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Systematic anchoring of global innovation processes and new industry formation – the emergence of on-site water recycling in China

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ABSTRACT

Understanding why and where emerging industries locate in today's globalizing economy is a much debated topic, especially in the context of the recent evolutionary turn in economic geography. This paper proposes a new perspective based on the technological innovation system (TIS) approach. It argues that existing theories on industry formation could be extended with a systemic and multi-scalar view on the social construction processes in the very early industry formation phase. It hypothesizes that regions which successfully locate new industries combine the build-up of a territorial embedded TIS with drawing on innovation dynamics from other regions of a globally distributed TIS. A respective analytical framework is introduced and exemplified with a case study on on-site water recycling technology, based on interviews with 40 experts in Beijing, Shanghai and Xi'an, China. Our data suggests that a considerable on-site water recycling industry developed only in Beijing, which seen from existing theories on industry formation provided the least favorable initial conditions. Its success appears to be explainable with a local innovation system build-up process that recurrently and effectively anchored global TIS dynamics in its local context. We conclude by discussing how the proposed framework can enhance the understanding of industry formation and argue for a systemic innovation policy approach for supporting new industries

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Abstract

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1 Introduction

The spatial context in which new industries emerge is changing. In a globalizing world, innovation and industry formation depend on increasingly mobilized knowledge dynamics and actors which are more and more transcending territorial borders (Crevoisier and Jeannerat 2009; Coe, Hess, Yeung, Dicken, et al. 2004; Bunnell and Coe 2001; Chesbrough 2003; Bell and Giuliani 2007). New industries therefore emerge in increasingly multiscalar settings, with important processes transcending long established territorial boundaries. This tendency gets visible – among others - in recently emerging 'clean-tech' sectors like electric vehicles or renewable energy technologies. Recent research suggests that such potential future growth industries develop in complex spatial configurations and increasingly in emerging economies, outside the traditional innovation centers of OECD countries (see e.g. Lewis 2007; de la Tour, Glachant, and Ménière 2011).

This paper argues that existing theories on industry formation from recent economic geography need to be extended with a systemic 'mobility and anchoring perspective' (Crevoisier and Jeannerat 2009) to tackle the new innovation dynamics in clean-tech sectors. At the risk of over-simplification, existing explanations on industry formation are based on two explanatory story lines of either exogenous or endogenous approaches to regional development. The former explain industry formation with external actors entering a region or by planned initiatives like science parks in the sense of dirigiste regional innovation systems (Boschma 1997; Storper and Walker 1989; Asheim, Boschma, and Cooke 2011; Cooke 2004). Endogenous approaches in contrast focus on path-dependency, path creation and new industries evolving out of the existing industrial structure and knowledge base of a region, much in the sense of regional branching, related variety and grassroot regional innovation systems (Cooke 2004; Asheim and Cooke 1998; Boschma and Frenken 2011b; Neffke, Henning, and Boschma 2011). Endogenous narratives have generated increased attention in a recent evolutionary turn in economic geography. Based on an analysis of (predominantly Western) high-tech sectors they developed elaborate concepts on how new industries develop out of pre-existing regional industrial structures. However, with the dominant focus in both approaches on incumbent high-tech industries and knowledge based perspectives, these literatures so far provide rather mono-causal and supply-side driven explanations on industry formation, which usually ignore demand side effects and the dynamics of very early new industrial paths ([redacted]). Applying either approach in isolation thus provides a relatively static account of industry formation, ignoring its underlying complex social construction processes.

