most basic level, a standard is a measurement, description, convention or design aimed at inducing conformity of practice or behaviour. And standardization is simply the process of establishing, adopting and conforming to standards. But from there things get complicated. Exactly how a standard is described, and how it is established and implemented, can vary considerably in different circumstances, as can its effects and impacts. So let us review some of the basics.

Standards can come about in essentially three ways:

- by convention – a practice, behaviour or configuration becomes broadly accepted through repetition and use, for example, designations of right and left;
- by fiat – imposed by an edict or regulation by a government or other institution;
- by negotiation – as agreed formally among stakeholders in an activity or enterprise.

However, these basic modalities are expressed in a variety of ways in the literature. David and Greenstein (1990) draw a fundamental distinction between ‘reference standards’, such as units of measurement, and ‘compatibility standards’ which describe how various physical or logical components can be combined and made to work together. Protocols for the interconnection of computer systems would fall into the latter category. Particularly in contexts such as environmental management or public safety, there is also a longstanding debate about the relative merits of ‘prescriptive standards’ that mandate a specific approach or method to achieving the condition described in the standard, versus ‘performance standards’ that specify a desired end without specifying the means of achieving it (Salter 1988; Breyer 1982).

Regardless of function or method, the terms *de facto* and *de jure* are often used. The former refers to standards that have come into being simply through wide acceptance, or lack of viable alternatives. The latter refers to standards that are the result of formal negotiation, usually under the auspices of a recognized institution according to an established set of rules. Some writers prefer to situate the origins of standards directly in a market context. They often refer to *de facto* standards as ‘market standards’, implying that a product or practice established in the market by commercial interests, sometimes even by a single firm, has become a standard by dint of broad acceptance and diffusion. The Windows operating system or the Google browser are frequently cited examples.

In this context, the *de jure* dimension is sometimes referred to as a ‘committee’ standard such as might be negotiated formally in one or more of the many institutions dedicated to this purpose. Throughout the *Handbook* readers will encounter frequent reference to two types of institution: the standards developing organization (SDO) and the standards setting organization (SSO). Generally speaking, an SDO is a national, regional or international body constituted for the sole purpose of developing and/or certifying compliance with standards that are negotiated formally according to a set of quasi-judicial rules and procedures designed to solicit a broad consensus of stakeholders. National and regional SDOs are affiliated with international bodies such as the International Organization for Standardization (ISO) or the International Electrotechnical Commission (IEC), or in the European Union, the European Committee for Standardization/European Committee for Electrotechnical Standardization (CEN/CENELEC). National bodies include the British Standards Institution (BSI), and the American National Standards Institute (ANSI). The term ‘SSO’ generally refers to an array of other organizations, variously referred to as consortia or forums, that set standards, but not necessarily standards that conform to SDO rules or that are fully coordinated with the SDO system. The Internet

Engineering Task Force (IETF) and World Wide Web Consortium (W3C) fall into this category.

Although the products of both SDOs and SSOs may perform similar functions once implemented, it is common to define standards developed in the SDO system as voluntary industry standards, or sometimes voluntary consensus standards. This is by way of distinguishing them from standards that are developed under SSO auspices, or from ‘proprietary standards’ as might be imposed by a company. As several authors in this volume are careful to note, these distinctions are important when standards are discussed in an innovation context, in that the manner of their development, management and application can have serious impacts on how markets for technological goods and services develop and evolve.

There can be much confusion also between standards and regulations. In practice, the difference can be only that regulations are imposed by a third party, typically government, and that conformance is typically mandatory with stronger sanctions for non-compliance. In reality, the line is often far less bold. Voluntary consensus standards are frequently referenced directly in legislation and regulation. This is the case, for example, with building and electrical codes, where the content of the standards is defined by industry, but conformance with them is made mandatory under statute and/or regulation. The situation is complicated further in that governments often encourage industry to self-regulate, which can involve the development and/or adoption of voluntary standards.

