

Chapter 2

Anchoring Global Networks in Urban Niches – How onsite water recycling emerged in three Chinese cities

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1. Introduction

Analyzing the spaces and places in which sustainability transitions evolve - and especially the crucial role of cities in this process - has moved center stage in academia and policy circles (Bulkeley et al., 2011; Hodson and Marvin, 2010). Evidence is growing that transition dynamics in urban contexts cannot be understood based on the specific actors and dynamics inside a city alone, but that they span actors and processes at multiple interrelated spatial scales (Betsill and Bulkeley, 2006; Hodson and Marvin, 2010). Yet, transition literature to date only provides a limited understanding on how multi-scalar spatial contexts influence transition pathways. It thus lacks explanations on why transitions emerge in specific places while they fail in others (Coenen and Truffer, 2012; Raven et al., 2012; Smith et al., 2010). As a consequence, it remains rather unclear by what strategies and under which conditions specific urban actors can make a difference in furthering sustainability transitions, for instance by acting as strategic niche managers for new technologies.

The present chapter aims at addressing this research gap by elaborating on the ability of urban actors in mediating local and global resource flows as a precondition for niche formation. Our analytical framework will draw on recent insights from economic geography and argue that an important element in explaining early niche formation processes is urban actor's ability to combine territorially embedded innovation processes with mobilizing resources through networks reaching outside the city. We propose the concept of socio-spatial anchoring to analyze how local niche activities get connected to international technological innovation systems and analyze what key role urban actors fulfill in these multi-scalar innovation systems.

2. Urban actors as intermediaries between local niches and global networks

Transition studies generally assume that sector-wide transformation is the outcome of interrelated processes at a niche, regime and landscape level (Geels, 2002). Especially the emergence and development of socio-technical niches and the mechanisms through which they build up a constituency behind new technologies is crucial for transition theory (Kemp et al., 1998). Recent empirical evidence shows that actors in specific urban contexts can play crucial roles in such niche upscaling dynamics (Bulkeley et al., 2011; Hodson and Marvin, 2010): E.g. urban governments can act as strategic niche managers by providing 'protected space' for experimentation (Hodson and Marvin, 2010), induce targeted niche policies (Carvalho et al., 2012), and often even coordinate niche experiments in wider inter-city networks (Betsill and Bulkeley, 2006). As Hodson and Marvin (2010, 477) put it, urban governments increasingly "have political aspirations to develop purposive and managed change in the socio-technical organization of infrastructure networks that can be characterized as 'systemic' transitions."

Yet, much of the work dealing with such urban transitions is still preoccupied with niche formation and governance processes at regional to national scales and rather ignores international interdependencies (Coenen et al., 2012). Existing literature does also not specify in much detail how pre-existing urban institutional and sectorial configurations influence niche formation processes. Recently, economic geographers have criticized this simplistic concept of geographic contexts in transition literature: In a globalizing knowledge economy, both regional (urban) contexts and global networks are key building blocks of a thorough understanding of innovation and niche formation processes (Bathelt et al., 2004; Coenen et al., 2012).

2.1 Insights from economic geography: Endogenous and exogenous transition dynamics

Economic geography literature provides two helpful perspectives for analyzing cities' role in niche formation: On the one hand an 'endogenous' view, which emphasizes innovation dynamics stemming from pre-existing social and institutional capital of territorial innovation systems; e.g. specific capabilities, industrial structures and local institutional arrangements (Boschma and Frenken, 2011; Moulaert and Sekia, 2003). In this view, regions or cities with a diverse actor base and historically grown culture fostering reciprocal trust and mutual learning have a higher propensity for innovation and industrial renewal (Moulaert and Sekia, 2003). Urban niche actors would arguably profit from such dense localized institutional arrangements (Dewald and Truffer, 2012) and from historically grown positive externalities like specialized workforces, knowledge infrastructures and governance arrangements that support continuous innovation (Boschma and Frenken, 2011). To understand the determinants of successful niche upscaling, a close focus on the local socio-technological contexts is thus indispensable.