Innovation studies and in particular the technological innovation system (TIS) approach have in turn developed an elaborate process view on early industry formation. They argue that locational dynamics in recent clean-tech sectors depend on both endogenous and exogenous elements and the active construction of a supportive institutional context by its early stakeholders (Rip and Kemp 1998; Garud and Karnoe 2003). However, this concept so far lacks a sound conceptualization of spatial scale and conceptualizes TIS as national or regional containers. This is problematic as with the growing mobility of knowledge, labor and capital, regional cumulative innovation dynamics (which are central also in most endogenous approaches) are losing their central position in explanations on innovation and new industry formation (Crevoisier and Jeannerat 2009). Rather, “the local capacity to formulate entrepreneurial projects and also the ability to mobilize knowledge and competences at medium and long distances” moves center stage (Crevoisier and Jeannerat 2009, 1225). This implies that industry formation in clean-tech sectors should not be understood as either endogenously or exogenously induced, but as a social construction *process* which combines elements from both perspectives and increasingly transcends territorial boundaries in a multiscalar way.

The present paper consequently aims at developing a multiscalar, social constructivist view on early industry formation and applying a respective analytical framework to a recently forming clean-tech industry in an emerging economy. It hypothesizes that mobilizing and anchoring of extra-regional innovation dynamics is becoming key to explanations on industry formation in such contexts (Crevoisier and Jeannerat 2009; Bunnell and Coe 2001; [redacted]). The formation of new industries is accordingly conceptualized as the outcome of anchoring innovation processes from a globally dispersed TIS in a regionally emerging, yet multiscalar TIS. This argument will be elaborated based on a case study on on-site water recycling technology (OST) in China. An OST industry developed most successfully in Beijing, even though this region provided relatively unfavorable initial conditions seen from existing endogenous or exogenous approaches. By comparing the success story of Beijing with two less successful regions in Shanghai and Xi'an, the basic conditions for effective industry formation in this sector will be elaborated. The research questions that will be addressed are thus as follows: How does anchoring of global innovation processes influence early industry formation and location? Applied to the case study: How did Beijing attract and anchor innovation dynamics from a global TIS in its emerging local OST industry?

The first question will be addressed in the next section in a discussion of existing literature on industry formation and regional development which further elaborates the need of a systemic and multiscalar 'mobility and anchoring' perspective on early industry emergence. Section 3 introduces the technological innovation system approach as a conceptual foundation of this perspective and proposes a framework for analysing key processes of TIS build-up. Section 4 introduces the dataset and methodology, building the basis for section 5, which applies the conceptual framework to emerging OST industry structures in three Chinese regions. Section 6 concludes by discussing how systemic anchoring can explain the success of Beijing, as well as the failure of Xi'an and Shanghai in developing a local OST industry.

2 Industry formation and anchoring of global innovation processes

As industry formation is an inherently spatial process, economic geography has a long tradition in analyzing it. To structure a discussion of the varying concepts that made contribution to this issue, we will differentiate between endogenous and exogenous approaches to regional development and discuss how they could be extended with a systemic and multiscalar perspective.

2.1 Exogenous and endogenous explanations of regional development

Exogenous approaches start from the assumption that regional innovation capacity and industrial dynamics can be strengthened 'from outside the region', e.g. by attracting foreign direct investment (see e.g. Feldman 2003), or by creating planned innovative agglomerations like science parks or technopoles (Asheim and Cooke 1998). They start from the observation that new industries often ask for radically new skills and knowledge which have to be created in a first place. They thus create a "window of locational opportunity" (WLO) in which all regions have the same potential of hosting new industries (Boschma 1997; Storper and Walker 1989). At the beginning of a WLO, contingency and entrepreneurial activity decides on where early industries start forming (Boschma 1997). Only later, when first companies have settled in a region and built up a localized supportive context, emerging industries get locked-in to a specific place or region (Storper and Walker 1989). This view thus explains regional industry formation with activities of external actors, but it does not specify in much detail the processes through which actors form a supportive context and get embedded in existing regional structures and institutional settings. Here, the regional innovation system (RIS) concept, and especially dirigiste RIS provide additional insights based on a systemic view of the wider context (Cooke 2004). Dirigiste RIS correspond with an exogenous view; they conceptualize innovative activity as animated mainly from outside and above the region itself (Cooke 2004). According to Asheim and Cooke (1999) dirigiste RIS are based on an innovative network that takes the form of technopoles or science parks. They emerge in two kinds of circumstances: (a) when large firms fragment their production structure and locate R&D activities in functionally specialized zones where synergies are expected to arise from co-location (as in Sophia Antipolis or Lille in France), or (b) by planned innovative milieus established to promote collaboration between universities and SMEs (as in science parks in the UK and USA). As such, initiation of action in a dirigiste RIS is a product of either national government policies or (multi)national companies setting up activities in a region (Cooke 2004).