The reader will not proceed very far without becoming aware that this basic schema, already somewhat complicated, has undergone significant evolution and has been the subject of intense debate. As several of the chapters document, the entire institutional structure of the formal international standards development system has undergone many changes and has adopted new business and operational models. Such changes can be significant. Egyedi and Ortt (Chapter 6) develop an argument as to how taxonomies and definitions can influence the ways in which their effects on innovation are perceived and investigated. And as Cargill notes (Chapter 20) there are significant new kinds of coordination and legitimization problems inherent in the evolution of this system.

Consequently, although contributors to the *Handbook* use definitions that are broadly in conformance with the framework presented above, the reader will encounter some diversity of opinion as to what constitutes a standard or a standardization process in different circumstances. At the risk of redundancy in some cases, we have been careful to allow authors to define the standardization environment as it pertains to their subject or issue in the ways that they see fit, relative to their observations and arguments.

1.3 DEFINING INNOVATION

Innovation is likewise both simple and complicated to define. In popular usage, innovations are simply changes – virtually any new technology, idea, practice, and so on – with no obvious need for more precision. Indeed, also in policy and corporate contexts, the terms ‘innovation’, ‘invention’, ‘R&D’ and even ‘science’, are often used interchangeably. But for social scientists who are concerned to understand innovation as a socio-economic phenomenon, especially when this might involve monitoring and measuring outcomes and impacts, definitional precision is important.

The fundamental distinction that has underpinned all current theories of innovation, innovation processes and innovation systems is that innovation is not the same thing as invention or discovery. In the conventional framework, inventions and discoveries are regarded to have only potential or latent value. Innovation is defined as an outcome in the form of new wealth from new combinations of factors of production, whether existing or new. Much of the effort in innovation studies has been devoted to determining just how inventions or discoveries might become innovations. But as Blind (Chapter 3) and Hawkins (Chapter 4) point out, the scope of what is included in this process has broadened well beyond the mere commercial application of an invention or discovery.

Most of the current definitional conventions harken back to the primal DNA of innovation studies in the work of Josef Schumpeter, whose theory of innovation was basically that economies grew through the entrepreneurial destabilization of existing economic activities and structures. Schumpeter defined innovation simply as ‘a change in the conduct of economic life’ (Schumpeter 1939). But he also gave quite explicit examples of how this could happen. Entrepreneurs could introduce new products and new methods of production, but they could also open up new markets for existing goods and services, develop new sources of supply for raw materials and other factors of production, or they could create new market structures. These categories, somewhat truncated, still form the basis of the official statistical definition in the Organisation for Economic Co-operation and Development (OECD)–Eurostat Oslo Manual for determining which activities to count and not to count as innovation-related activities in official statistics (OECD and Eurostat 2005).

The chapters in this collection broadly adopt definitions conforming to the Oslo convention, although the focus on standards raises several questions as to whether the distinction between invention and innovation is as stark as sometimes claimed. As many of the chapters in this collection illustrate, a considerable part of the standardization effort is applied

within existing supply chains and production systems. This complicates matters when trying to determine how, when and where a standard might be contributing to new growth. Growth may be stimulated upstream if standards make production more efficient. But downstream effects on growth may also occur, for example where standards lower information costs, thus facilitating market access for new systems and devices by lowering the risks of adoption.

1.4 PUTTING STANDARDS AND INNOVATION TOGETHER

As noted already, as yet there is no general theory of how standards actually contribute to innovation. However, it is not difficult to see how standards and standardization might fit various descriptions or categories of innovation as outlined above. This fit was already apparent in some of the earliest scholarly papers on industrial standards. In Chapter 4, Hawkins refers to Thompson's (1954) case study of the early twentieth-century US automobile industry, which shows that technological progress in the industry occurred in the period following the adoption of standards for basic mechanical components and fasteners. These items were formerly made to different specifications for each manufacturer, incurring high costs and risks for suppliers, but also reducing the design flexibility of automobile manufacturers. Reducing the costs of these basic components facilitated and stimulated technological improvements. Imposing a degree of conformity with standards made it possible to focus on doing differently only those things that created genuine competitive advantages.