A second – 'exogenous' - perspective argues that innovation is increasingly shaped by international networks, mobile actors and multi-locational knowledge dynamics (Crevoisier and Jeannerat, 2009). In today's globalizing knowledge economy there is a shift "from specialization within regional production systems to [...] knowledge and resources within multi-location networks of mobility and anchoring" (Crevoisier and Jeannerat, 2009: 1225). Innovation is still conditioned by territorial

agglomeration, but exchange processes between distant places gets increasingly important, too. This applies in particular to cities, whose actors often occupy central positions in global knowledge-, capital- or specialized labor networks (ibid.). Cities can accordingly be seen as unique spatial contexts in which radically new products and technologies can profit from locally specific institutional structures as well as resources stemming from trans-local networks (Binz et al., submitted).

The early formation and later development of niche technologies in a given city thus depend on how well urban actors are able to mobilize extra-regional networks, resources and knowledge, and mobilize them in sustained local niche formation processes. This involves a series of mediation activities between production and consumption, between different political priorities and between planning and implementation (see Hodson and Marvin, 2010:482), which we conceptualize here as ‘anchoring’ (Crevoisier and Jeannerat, 2009). We understand anchoring as a *systemic* process through which actors in a city manage to actively embed external knowledge, actors and resources into local supply and demand structures and the wider institutional context.¹

2.2 Analytical framework: Anchoring of global innovation system resources

We conceptualize anchoring by drawing on recent insights from the technological innovation system (TIS) approach. TIS are generally defined as “a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” (Markard and Truffer, 2008: 611). Besides the core structural elements (actors, networks and institutions) TIS research focuses on seven key formation processes (also called ‘functions’)² to analyze early gestation processes in socio-technical niches (Bergek et al., 2008; Markard and Truffer, 2008). How well a niche is developing, diffusing and utilizing an innovation can be analyzed by assessing the performance of these processes (Bergek et al., 2008).

In the present chapter we thus assume a direct relationship between TIS formation and the evolution of urban niches: The better the TIS performs in a specific urban context - i.e. the more system building processes its actors activate and the more system structure they build in a cumulative causation process - the better the development potential of an emerging niche technology in a city. We furthermore posit that TIS performance cannot be assessed with a myopic focus on local system structure, but that international connections have to be equally taken into account (Gosens et al., 2013). The development of the TIS thus depends on connections between actors and processes emerging both endogenously in the city and exogenously in wider networks of a ‘global TIS’ (for a more detailed discussion see Binz et al., 2014; Binz et al., submitted).

Based on these foundations, we define “anchoring” as the buildup of a local innovation system, which embraces and supports local actor’s capability to access, interact with and ‘capture’ knowledge, information, ideas or any form of tangible and intangible asset from other places in the global TIS. Through interactive learning and the increasing integration of local and extra-regional inputs, TIS formation may be anchored in a specific urban context, leading to increasingly spatially

¹ Note that we understand anchoring in a geographic sense of Crevoisier et al. (2009), not related to regime-niche interaction (Elzen et al., 2012).

² Knowledge creation, entrepreneurial experimentation, market formation, guidance of the search, creation of legitimacy, resource mobilization and creation of positive externalities (for an overview see Bergek et al. 2008 and Hekkert et al. 2007). We refrain from analyzing positive externalities here as urban studies usually see them as a cumulative outcome of the other system building processes.

'sticky' resources for (radical) innovation. Over time, the relevant actors, networks and institutions stabilize and the proto-TIS scales up, evolving into a proto-regime that increasingly challenges dominant regime structures inside and beyond a given urban context.

3 On-site water recycling as an empirical case and methodological approach

We will illustrate this framework with the transition to onsite water recycling (OST) technology in China. OST is based on washing-machine sized wastewater treatment plants that produce recycled water in the basement of buildings. It represents a disruptive innovation with transformational potential to the wastewater sector's dominant regime: Instead of relying on extended sewer networks and centralized, utility-based organizational forms, OST allows for mass-produced modular treatment and decentralized operation and maintenance.

