IT STANDARDISATION – THE ECONOMIC AND THE SOCIOLOGY ACCOUNT

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Abstract:

Information Technology (IT) standards play an important role for the evolution of IT systems. Existing research has addressed the standardisation process from a variety of perspectives ranging from the economic theory to the sociological approach. However, by and large, such standardisation literature has documented standards as static artefacts with a bias towards the standard creation process, rather than standard use. Only few studies address the dynamic aspects of a standards development and use and the respective underlying rich social processes characterised by a process of negotiation amongst the interested actors. This paper reviews the existing economic and sociological literature addressing the history, content and use of IT standards, and identifies future areas of research analysing the dynamics of standards.

1. INTRODUCTION

The crucial role that standards play for the evolution of information and communication technologies has been largely documented in the literature. Information technology standards have been found to have a major impact on technology innovations (Jakobs, 1998), to represent an endogenous factor that shapes technology development (Egyedi, 1996), and to affect the rate and direction of innovation (David and Steinmueller, 1994). A growing body of literature has thus emerged investigating the factors shaping the standards development process and its outcomes. The processes underlining the development of standards have been largely addressed in existing literature from a variety of theoretical perspectives ranging from the economic theory to sociology based approaches. However, few studies address what happens to standards once the initial development stage is over and they are implemented and used in the market.

Standards are not static artifacts which are created fully-formed and are immutably diffused as users adopt them. As pointed out by Egyedi and Hudson (2001), once published, many standards undergo a transformation process during use. Such deviation can occur either as a result of competitive actions of implementers which aim to lock in customers, or due to genuine reasons such as the lack of relevance of some of the features of the standard to the specific contexts of use (Egyedi & Hudson, 2001). At the same time, during implementation and use, standards can be interpreted by users and adapted to the users' specific requirements.

Such a dynamic perspective sees standards as being created in a rich social process within which they evolve from loose requirements into defined specifications embedded in documentation through a process of negotiation amongst interested actors. This negotiation process continues after the specifications are approved and adopted, and leads to changes of the standard, either as succession of different versions or as different standards (see for example Egyedi and Loeffen (2002) study of the succession of XML from SGML).

A major focus of a study on standards dynamics is unavoidably the processes in which actors negotiate the content of standards within the standard setting bodies. This paper provides an overview of the existing literature addressing the history, content and use of IT standards that provides some insights into the dynamics of standards. The review is structured along two major theoretical strands in the standardisation literature, namely the economic approach which extends into the political and law based studies on standards, and the sociological approach including the institutional perspective on standardisation and the sociology of technology.

2. SOME DEFINITIONS

Ironically, there is still not one agreed standard definition of what a standard is in the literature. The existing definitions range from the very general, for example "*standards are pieces of general advice offered to large number of potential adopters*" (Brunsson & Jacobsson, 2000, pg. 2), to the very specific, such as the ISO/IEC definition:

"*[a standard is] a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*" (de Vries, 1999, pg. 14).

For the purposes of this paper, David and Steinmueller's (1994) definition is adopted because it encompasses both the broad and the specialised senses of the "standard". Consequently, for the purposes of this paper, a standard is *"a set of technical specifications that can be adhered to by a producer, either tacitly, or in accord with some formal agreement, or in conformity with explicit regulatory authority*" (David & Steinmueller, 1994, pg. 218). This definition emphasizes the different ways in which standards may emerge. Standards are created either through market mechanisms, in which case users tacitly join a community of users, or through agreements within standards committees, in which case adherence to the standard can be either voluntary or mandatory.

2. ECONOMIC LITERATURE REVIEW

By and large, the mainstream literature has addressed IT standardization from an economic perspective. Some of the earliest accounts of standardisation are made by economic historians. Thompson's study (1954), for example, explains the relationship between economic conditions and technological evolution by identifying the economic and technical considerations that have encouraged and respectively deterred the standardisation efforts in the US automotive industry up to the 1930s. Such early accounts of standardisation have raised the interest in applying the economic theory to study the standardisation process. Since the mid 1980s, economic models are used:

- ⇒ to study the process and effects of market driven standardization (Farrell & Saloner, 1985; 1986; David, 1987; Katz & Shapiro, 1986),
- ⇒ to compare different forms of standard settings (Farrell & Saloner, 1988; Genschel, 1997),

⇒ to analyze firm's choice between the standard settings available (Besen & Farrell, 1994), and

⇒ to explain the standardisation process outside the market realm (David & Shurmer, 1996; Hawkins, 1999; Swan, 2000).