Most of Schumpeter's descriptive categories of innovation are visible in some way in this example. Arguably, standardization of common components resulted in new methods and protocols for design and production. Component suppliers were free to develop new markets for existing products, to diversify these markets and to improve products and services independently. Supply chains were opened up. And the relationship between component suppliers and manufacturers was completely restructured. And eventually, of course, the entire structure of the industry and its markets changed as more integrated supply chains facilitated mergers, takeovers and general consolidation into just a few large multinational firms. New sources of value and growth were created at every level.

However, it was not until the 1980s that a small group of social scientists began to investigate such phenomena more systematically. Before this time, scholarly literature on standards was very sparse, and concerned

mostly with industrial efficiency, public safety and international trade. But in roughly the same period, the study of innovation was also in its early stages, and mostly also situated at the margins of mainstream social science.

Significant scholarly interest in both standards and innovation began to become more visible and influential mostly in the 1980s. To a large extent it was motivated by the need to explain the unfolding drama of the information revolution. Indeed, it would be fair to say that since this time, probably the bulk of scholarly literature linking standardization and innovation has been rooted specifically in the computing and communication technology industries.

Concerns about the market power of huge computer giants selling wholly proprietary mainframe systems that could not talk to one another or accept peripherals and software from third party suppliers was a problem for competition policy. But would such problems of market power be solved simply by the rise of the dynamic independent semiconductor industry that was developing quickly in California and in a few other clusters around the world? The answer proved to be highly complex, spawning a new scholarly industry around questions related to the interconnection and interoperation of components and the transmission of messages across different public and private networks; all standards issues that had clear impacts on innovation.

Concerns like these brought the subject of standards firmly into the information economy orbit. This broadened the whole perspective. From its traditional locus in mechanical engineering and manufacturing, questions about standards shifted rapidly to the arena of intangibles: software, services and even management. It also amplified questions and concerns about the strategic and competitiveness dimensions of standards in a much greater variety of contexts. At the same time, the prospect of a semiconductor-based economy with high R&D inputs, unprecedentedly rapid product cycles and dramatic rates of company growth quickly became a cauldron for new thinking and research about innovation.

The information dimension also played out in terms of the development of a much more sophisticated theoretical and empirical framework for investigating and explaining standards and standardization as phenomena. In an earlier volume on standards from the same publisher as this *Handbook*, Paul David, one of the very first scholars to tackle this conceptual challenge, commented that the study of standards falls first into the domain of information economics; that the supply and demand dynamic of standards is typical of any information good (David 1995). Standards codify and convey information to adopters of technologies, processes and practices. This information has the effect of reducing the variety of

choices that a user must make, thus reducing transaction costs. As David also points out, within this information goods framework, the key questions concerning standards and the innovation process shift quickly from conformity versus diversity or stasis versus change. Instead they become all about degrees of freedom and how these are increased or decreased by the presence of standards. And such concerns bring the subjects of standardization and innovation firmly into contact.

1.5 HISTORY, THEORY AND EVIDENCE

In Chapter 2, Swann and Lambert open up the discussion by laying out some of the essential dimensions of any relationship between standards and innovation. They stress that depending on the circumstances, standards can either support or constrain innovation, a point also stressed by several of the other authors in this collection. Swann and Lambert also draw attention to the fact that innovations never stand alone and that compatibility and coordination are key aspects of the innovation process. They then review evidence from econometric studies indicating that there are perceptible, if not always definitive, links between standards and phenomena such as growth, productivity and trade. But they also note the limitations of this analysis, pointing out that standards are used mainly as proxies for innovation in this framework. Thus, they do not explain the mechanisms through which standards can have impacts on innovation outcomes. Reviewing other studies specifically focused on mechanisms, they note that sometimes standards have a direct ‘one-step’ impact in motivating or enabling innovation, while at other times the impacts are two or more steps removed. In such cases, standards act primarily on intermediate variables in the innovation process; for example, regarding transaction costs, networking effects and risk management. Swann and Lambert propose that progress in understanding the standards–innovation nexus is more likely to come from opening up this ‘black box’ of mechanisms from a greater variety of disciplinary perspectives.