The technology has not yet left the niche stadium. Except for Japan and the USA, OST niches are mainly served by small to medium enterprises and no dominant design for OST plants has emerged yet (Truffer et al., 2012). Nevertheless, OST technologies' R&D networks are globalized with associations and epistemic communities integrating experiences from different OST niches at an international level. A relevant 'global OST TIS' has formed and OST applications are gradually expanding in many places around the world (Binz et al., 2014).

We focus on OST in China for two main reasons. First, Chinese cities are all latecomers in the OST field, so focusing on China allows reconstructing the full development cycle of OST niches over a relatively condensed timespan. Second, desk research showed that China's pressing urban water problems created a lot of activity in the OST field, leading to easily comparable success and failure cases. So far, a considerable OST niche emerged only in Beijing, where 2'000 to 3'000 OST systems have been installed over the last twenty years. Its success story was chosen for in-depth investigation, whereas Shanghai and Xi'an represent contrasting failure cases.

According to the existing literature elaborated in section 2.1, we would expect strong OST niches to emerge in regions which provide either strong endogenous innovation potential (incumbent related industries, supportive institutional arrangements) and/or have strong access to international knowledge networks.

Table 1: Initial development potential and TIS performance in three Chinese cities

Location	Endogenous potential	Exogenous potential	Landscape pressure	Performance of OST TIS
Beijing	+	+	+++	+++
Shanghai	+++	+++	+	+
Xi'an	+	++	+++	+

+ = weak, ++ = medium, +++ = strong

Among the three considered city regions, endogenous development potential was arguably strongest in Shanghai. When first OST experiments started in the late eighties, the city could already provide basic know-how and a specialized workforce in related industries (e.g. pumping, process engineering).

Xi'an and Beijing could not provide comparable industrial capabilities. Also in terms of exogenous development potential, both Xi'an and Shanghai had more promising preconditions than Beijing: Shanghai was the most internationalized commercial center of China, while Xi'an hosted a very active returnee entrepreneur³ who tried to push OST from the early nineties (see section 6.3). Finally, in terms of landscape factors, both Beijing and Xi'an historically have very pressing water shortages that exert a strong push on local governments to explore new water-saving solutions. This pressure is less pronounced in Shanghai, which however struggles with heavy water pollution (Lee, 2006). As can be seen from this short discussion and Table 1, Beijing initially provided quite weak endogenous and exogenous development conditions, but still developed into the only Chinese city where substantial TIS development can be observed. In the remainder we will try to explain this seemingly contradictory observation based on our framework.

Methods

Applying functional TIS analysis (Bergek et al., 2008; Hekkert et al., 2007) with a focus on international linkages poses specific challenges to the research design and methods (for an overview see e.g. Binz et al., 2014; Gosens et al., 2013). In this study we decided to use an expert interview-based, comparative case study design. 40 interviews were conducted between November 2010 and May 2011, covering experts from all relevant TIS actor groups (Table 2). Interview transcripts were codified and analyzed with qualitative content analysis and the results triangulated with secondary data sources and existing literature.

Table 2: Interviews in China

Actor group	Interviews Beijing	Interviews Shanghai	Interviews Xi'an	Sum
Academia	10	2	1	13
Companies	12	6	0	18
Policy experts	3	2	1	6
Associations	2	0	1	3
Total	27	10	3	40

4 The emergence of onsite water recycling in Beijing, Xi'an and Shanghai

In the remainder we will first describe the emergence of Beijing's OST niche (for a more detailed discussion see Binz et al., submitted) and then shortly compare it to the two unsuccessful cases in Shanghai and Xi'an.