One of the first studies to address **the standardisation process within the market**, what has been called later *de facto* standardisation (David, 1987), is David's historical narrative (1985) to illustrate the path dependence character of the personal computer keyboard standardisation process. Starting with David's (1985) account of the QWERTY standardisation process, the economic literature has extensively applied Arthur's (1989) analysis based on network externalities, increasing returns, and switching costs to explain the effects of market driven standardization, in particular the danger of lock in into an inferior standard (David, 1985; Farrell & Saloner, 1985; Katz & Shapiro, 1986).

Applying the game theory model, Farrell and Saloner (1985) found that in conditions of incomplete information, excess inertia arises impeding a collective switch from a common standard to a superior one, thus creating the danger of lock in to an inferior standard. However, the model presumes that all firms are identical in the sense that they all have the opportunity to switch to the new standard at the same time. In a following study, the model of excess inertia associated with de facto standardisation is developed further through the introduction of the time dimension (Farrell & Saloner, 1986). When time is considered for, excess inertia appears even under complete information, depending on the size of the installed base, on the speed at which the network benefits of the new standards are realised, and on the relatively superiority of the new standard[1]. Due to the biases of the installed base, excess inertia can also results from anticompetitive measures such as predatory pricing[2] and anti-competitive pre-announcements[3]. Apart from the danger of lock in to an inferior standard due to excess inertia, the model also discusses the inefficient adoption of a new standard, what the authors call excess momentum. Excess momentum may occur when users are willing to adopt the new standard even if benefits are late to manifest because it offers early adopters an advantage over the current standard (Farrell & Saloner, 1986).

The danger of lock in into an inferior standards thus appears as the result of the existence of costs associated with switching to a new standard. Such costs coupled with network externalities (Farrell & Saloner, 1985; 1986) or economies of scale (Klemperer, 1987a; 1987b) give a cost advantage to the incumbent over the new entrants. In these conditions, an opportunistic incumbent (seller of the current standard) could increase the price above competitors (entrants) by an amount equal to the buyers' switching costs. However, although the presence of switching costs make it harder for entering firms to attract established buyers, they actually encourage entry into the market to serve unattached users. As a result, switching costs alone do not form an entry barrier, but only in

[1] For example, if the installed base is large, and the network benefits of switching are slow to manifest, users are reluctant to switch even if it would be more efficient for them to do so.

[2] when the supplier of the current standard reduces the prices in response to the entry of new standards.

[3] such pre-announcements can prevent the bandwagon to gain momentum.

combination with network externalities or economies of scale they enable an incumbent firm to exclude competitors while still making positive economic returns (Farrell & Shapiro, 1988).

Much of the subsequent research looked at the negative effect that de facto standardisation can have on the market, in particular lock in into an inferior standard due to network externalities (Katz & Shapiro, 1986; 1994; Liebowitz & Margolis, 1994). David and Steinmueller (1994) and Swan (2000) provide a comprehensive review of the pro and anti competitive effects of de facto standardization including lower transaction costs and entry barriers, but also restriction on innovation and inducing predatory pricing behaviours.

As the understanding of the process of market driven standardisation was advancing, research focused on **comparing alternative forms of standard setting**. In a pioneering study, Farrell and Saloner (1988) compare three alternative modes of standardisation: market driven standardisation – characterised by the bandwagon effect; committee based standardisation – or formal coordination characterised by the battle of sexes model; and a hybrid model – which combines committees with market driven standardisation. Their analysis finds that whereas the formal standardisation outperforms the market driven standardisation (i.e. the standard fits better the requirements of the actors involved), the differences in payoff between the two models is gradually reduced as the time allowed for achieving standardisation increases. In other words, committees have significantly higher efficiency then the market model when the deadline for achieving the standard is sooner. In contrast, in the market driven model, the standard is obtained quicker, but it is not necessarily the best, whereas the hybrid model gives greater payoffs than the pure committee model. These results are supported by following research which finds that formal negotiation leads to late adoption, whereas market driven standardisation leads to excessive early adoption (Belleflame, 2002).

The same game theory model is used in Besen and Farrell (1994) study to analyse **firms' choice between alternative standardisation strategies**: either to engage in market driven standardisation process, to become involved in formal standardisation process, or to develop a proprietary standard. Genschel (1997) extends the model to explain for the co-existence of multiple formal standard developing organisations (SDOs) in the telecommunication industry. Genschel's (1997) analysis combines the economic approach with political science to analyse the factors that have led to firms choosing to participate in different formal SDOs, hence supporting a fragmented structure of the standardisation market in telecommunication.

With the huge expansion in the number of standard bodies during the mid 1980s and 1990s, the research focus has moved towards the analysis of the **different types of standard settings outside the market realm**.