In Chapter 3, Blind confirms many of these observations and pries open the black box a little further. He notes how standards can form a significant part of both the process of creating new knowledge and applying it to products and services. Participation in standards development can add significantly to the knowledge base of innovating firms. But he also notes that standards can generate negative effects, thereby opening up the discussion about the relationship between how and under which auspices standards are developed and their ultimate outcomes in terms of stimulating or retarding innovation. This in turn opens up an important

discussion, echoed by many of the other chapters in the collection, as to the question of the legitimacy of standards and the role of institutions and rules in reflecting a legitimate consensus of affected stakeholders. These fundamentals are then explored in terms of their economic implications for several of the key activities and practices associated with innovation, for example R&D, public procurement and intellectual property rights (IPR), and in terms of the many questions that remain about the roles of standards in such activities as technology transfer and the creation of market demand.

In Chapter 4, Hawkins situates the standards–innovation nexus within the historical development of the ‘systems of innovation’ concept, which has become a dominant organizational paradigm particularly for comparative studies of national and regional innovation performance. In this role, it has also become a core paradigm for the development of science, technology and innovation policy. He points out that the roots of this concept lie in the simple observation that innovations typically are not the product of individual genius or enterprise and that they require the coordination of an array of institutional inputs. This creates an obvious niche for coordinating mechanisms, of which standards certainly are one. However, the exact function of standards in this systems model has never been explicitly defined other than as a contributor or facilitator to other processes of technology development and adoption. Hawkins suggests that the focus on disruption and change in innovation policy has overshadowed the complementary need for stability, consolidation and industry building, which is where the functional role of standards becomes most visible.

In Chapter 5, Steinmueller delves further into the historical origins and contemporary relevance of ‘platforms’, a term which has evolved from the study of large technical systems and networking. The coordination problems inherent in such systems were central in elevating the study of standards from examination of specific cases in specific manufacturing industries, to more general concerns about compatibility and interoperability of components in highly sophisticated and decentralization technological constructs. This leads to a discussion of the problem of history; specifically, the question of why some standards persist and evolve over long periods of time whereas others do not. In sorting this out, Steinmueller stresses that standards have a political as well as a technical dimension in that they assume a central role in both defining and controlling the division of labour. In explaining these more political dimensions, he traces historical phases in the function of standards, beginning with the need to define and coordinate manufacturing practices for mass production and following through to the need of dominant proprietors to gain control over the development of complex technological systems.

In all of the above discussions, the question is never far from the surface as to how the ways in which we define and classify standards might influence how we investigate their implications for innovation. In Chapter 6, Egyedi and Ortt round out the first part of the *Handbook* by summarizing a large part of the literature on the taxonomical and definitional issues in standards research in a way that lays out these implications for purposes of research into the standards–innovation nexus. The authors make a case that a functional focus is required in order to accommodate the many beliefs and assumptions that have emerged within the highly interdisciplinary milieu that has characterized the study of both standards and innovation. The chapter provides a useful transition to further consideration of how the standards–innovation nexus plays out in shaping the industrial landscape.

1.6 STANDARDS, INNOVATION AND INDUSTRY

In Chapter 7, Tassej shifts the focus to the roles of both standardization and innovation in the development and growth of new industry. He proposes that high-technology industries are dependent upon frameworks of standards in that they constitute an infrastructure which extends all the way from upstream activities such as R&D to the market. Specifically, he discusses ‘knowledge-intensive’ industries which are characterized by the need to maintain close contact with the pace of scientific and technological change and to implement highly sophisticated production processes along with systems to monitor and measure their performance. All of these requirements are typically standards-intensive, but standards must evolve with changes in technology. Tassej argues that standards are relevant at every stage of a technology life cycle, and that ultimately they affect the ‘expansion path’ of a high-technology industry. Moreover, different types of standards can play different economic roles in these expansion paths.