4.1 OST in Beijing

1990-2000: OST is established in an internationalized hotel niche

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First OST activities in Beijing started in the late 80ies, driven by strong water problems: In 1987, the city government formulated a regulation that forced large hotels to introduce onsite water recycling facilities and thereby created a protected market niche for OST (Mels et al., 2007). At the time, local know-how on wastewater treatment was still very limited, so hotels had to refer to foreign companies (mainly from Japan, Germany and France) to comply with that regulation.

The first OST systems in hotels performed quite well. As hotels could provide professional operation of their OST plants, basic *legitimacy* for the concept developed, and local engineers, policy makers and practitioners first realized OST's full potential. Several local universities and research institutes started experimenting with OST pilots. Yet, these *knowledge creation* activities were still explorative, aimed at scientific discoveries and not connected to local industrial partners. *Entrepreneurial experimentation* was almost exclusively imported from outside of China: Many foreign firms competed in Beijing's small hotel market, but none of them could achieve a dominant market position. Domestic competition formed only in the late nineties when first Chinese companies developed their own OST systems, though at a very basic technological level. As the hotel niche was strongly driven by extra-local actors and international hotel chains, also *resource mobilization and guidance of the search* did not emerge locally, but were mostly imported from outside Beijing.

Until the late 90ies, only few TIS structures and processes emerged locally. Beijing's hotel niche was mainly kept alive by connections to niche actors from other places in an otherwise globalized TIS. Only little anchoring could be observed.

2000-2007: Localized system building in a residential building niche

In the early 2000s, Beijing's city government decided to extend the successful water recycling legislation from hotels to residential buildings. This small addition to existing city regulation essentially forced most new residential projects in Beijing to include onsite systems and opened a big new niche market, which induced a surge in the local actors' system building activities.

As the market potential of OST suddenly skyrocketed, new companies were established that tried to serve this market. Several firms were founded around the year 2000 by returnee entrepreneurs or as spin-offs from Beijing's universities (*entrepreneurial experimentation*). This emerging industry maintained strong international ties through migrating expert's personal networks and the city's internationally well connected universities. We therefore observe an early form of anchoring of international capability stocks in the local context. According to our interviewees, in the first few years, the new local actors were mainly involved in "learning by doing": They installed premature own designs and then learned on the spot about the specific challenges in running and maintaining OST plants in residential buildings. In parallel to this practical learning, knowledge creation in local universities also intensified. As start-ups needed consulting expertise in configuring and operating OST plants, the local industry built up dense cooperation with local research institutes. *Knowledge creation* between local start-ups and research organizations took on an increasingly reciprocal character.

Yet, despite dynamic knowledge creation, after five years the residential building niche run into considerable problems, mainly due to misalignments in residential OST project's institutional context (weak regulation enforcement, dysfunctional operation & maintenance systems, low prices for recycled water, etc.). Our interviewees contend that a big fraction of the residential OST systems are not fully operational anymore today. This fiasco strongly *delegitimized* OST in Beijing and made the

technology increasingly look like a very undesirable solution. Nevertheless, in that second phase also other system building processes started emerging locally: *Resource mobilization* was now provided by real estate developers that were essentially forced to integrate OST systems into new buildings and bear the capital costs. *Direction of the search* increasingly developed in regular meetings, trade fairs and policy symposia of the local industry associations and research groups.

In sum, despite clear problems in the residential OST market, a proto-TIS emerged in this second phase in Beijing that increasingly anchored external knowledge and resources in a dynamic local entrepreneurial experimentation process. Still, also connections to the global TIS remained crucial, mainly through returning experts and internationally well connected academicians.