The economic research suggests that the SDOs are characterised by a number of shared principles: due process, fairness and transparency, consensus and voluntarism. Such principles support a technocratic approach to standardisation which should ensure that standards are free from the political interests of the participants and represent the best solution to a problem. However, because of the highly bureaucratic process involved, such technocratic approach leads to slow and cumbersome standardisation (Besen &

Farrell, 1991; David & Shurmer, 1996; Swan, 2000). In contrast, such studies maintain that private consortia are more flexible and faster as their membership, internal procedures and rules can be tailored to specific tasks (David & Shurmer, 1996; Hawkins, 1999). According to Swann (2000), this excess inertia of the SDOs – i.e. the slow standardisation process that lags behind the technology innovation process – can be also seen as an excess haste from the part of the technology producers. As a result, the rate of innovation that cannot be supported by formal standardisation process is understood by Swann (2000) as being "too fast", rather than the formal standardisation process being seen as "too slow". At the same time, researchers argue that the argument that private consortia reduce the "time to market" is overestimated. First, it is based on the false assumption that all members are positively engaged in the work of consortia in which they belong (Hawkins, 1999). And second, in response to the emergence of private consortia, many formal SDOs are reforming their procedures to support faster and less bureaucratic standardisation process (Rada & Ketchell, 2000).

To summarise, starting with an economic account of the history of standards, until the 1980s the economic research has focused on the market driven standardisation, and the effects that is has on the market. Although not as numerous, a different stream of economic researchers have focused on explaining why firms engage in market standardisation rather than other forms of standardisation such as formal, committee based standardisation. The focus is on the firm's choice between alternative forms of standard settings which is based on efficiency criteria and it is analysed employing the game model theory (Belleflame, 2002; Besen & Farrell, 1994; Farrell & Saloner, 1988; Genschel, 1997). In general, the economic argument goes that committee standardisation, i.e. standardisation within standard bodies, is more efficient but slower than market standardisation (Farrell & Saloner, 1988).

The advance of IT during the last two decades, and the importance that IT standards play in shaping the evolution of technology led to an increase in the interest in standardisation issues outside the purely economic field. Comparing alternative forms of standardisation became a recurrent theme in other economic related fields such as political theory and law literature.

Political theory researchers have adopted the economic arguments and have analysed the evolution and characteristics of the various forms of standard setting bodies. Such studies suggests that the firm's choice between different forms of standardisation depends on standard settings bodies' characteristics such as the cost of vote recruiting, number of actors and procedural mechanisms (Austin & Milner, 2001; Weiss, 1993). Political theory was also applied to understand the political process through which standard setting emerge (Nicolaodis & Egan, 2001; Pelkams, 2001). The economic account has also pervaded the law literature that focuses on the connections between standardisation and intellectual property rights (Smooth, 1995). Smooth (1995) points out that although proprietary rights are frequently alleged to be inimical to the standard process, in practice standardisation seems to have taken proprietary claims to its stride.

All the economic models of standardisation are based on the fundamental assumption that the actors involved in the standard setting process are seeking economic benefits. A critical variable in the game theory and governance decision analysis models is the payoff for the firms involved, where the payoff represents economic returns (Besen & Farrell,

1994). The social processes that underlie the standardisation process are excluded from the analysis. Economic theory explains why standardisation takes place within committees rather than other forms of standard settings, and why such committees exist. However, the exclusive economic focus restricts its ability to explain how these committees are organized and how actors are enrolled. To address the rich social processes that characterize the standardization process and which cannot be captured in an economic account, standardization researchers have increasingly adopted social theories such as social shaping of technology (Graham et al, 1995), social constructivism and institutional theory (Schmidt & Werle, 1993; 1998).

3. SOCIOLOGY APPROACHES TO STANDARDISATION

A significant insight from the sociology of science and technology relevant to the study of standards is the critique of technological determinism: technology is seen as a social product, patterned by the conditions of its creation and use. A variety of technical options are available at every stage, in both the generation and implementation of new technologies. The option that is selected cannot be reduced to simple technical considerations, but is shaped by a broader range of social, economic and political factors (Bijker, 1995; Williams & Edge, 1996). As a result, it is not necessarily the "best" standard that will emerge as the dominant technology[4]. The standard which becomes accepted as a dominant design (Abernathy & Utterback, 1978), cannot be seen as a function of technological determinism (Anderson & Tushman, 1990) as often rival designs may be technologically superior (as in the case of QWERTY, see David, 1985). The sociology approach sees the emergence of dominant design as a result of the actions of individuals, organisations and the networks of organisations. The process is thus contingent on the social and organisational context (Anderson & Tushman 1990). Additionally, the dominance of "dominant designs" also provides a template for competing solutions: a standard may therefore exert mimetic influence over apparently competing standards developments. For example, the HTML standardisation was used as an exemplar for the development and diffusion of XML standards (Egyedi & Loeffen, 2002).