In Chapter 8, King, Lambert and Temple turn our attention to productivity spillovers, which in an innovation context are defined mostly in terms of learning effects. In this case the authors note that voluntary consensus standards constitute a venue for such spillovers in that they produce a body of codified knowledge which empirical studies have indicated has a close relationship to productivity growth at the level of national economies. But echoing Swann and Lambert (Chapter 2), the questions of mechanism remain less well understood. In addressing these questions, the authors focus on metrology, probably the most basic and ubiquitous of all standards frameworks. Many of Tassej’s observations about infrastructures again loom large in this discussion. In this case,

King, Lambert and Temple argue that it is the integration of measurement infrastructures into standards themselves that generates productivity growth. Thus, they suggest that the measurement infrastructure is an important subsystem that could indicate empirically many of the relationships between knowledge spillovers and innovation.

Our next chapter leads us away from primarily a manufacturing industry focus to services. The service sector is now usually reckoned to constitute between 50 per cent and 80 per cent of gross domestic product (GDP) in various OECD economies. However, the entire subject of services is a reactively recent arrival on the agenda of innovation studies (see Gallouj and Djellal 2011 for an overview). As de Vries and Wiegmann note in Chapter 9, it is also only beginning to take hold among standardization scholars. However, considering that a major thrust in formal standardization initiatives in the ISO orbit revolves around standards related to areas such as quality assurance and management, arguably as much related to services as to goods, this is a fecund area for research. Elsewhere in this volume (Chapters 13 and 19), further discussion will be found of frameworks such as ISO 9001 and ISO 14000. De Vries and Wiegmann provide a useful review of the empirical evidence on the impacts of standards in a services context along with a case study to illuminate some of the mechanisms.

Chapter 10 presents a specific case of industrial development that is being championed by several national and regional authorities in Europe and that presents an interesting context for consideration of the effects of standards on industrial growth and development. Stolwijk, Punter and Montalvo ponder the case of ‘Smart Industry’ which displays all of the characteristics of knowledge intensity as described earlier by Tassey. Smart Industry is basically a strategy to link automation and new manufacturing technologies to the exchange of data. Owing to the fluid nature of the initiative, the authors speculate that both formal and informal standardization will likely play an important role in the success of these initiatives. The case illustrates many of the key issues that pertain to the need to ensure the interoperability of many components through standards, while at the same time allowing for product differentiation within this complex of technologies. The example also reveals the many links with policy as various governments attempt to stimulate the development of Smart Industry in order to generate new sources of growth. Inevitably this extends to encouraging and shaping the standardization process, an observation that Frankel and Galland elaborate further in Chapter 14.

Intellectual property is a major issue with respect to the development and implementation of standards in most industrial contexts, especially where negotiated voluntary consensus standards are concerned. We

have included a pair of chapters on this important issue that examine it from different perspectives. In Chapter 11, after noting many of the ways in which standards can both contribute and limit technical change, Bekkers discusses the complications that can occur when intellectual property rights are introduced into standards development and application. He notes discrepancies in the ways patent laws and standardization are positioned with respect to innovation. He then focuses on situations where incorporating patents into standards is unavoidable, and on the many legal, management, governance and disclosure issues surrounding 'standard-essential patents' (SEPs).

In Chapter 12, Simcoe and Righi review the intellectual property element from the perspective of what monitoring the use of patents in standardization can tell us about innovation. Specifically, they emphasize the cumulative nature of innovation in that it results from the elaboration and combination of existing stocks of knowledge. Echoing Steinmueller's comments in Chapter 5, they note the role of standards in this context in fostering a productive division of innovative labour. They also note the potential costs that patents can impose. These and many other issues are explored in a review of empirical studies based in data on disclosed patents. These show a number of trends and patterns with respect to the effects of patent disclosure on standardization outcomes and hence on innovation.

