Research Policy 45 (2016) 546–559

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Meso-level factors in technological transitions: The development of TD-SCDMA in China

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ARTICLE INFO

Article history:
Received 30 May 2014
Received in revised form
20 November 2015
Accepted 20 November 2015
Available online 8 December 2015

Keywords:
Technological transitions
Multi-level perspective
Meso-level factors
TD-SCDMA
3G mobile networks
China

ABSTRACT

This paper uses an industry case study of technological transition from second-generation (2G) to third-generation (3G) networks in China to unfold how meso-level factors drove the development of TD-SCDMA, China's home-born 3G standard. In this purposive transitional process, under the coordination of a central authority, multiple 'regime actors' (government agencies) engaged in bargaining, negotiation and consensus building that determined the developmental directions and outcome of TD-SCDMA. TD-SCDMA proved to be a political success but an economic failure. The policy implications are profound. In particular, as the 'silo regulatory model' of policy making which focuses on a single industry is gradually replaced by a collective model involving interindustry players, issues about how to manage the collective model pose a serious challenge to policy makers in China and other emerging countries. The paper provides evidence for the importance of meso-level factors in the multi level perspective (MLP) framework of sociotechnical transitions.

1. Introduction

Technological transitions in a sociotechnical system are not only technical in nature but also institutional (Hoffman, 1999). The mechanisms that drive technological transitions in such systems are often complex. Although 'Darwinist' processes of variation and selection (Nelson and Winter, 1982) are important in determining the outcome, in many cases the transition is also subject to government intervention (Ansari and Garud, 2009; De Jong and Stout, 2007).

The multi-level perspective (MLP) (Rip and Kemp, 1998) is commonly used to understand system transitions. It argues that internal momentum from niche-innovations at the micro level and external pressures from changes in landscape at the macro level can create destabilization in the sociotechnical regime (Geels and Schot, 2007). Smith et al. (2005) recognize the importance of meso-level factors. They argue that, in addition to selection pressures bearing upon a regime at the macro level and the availability of resources at the micro level, the ability to coordinate those resources at the meso (institutional) level is equally important in sociotechnical transition. Regime actors at the meso level play a significant and active role by enacting public policies, offering incentives, mobilizing resources and coordinating the efforts of a wide array of stakeholders (Kemp et al., 2001). There is, however, a lack of empirical research that systematically identifies and/or analyzes how meso-level factors operate and influence the directions and outcomes of such transitions (Genus and Coles, 2008; Smith et al., 2005). This paper aims to fill this gap by analyzing the role played by meso-level factors in a significant transition of mobile communication networks in China.

Mobile communication networks are complex sociotechnical systems that are composed of many subsystems, the interoperability of which is achieved by standards. Technological transitions of such networks have largely followed generational changes in standards, driven by the needs for more capacity, higher speed of transmission, and smoother global roaming (Ansari and Garud, 2009). First-generation (1G) wireless networks were analog systems that enabled basic voice transmission, with no internetwork compatibility or global roaming. 1G mobile networks were commercialized in many industrialized countries in the 1980s and entered China in 1992. Second-generation (2G) networks were digital systems enabling voice and low-bandwidth data transmission, as well as limited global roaming. 2G digital networks were commercialized in Europe, Japan and the US in the mid 1990s, and China was not far behind. Third-generation (3G) networks enabled broadband and high-quality data and voice transmission, as well as seamless global roaming. The transition from 1G to 2G was largely a generational change focusing on performance upgrades. However, rather than just being a performance upgrade along the same technological trajectory, the transition from 2G to 3G was a paradigm

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http://dx.doi.org/10.1016/j.respol.2015.11.006
0048-7333/

shift in which networks, consumer behavior, the industry value chain, R&D, the regime (regulators and rules) and even the meaning of using a mobile phone all changed dramatically. This transition saw the functionality of mobile communications changed from a communication tool based on telecommunication networks to a mobile Internet platform based on converged networks (Ansari and Garud, 2009) and was, thus, not just about the evolution of core technologies, but the *co-evolution* of technical and social elements on the entire industry value chain.

Though R&D for 3G standards started in the 1980s, it was not until 1996 that the International Telecom Union (ITU) released the technical requirements for 3G standards. There are three ITU-approved 3G standards: WCDMA (wideband code division multiple access) developed and sponsored by European telecom manufacturers; cdma2000 by an American and Korean consortium; and TD-SCDMA (time division-synchronous CDMA), proposed by the Chinese government. At the time TD-SCDMA was approved as a global 3G standard, it was in its infancy compared to its two rivals. Despite apparent limitations, in 2009 – nearly a decade after the world's first 3G network was commercialized – China Mobile, the dominant mobile operator, was granted a license to commercialize the TD-SCDMA standard. By then, WCDMA had 284 commercial networks and cdma2000 106 networks worldwide (ITU, 2010). China was the only market where TD-SCDMA was commercialized. China Mobile's 78.1% share of the 2G market in 2009 dropped to 38.3% in the 3G market in 2012 (MIIT, 2013).