2007-today: Beijing's OST niche starts scaling up

In this last phase, the local industry increasingly consolidated and –through its growing lobbying power - convinced the city government to install several 100 OST systems in the rural suburbs of Beijing. These rural systems were now delivered including a comprehensive operation and maintenance package and operational costs were completely covered by the suburb's local governments. Also foreign OST companies re-entered the Beijing market and induced further *entrepreneurial experimentation* in the rural niche. Concomitantly, *OST markets formed* in other Chinese regions, especially in rich Southern provinces or the urban fringe of large cities. Also *guidance of the search* was further pushed by academia, associations and in growing interpersonal ('guanxi-') networks. The Chinese Academy of Science founded a competence center for rural OST systems and also international advocacy coalitions increased their influence in Beijing, mainly through highly devoted individuals and the organization of policy symposia and conferences. *Legitimacy* was still hampered by problems in the residential niche, but Beijing's TIS actors compensated by investing heavily in presentations and lobbying activities to re-establish political support for the concept. Finally, also *knowledge creation* further intensified, mainly in tight university-industry linkages and the emerging specialized labor force.

In this last phase, a complex anchoring process that had lasted for about 30 years started to bear fruit: Beijing's OST niche started scaling up and some local TIS actors increasingly extended their activities to other regions and even internationally. They also started challenging the dominant centralized urban water management regime in several other Chinese cities. This success story will now shortly be compared to the two other case studies with seemingly better starting conditions.

4.2 OST in Shanghai

Actors in Shanghai – despite being in a very favorable initial position for developing OST activities - never created a viable OST niche and prioritized centralized wastewater technology. Our interviewees explained this outcome as follows: In the late 80ies the local government was confronted with very pressing water pollution problems, so together with international donor agencies, TNCs and consultants city authorities implemented a massive infrastructure build-up project based on large-scale end of pipe solutions (also see Lee, 2006). As a consequence, in the Shanghai case, international networks supported the import of centralized regime logic. In that process, OST got increasingly marginalized: resources were mobilized only for large scale, centralized wastewater technologies, OST market formation was blocked, entrepreneurial experimentation was limited to mass-producing component suppliers and also the local science system did not get involved in the international networks of OST technology. Incumbent companies and spin-offs took

up OST activities only very recently and now mainly serve rural and industrial niche markets. Shanghai's actors thus missed the early formation phase and therefore still lag behind Beijing in anchoring external dynamics to build up a local TIS.

4.3 OST in Xi'an

Xi'an's experience with OST implementation again strongly differs from the other two cases: Its initial conditions in the early 90ies were quite comparable to Beijing: The city was also confronted with pressing water scarcity and fast city growth and could not provide much indigenous know-how on how to deal with the problem. Yet, in contrast to Beijing and Shanghai, in Xi'an, OST was from the outset visible on the policy agenda. A very entrepreneurial professor tried to push OST with his research group at Xi'an University of Architecture and Technology. He had studied in Japan and learned about Japan's successful rural OST niches. Upon his return to Xi'an, he had a strong vision to introduce this idea into the city and also the rest of China. He was very active in building pilot plants and successfully implemented OST systems in several local residential districts (Wang et al., 2008). Yet, despite his enthusiasm and encouraging research results, Xi'an never developed a viable OST niche. Even though his research group was actively building-up local TIS structures and trying to leverage networks with local design institutes and authorities, they failed to induce broader system building processes. Prof Wang's activities contributed a lot to knowledge creation (which also became available for the other regions) and created legitimacy for the OST concept beyond the borders of Xi'an. Yet, other crucial processes like market formation, entrepreneurial experimentation or resource mobilization did not develop in the city, leaving Xi'an as a lighthouse for OST, but without a niche with considerable upscaling potential.

5 Discussion

Table 3 condenses the insights from these three cases. In Beijing, TIS buildup evolved from a strongly internationalized structure to a more and more regionally anchored setup: Whereas in a first phase, most system building processes were imported from the outside, they were gradually turned into sticky resources in later development stages. In a nutshell, Beijing actor's success lies in a three step anchoring process: First the city government attracted actors from other places through opening a small market to foreign companies. Then this cutting edge know-how was transformed by local start-ups and universities through interactive learning-by-doing. Finally, a local TIS emerged that retained learning and capability buildup in a mix of local and global networks. In the process, the local industry champions gradually upgraded their competencies and have now almost reached the international technological frontier. Beijing's OST niche thus developed thanks to co-evolving city regulation, market segments and the strategic agency of industry and academic experts that built and maintained network ties both locally and internationally. Interestingly, this process was not planned at the outset but emerged out of a conducive mix of regional policies and emergent local-global system building processes.