1.7 STANDARDS, INNOVATION AND MARKETS

A core element in any accepted definition of innovation is that as new combinations of factors are made, new sources of value and growth open up. This of course does not happen automatically when technologies and processes change. It requires the coordinated efforts of many actors including research institutions, scientists and inventors, firms, financial institutions, governments and many others. The next group of chapters in the *Handbook* examines several cases of such elements being combined that in various ways are also dependent upon standards and standardization.

In Chapter 13, Hudson and Orviska lead off the discussion by asking the very basic question of why firms elect to use standards in the first place. They cast the essential change versus stasis question in terms of product differentiation strategies. Proceeding from a theoretical exposition of the logic of how firms act in imperfect markets, they take a look at several types of standards and at different types of firms. They conclude that the benefits of standards vary with the firm and the type of standard and that the cost–benefit structure of standards is biased towards larger

firms which are more likely to be able to influence the content of standards. This casts some doubt on the possible effectiveness of any third party use of standards, for example in an industrial or trade policy role.

In Chapter 14, Frankel and Galland explore further the issue of third party intervention, focusing in on the use of standards as an industrial and trade policy tool in the construction of the European Single Market. They examine the potentially positive effects of using industry standards in order to secure a compromise between the goals of providing stable, predictable trade conditions and the goal of stimulating innovation. In examining how this has played out in practice, however, they argue that the efficiency gains promised by the New Approach and the Global Approach to standardization in the European Union (EU) has resulted mainly in a complex architecture that has not removed contradictions between regulation and innovation.

The three remaining chapters examine specific cases – transport systems, digital television and nanotechnology – where the relationship between standards and innovation has played out in various direct ways in the creation of markets for new systems and concepts, or in the case of nanotechnology, for defining possibilities and constraints for the application of radical new discoveries.

In Chapter 15, Iversen focuses in on the problems of creating and revitalizing markets for new technologies and systems in the presence of strong incumbents. His arguments stem from a critical look at conventional theories of technological diffusion and from the observation that innovation does not always follow the widely accepted ‘s-curve’ pattern of technological substitution. Transport systems are characterized by huge infrastructural investments and monopolistic tendencies that trap investment in entrenched technologies and systems. Iversen looks in detail at the development of battery electric vehicles (BEVs) and argues that standards contribute to innovation in different ways at each stage of a long evolutionary process.

In Chapter 16, Delaere and Ballon shift the discussion of market creation towards business models, how firms and industries create new ways of capturing value from products and services. This is often a complicated matter, typically going far beyond merely selling the good or service as such, to encompass all manner of neighbouring opportunities for creating additional revenue. Indeed, such activity in itself conforms quite well to any definition of innovation. Using the example of digital radio broadcasting, they show how the development of standards was also part of the process of working out various business models to expand the commercial possibilities of this technology, thus integrating the standardization and innovation processes in a particularly direct way.

In Chapter 17, Delemarle rounds out this discussion by looking at the role of standards with respect to a radical new technology with innovation potential across a huge spectrum of application contexts. By employing the concept of market framing, she examines the role of standards in shaping future markets for products based in nanoscience and nanotechnology. In this case, owing to the many public interest and safety concerns, a strong case can be made that a role for standards develops early on in the market framing process. This process is explored through a detailed ethnographic examination the work of ISO Technical Committee 229 on nanotechnologies.

1.8 STRATEGIES, STANDARDS AND INNOVATION: A PRACTITIONER PERSPECTIVE

In one way or another, most of the above chapters point to the issue of mechanism and the importance for understanding how standards come into being and are applied, in order to determine their possible effects on innovation. Our final section considers the standards–innovation nexus from inside these mechanisms, as seen from the perspective of those with experience of engaging directly in the development, implementation and management of standards. The three chapters presented here discuss these issues in terms of how standards are managed in firms, how they are developed in large complex international and multi-firm contexts, and how evolution in the legal, procedural and organizational environment for standards development can have major implications for innovation strategy in high-technology firms.