The transition to 3G was especially complex, because it involved competition between different 3G standards, and competition between the vested interest groups behind each standard. The transition to 3G in China was an exceptional manifestation of a 'standards war', involving competition between multiple stakeholders at multiple levels. By opening the 'black box' of the developmental process of TD-SCDMA, based on a meso-level analysis, this paper aims to examine why TD-SCDMA was adopted as a primary 3G standard by the country's monopolistic operator when more mature and cost-effective rivals were available; the driving forces behind this transition; and the way these factors operated during this transition. The paper illustrates how in China meso-level factors interplay and collectively drive sociotechnical transitions and exemplifies how policymaking emerges from a balance in power between multiple regime actors operating under higher-order coordination.

The rest of the paper is organized as follows: Section 2 discusses theoretical perspectives; this is followed by a description of the research methods in Section 3; the findings of the case are presented in Section 4; Section 5 discusses critical issues that emerge in the case against the backdrop of the theoretical framework, and draws policy implications; and Section 6 concludes the paper.

2. Theoretical background

2.1. Technological transitions

The concept of transition is about the transformational processes by which society changes in a fundamental way over a substantial period of time (Rotmans et al., 2001). Transition management research deals with system change or system innovation, highlighting the adaptive behaviors of multiple actors (Geels, 2004; Kemp et al., 2007; Nill and Kemp, 2009; Rotmans et al., 2001). Where technological advancement plays a critical role, the transitions are defined as "...major, long-term technological changes in the way societal functions are fulfilled" (Geels, 2002: 1257). Hughes (1987) uses the concept 'large technical systems' to describe networks that fulfill functions of social infrastructure. Geels (2002) adds the social aspect to such systems, renaming them sociotechnical system. Recent literature defines a sociotechnical system as a network built upon capital-intensive infrastructures, based on relatively stable configurations of institutions, techniques and artifacts, as well as rules and practices that determine technological transitions (Geels, 2002; Geels and Schot, 2007; Markard and Truffer, 2006). Therefore, technological transitions of a sociotechnical system "do not only involve changes in technology, but also changes in user practices, regulation, industrial networks, infrastructure, and symbolic meaning or culture" (Geels, 2002: 1257).

Indeed, sociotechnical transitions are not just functional improvements along a series of S-curves (Ansari et al., 2010); rather they often involve more radical changes in fundamental thinking and practice – what Kuhn (1962) calls 'paradigm shifts' – resulting in transformations of knowledge base, R&D, organizational learning, manufacturing, and institutions from the old system. Indeed, in sociotechnical systems that fulfill significant social and political functionalities, political attributes are embedded in those systems (Courvisanos, 2009). Transitions with radical breakthroughs have to compete not just with legacy technologies, but with institutional settings that create and sustain the stability of the old system. This is because, on the one hand, during transitions incumbent technological regimes persist even when they are inferior to the new ones, and, on the other hand, new technological regimes find it hard to be formalized to fit into the existing frameworks of infrastructure, applications and institutions. Nelson and Winter (1982) refer to those frameworks supporting incumbent technologies as the 'genes' of a regime, while David (1994) describes them as 'carriers of history'. Both metaphors imply that technological regimes are subject to strong path dependence. In other words, the regime provides a high degree of stability and inertia in the system. Despite the importance of the regime, it is portrayed as passively responding to endogenous factors in transitions (Genus and Coles, 2008; Smith et al., 2005). Overall, there is a lack of empirical evidence about the role played by regime actors in sociotechnical transitions.

2.2. The multi-level perspective (MLP)

The mechanisms that drive technological transitions in sociotechnical systems are complex, caused by dynamic interactions and feedback loops between system elements in a non-linear fashion (Geels and Schot, 2007). Though there are multiple sources of causality and co-evolution caused by independent developments of multiple elements following an evolutionary process, such transitions are also subject to government intervention (Ansari and Garud, 2009; De Jong and Stout, 2007).

Though it has received criticism for a lack of attention to the role played by agency and power in sociotechnical transitions (Genus and Coles, 2008; Smith et al., 2005) and for its exclusive reliance on inductive case studies (Papachristos, 2014), the MLP of technological transitions proposed by Rip and Kemp (1998) provides an overarching theoretical framework that has been widely used in analyzing system transitions. In it, the co-evolution caused by independent developments of multiple factors in a system can be divided into three layers: at the macro level, the sociotechnical landscape defines infrastructure, politics, culture, social values, demography, macro economics and the natural environment; at the meso level, the sociotechnical regime determines dominant practices, rules, interests and shared assumptions which underlie public policy and the collective and/or private actions of firms; at the micro level, niches provide protected space and time where variations to and deviations from the mainstream technology can emerge, be cultivated and grow (Geels, 2002, 2010). The MLP emphasizes the factors at the micro and the macro levels that destabilize a sociotechnical regime (Geels and Schot, 2007). Yet, it is not clear what those meso level factors are and how they operate in sociotechnical transitions.