Table 3: System building processes in Beijing, Shanghai and Xi'an

Beijing		Knowledge creation	Market formation	Entrepreneurial experimentation	Creation of Legitimacy	Guidance of the search	Resource mobilization
Hotels 87-00	Exogenous	++		++	++	+	++
	Endogenous	+	++				
Residential 00-07	Exog.	+++		+	++	+	
	Endog.	++	+++	+++	---		++
Rural 07-12	Exog.	+		+		+	+
	Endog.	++	+++	++	++	++	++
		Knowledge creation	Market formation	Entrepreneurial experimentation	Creation of Legitimacy	Guidance of the search	Resource mobilization
Shanghai	Exog.			+			
	Endog.	+		+			
Xi'an	Exog.	+					
	Endog.	+++		+	++	+	

+ weak; ++ medium; +++ strong; --- hindering;

Actors in Shanghai and Xi'an developed OST in a significantly less systemic way, which did not mobilize all key processes and which did not provide constructive coupling to the global TIS level. Especially a policy push and the succession of a set of differing market segments were crucial missing factors in both Xi'an and Shanghai. Actors in Shanghai furthermore did not mobilize international connections for system building in OST technology, but rather for developing conventional wastewater technologies. This shows how decisively urban niche upscaling depends on the specific connections to external actors and the way they get mobilized in a local system building process. Interestingly, in all presented cases, the national level's influence on niche upscaling is less relevant than existing literature would expect. This further emphasizes urban actor's important role as direct intermediaries between local niche contexts and global networks.

6 Conclusions

This chapter aimed at complementing urban transition study's focus on national to regional scales with a more international perspective on the early formation dynamics in urban niches. Our evidence suggests that a TIS-based anchoring framework can fruitfully account for the complex interplay of endogenous and exogenous innovation processes in early niche formation. Multi-scalar interdependencies in urban niches appeared to be just as complex as in regime structures. In fact, leveraging exogenous innovation resources was a key strategy for urban niche actors to improve their transformative capacity: In the Beijing case, getting connected to resourceful actors in distant places allowed the local constituents of OST to develop the knowledge, resources, experimental

space, markets and legitimacy needed to induce niche upscaling and starting to challenge dominant regime structures. While such anchoring-based niche formation is certainly not an exclusively urban phenomenon, cities' high density of potential market niches, global knowledge networks, internationally mobile workforces as well as particularly pressing environmental problems likely increase the probability for successful anchoring in urban areas.

The anchoring process described in the Beijing case study might accordingly be used to inform policy makers and other actors involved in urban transition processes. Our case studies show that not only local governments, but also companies and universities can play key roles in building up and maintaining connections between localized resources and international networks. When acting as strategic niche managers, they should accordingly not only focus on creating local coalitions and transition arenas, but equally on getting connected to relevant TIS actors and resources in different places around the world. Policy interventions to support such anchored niche formation could include encouraging returnee entrepreneurship, supporting extra-regional knowledge networks (e.g. through conferences and symposia), providing global-local interaction platforms (associations, exchange programs, partnerships) as well as stimulating a variety of market segments.

In conclusion, this chapter illustrates a strong need to address urban transition dynamics from a more multi-scalar spatial perspective and to improve our conceptual understanding on the geographic context in which the relevant niche formation processes take place (or not). The proposed TIS-based approach provides promising analytical guidance here, but also shows some limitations. In particular, it overemphasizes supply-side innovation dynamics and tends to downplay complex power struggles in niche-regime interactions. Future work should thus try to embrace a concept of niche-regime interaction (e.g. as proposed by Elzen et al. 2012) and better connect the multi-scalar view on niche formation with an (equally multi-scalar) view on regime dynamics. It should also further elaborate why and how TIS formation processes unfold in specific places.

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