Jakobs begins this discussion by exploring how and why firms in the information and communication technology (ICT) sector participate in standards setting, and how different strategies emerge depending upon the relative importance of various strategic and tactical factors in participating firms. In Chapter 18, he reviews three cases that illustrate the variety of approaches to standards and standardization that firms and organizations might adopt, relative to several essential factors as drawn from the literature on both standards and innovation. He concludes that the increasingly complex environment in which standards are now developed mandates a much more strategic and professionalized approach at the firm level, geared to better intelligence as to the emergent issues and initiatives in any given standardization arena. He also notes that many of the opportunities to leverage innovation with standards occur within the process itself, and often become evident only as the process plays out.

In Chapter 19, Page discusses the history and current development

challenges of one of the largest and currently most high-profile international standards frameworks. Climate change is certainly among the most pressing international social and political issues. One of the major problems in obtaining consensus on how to control or reduce it centres on how industry can manage, measure and monitor progress in meeting national and international environmental targets. Begun following the Rio Summit, the ISO 14000 framework of environmental management standards is an ongoing global effort to facilitate this objective. As Page recounts, although the ISO 14000 framework is an innovation in itself in terms of environmental management, the constant challenge is to ensure that the goals of environmental mitigation through standards also support efforts to innovate more broadly in environmental technologies and practices throughout the industrial spectrum.

As so much of the serious investigation of standards and standardization as socio-economic phenomena was prompted by the emergence of the ICT industry, it is fitting that we round out this volume with a perspective from within that very industry. How has this massive standardization effort worked out in practice? In Chapter 20, Cargill recounts many lessons from long experience in corporate standardization strategy. In particular focusing in on the evolution of the institutional environment, especially the proliferation of industry consortia in the SSO genre, Cargill presents a critical view of to what degree the coordination issues that standards were meant to address have actually been resolved. He emphasizes that throughout history standards have never been mere technical specifications; that they also define what is and is not possible in a technological environment for both producers and users alike. He concludes that truly disruptive technologies are rare and, reflective of many comments elsewhere in the collection, that innovation is more likely to build upon existing knowledge and current practices. Standards play an essential role in this regard, but as Cargill warns, their effectiveness in this role can be hindered if the standardization process becomes subject to capture. His is a salutary reminder of the need to link analytical work on standardization phenomena more closely with practice.

1.9 GOING FORWARD

We began with the observation that although standards and innovation were quite clearly part and parcel of the same process of industrial development and growth, no general theory concerning this relationship had emerged. And as the chapters in this collection indicate, perhaps this is no bad thing. As Nelson and Winter (1977) cautioned 40 years ago,

innovation is probably best investigated at the level of mid-range theory: generalizations pertaining only to limited ranges of cases. The same is probably true for standards.

Nevertheless, collectively, the chapters in this volume all point to the conclusion that both standards and the various mechanisms for developing and implementing them are integral to processes and systems of innovation. This is significant in that the dominant viewpoints on how innovation creates value stress mainly its disruptive dimensions. And, certainly, many of the authors have illustrated how accelerating the process of change is often facilitated by reducing the number of variables that need be subject to change, by facilitating new learning routines and knowledge spillovers among stakeholders in innovation, and by priming the market with information that eases pathways to the adoption of new technologies, processes and practices, and to the establishment of new industries. But they have also explored that how standards can regulate the pace of change, whether positively or negatively, reinforces the need to double down on obtaining a much more detailed and nuanced characterization of the full scope of their role in innovation.

Although much work has been done on many of these issues in isolation, the time is clearly right for integrating the research milieus surrounding standards and innovation at much deeper conceptual and methodological levels. And considering the complexity of the problem, progress towards this goal will require even more crossover between disciplinary perspectives. All of the chapters in this volume show in one way or another that standards can never be seen only as technological artifacts, even if that turns out to be their primary function. Most authors point to the absolute necessity of focusing in on ‘mechanism’ – how standards are made – which is a multifaceted enterprise encompassing scientific, technological, political, social, economic and commercial dimensions in virtually every case. The reader will find the contributions to this volume to be replete with fascinating questions for further exploration. With great optimism, we turn these opportunities over to all of the communities of scholars, practitioners and stakeholders who have an interest in better understanding the relationship between standards and innovation.

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