A valuable concept for the study of the dynamics of standards is "interpretative flexibility" (Bijker, 1995): the scope for technological artefacts to be adapted and used in ways not envisaged by the developers. The use of this flexibility during implementation is a major element of standards dynamics, placing the use of standards out of the control of the actors maintaining and publishing them. For example, the tension between standardisation and flexibility in IT implementation was highlighted by Hanseth et al (1996).

Drawing from the **social shaping of technology** perspective, the standardisation process is seen as locally constructed, negotiable and contingent (Graham et al, 1995; Williams, 1997). The actors involved in standard creation try to translate their interests into the standard, and hence the outcome of standardisation is seen as the result of this negotiating process (Graham et al, 1995; Monteiro & Hanseth, 1995; Spinardi et al, 1996).

[4] where the "best" standard is seen as a superior standard from a technical standpoint.

Standardisation is thus not only about providing workable solutions, but it refers to articulating and aligning expectations and interests (Williams, 1997). The formation of social networks was found to be crucial in shaping the development of electronic data interchange standards (EDI) as they allow the collective benefits of the users involved to be understood and the necessary resources to be coordinated between participants (Graham et al, 1995). Political and organisational factors were found to shape EDI standard adoption rather than the technical characteristics of the technology (Spinardi et al, 1996).

Standards are seen as *"socially constructed*" where "*technological choices can be explained as the outcomes of the interactions between intentional actors*" (Schmidt & Werle, 1998, pg. 16). Coordination is difficult in such circumstances since large technical systems rely on the coordination of autonomous action of multitude of individuals and organisations. Some researchers argue that in the social approaches the location of relevant social groups has been neglected and that institutional and organisational factors have to be included in the analysis to identify the membership and boundaries of such groups (see for example Pinch & Bilker, 1984; Hughes, 1987). To address this limitation, Schmidt and Werle (1993; 1998) **combine the social constructivism approach with the institutional theory**. Such an approach allows the authors to analyse the organisations coordinating standard development as emerging institutions, stressing the institutional settings and rules that help to achieve such coordination. Schmidt and Werle (1998) argue that both artefacts and institutions are channelling, framing and contextualising the actions and interactions of these *"intentional actors"* involved in standard creation. The standardisation field is conceived as highly institutionalised. Such institutions are claimed to "*shape technological development by providing a normative and cognitive frame, a specific rationality for action, and often also an arena, in which institutionally defined and invoked relevant actors create and decide upon different options or paths of development. They create opportunities and constraints which channel but do not determine individual action.*" (Schmidt & Werle, 1993, pg. 8). The standardisation environment provides standard organisations with institutional rules that determine their *"general procedure, the decision process, sometimes the legitimacy of arguments, and the value of consensus"* (Schmidt & Werle, 1998, pg. 19) and shape the negotiation process within standard committees (Schmidt & Werle, 1993). In this way, institutions contextualise situations by providing specific rationales for actions to the actors involved in the standardisation process (Schmidt and Werle, 1993; 1998). With respect to rationales regarding technology, the authors identify four categories of perspectives (or type of reasoning): technical, economic, political and scientific type of reasoning. The influence of these perspectives depends on institutional and organisational factors. The authors argue that apart from membership and decision rules, the different existing standard setting committees are also governed by these rules regarding the legitimacy of the different types of reasoning (Schmidt & Werle, 1993).

Schmidt and Werle's (1993; 1998) studies emphasize the influence that institutional rules have on the way actors coordinate standards development. Along a similar line of argument, Egyedi (2000) argues that standard setting is shaped by the beliefs, values and assumptions embedded in the standard organizational procedure. This "*standardization ideology*" regulates the committee process and shapes the rules that govern the standard creation process (Egyedi, 2000).

In a following work, Werle (2001) examined the institutional aspects related to different forms of SDOs. Werle's study (2001) identified the co-existence of several competing forms of SDOs. Despite this competition, the study found that many of the SDOs share similar institutional features: negotiation, voluntary participation, consensus-based decision making and inclusiveness of committees. Therefore, even though SDOs differ in institutional settings and in their internal organisational structure, Werle (2001) points out that SDOs have developed both mimetic and coercive isomorphism. According to Werle (2001), it is this institutional isomorphism that explains the peaceful coexistence of so many different SDOs with overlapping jurisdiction.

Isomorphism develops not only between organisations that develop standards, but also among organisations that use these standards. Lawrence (1999) found that standards led to coercive (standards imposed through regulation) and mimetic (as in the case of de facto standards) isomorphism for the organisations that adopt them. According to Lawrence (1999), standardisation in general is concerned with the establishment of technical, legal or informal standards that define what is "normal" for a practice, product or service either through regulation or through enactment of less formalized norms or standards. The author argues that standardisation strategies are not about organisations adopting practices which are already normatively sanctioned in order to legitimate their own existence, but about the movement of practices from the realm of technical rationality to that of institutional rationality (Lawrence, 1999).

To summarise, the sociology of technology sees standardisation as socially constructed, as a process of articulating and aligning expectations and interests (Williams, 1997). However, such studies have difficulties in accounting for the influence of the prior history on the process, and for the taken for granted relations, routines and the broader context and structures. To account for some of these limitations, a number of sociological studies on standardisation incorporate in their framework the institutional theory (notably Schmidt and Werle, 1993; 1998). Such studies aim to explain the influences that both the artefacts and the institutions have on the actions of the actors involved in the standardisation process. Institutional studies on standardization explain the existence of isomorphism in the context of standard setting (Werle, 2001) and standard user (Lawrence, 1999) organisations, and the role that institutional context plays in framing the standard development process (Schmidt and Werle, 1998). However, existing institutional research in the standardisation arena focuses on the similarities between emerging standard setting bodies rather than on their broad variety. In contrast, economic research points out the broad diversity that characterizes the private standard consortia realm that share only the informal character of their "formal structure". (Hawkins, 1999). At the same time, existing studies show that even the established, formal SDOs are in a process of constant change as they are attempting to adapt to the increasing competition and new demands for a faster and more efficient standardisation process (David and Shurmer, 1996; Rada & Ketchell, 2000), which leads to significant transformations in the institutional environment in which standard setting operates.

4. CONCLUSIONS

This paper has reviewed the existing economic and sociology approaches to IT standards. Whereas the economic theory explains why standardisation takes place within a particular

form of standard setting, and why such settings exist, the sociological account sees standardisation as socially constructed and as a process of articulating and aligning expectations and interests. Sociological studies attempt to explain, for example, how these committees are organised and how are actors enrolled. Nevertheless, such studies have difficulties in accounting for the influence of the prior history on the process, taken for granted relations, routines and the broader context and structures. To account for such limitations, standardisation researchers have relied on institutional theory to bridge the gap in explaining the influences that both the artefacts and the institutions have on the actions of the actors involved in the standardisation process. Whereas the institutional theory may offer the theoretical framework to address both the local and the broader influences on the standardisation process, existing institutional studies in the standardisation arena tend to focus on the similarities between emerging standard setting bodies rather than on their broad variety.

Additionally, although different in their underlying understandings, the economic and sociological account focus largely on the standard creation and development process, rather then on the standard implementation and use.

The analysis of existing standardisation literature highlighted two areas that are relatively under-represented in the standardisation literature. The first concerns the co-evolution of the standards and the SDOs themselves which has not been widely described in the literature because there have been few ethnographic studies of the negotiation of standards in SDOs. The second lacuna in the literature concerns the dynamics of standards in use, as users adapt standards to suit a local context. As standards are technological artefacts we would expect the exploitation by users of the interpretative flexibility that this provides to have been widely studied. However it may be that the assumption that standards are immutable has led researchers away from studying their dynamics in use; it may be that to study the local redefinition or interpretation of standards is seen as being a study of the abuse, rather than use, of standards.

Future empirical research is required to address these gaps. First, in-depth case studies of the standard settings are required in order to explore the rich social processes that characterise the negotiations surrounding standard development. Such studies should bridge the gap between social shaping of technology accounts that tend to focus too much on the specificity of the actors, and the institutional studies that tend to emphasise the institutionalised environment, ignoring the significance of contingencies in shaping the standardisation process. Second, empirical studies should address the adoption and use of the technologies embedding such standards within specific organisations, with an emphasis on the "standard" element of these technologies. Such studies should explore the way users adopt and (might) change the standard to fit their specific requirements, and how such changes (might) reflect back into the standard development process leading either to a replacement of the initial standard or to the emergence of a new version of the same standard. In a first instance, these studies should take the form of single, in-depth case studies in order to explore this under-research are of "standards in use". Based on the insights from these in-depth case studies, following studies should conduct a large scale survey in order to provide an overview picture of this phenomenon, and identify generic trends.

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