Endogenous approaches, in contrast, focus on strengthening regional innovation capacity from within the region, in a bottom-up way. Regional branching literature argues based on concepts from evolutionary economics (Nelson and Winter 1982), that locational dynamics are strongly affected by path dependencies inherent in the existing industrial and institutional configuration of territorial production and innovation systems (Boschma and Frenken 2011b; Simmie 2012a). In this perspective, new industries and regional branching can develop out of ‘related variety’, a sufficiently diverse, yet proximate industry base in a region or country (Boschma and Frenken 2011b; Frenken, Van Oort, and Verburg 2007; Frenken and Boschma 2007). This perspective is in turn put in a wider systemic context by grassroot RIS concepts. Grassroot RIS are based upon a pre-existing regionally or locally delineated cluster of small and medium enterprises and a related knowledge infrastructure. Actors in such RISs will have had a lengthy tradition of interacting and learning from one another, successfully competing on the basis of, as needed, co-operative innovation practices. In such a setting of high trust and flexible specialization, new trends and changing demand conditions are relatively quickly translated to renewed industrial networks or completely new industries. Examples of such endogenous innovation models are to be found in southern Germany (e.g. Baden-Württemberg) and the industrial districts of the Third Italy (e.g. Tuscany or Emilia-Romagna). In this model, business innovation and start-up or spin-off activities remain localist and strongly embedded in a historically grown local culture (Cooke 2004). In an endogenous approach, new industries thus emerge in an evolutionary process of regional branching that is mainly fuelled by internal dynamics in clusters, milieus or industrial districts (Neffke, Henning, and Boschma 2011; Simmie 2012b; Moulaert and Sekia 2003; Boschma and Lambooy 2002).

2.2 The need for a systemic and multiscalar perspective on early industry formation

Both approaches have provided rich explanations on industry formation and regional development. Yet, especially when considering the industrial dynamics of clean-tech sectors, they show some important shortcomings. Firstly, exogenous approaches tend to overemphasize the role of supply-side innovation support in early industry formation, by assuming that external actors or policies can somewhat automatically implement a new industry in a region. This proposition is questionable on several grounds. First of all, research on the effects of FDI shows that the location and investments of external companies in a region far from automatically induce a sustained regional development process (see e.g. De Propris and Driffield 2006). A similar critique has readily been applied to dirigiste RIS (see e.g. Asheim and Cooke 1998): Science parks as an example tend to have rather weak local cooperative environments (Henry, Massey, and Wield 1995), which result in a failure to develop inter-firm networking and interactive learning in the parks (Asheim and Cooke 1998).

Thirdly, also research on emerging renewable energy technologies shows that such new industries are seldom induced by isolated actors or single policy interventions (Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008; Jacobsson 2006). Rather, complementary actors usually have to interact and form a small innovation system that sustains early industries, lobbies for subsidies of regulative change and diffuses knowledge about a new technology (Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008). Recent examples form photovoltaics or wind industries show that industry formation depended critically on systemic interaction between complementary actors and social construction processes, which induced new market segments and user profiles, adapted regulations, lobbied for subsidies or defined new technical standards (Simmie 2012a; [redacted]; Karnøe and Garud 2012; Theyel 2012). Such new industries are thus increasingly seen as the outcome of a systemic social construction process in which actors and supportive institutional contexts co-evolve.

Endogenous approaches can in turn be criticized for overemphasizing the importance of territorial embedded innovation processes and claiming that early industries arise somewhat automatically out of the historically grown industrial and institutional system of a region (Moulaert and Mehmood 2010). Even though there is ample evidence on the importance of co-location in many innovation processes, agglomerated economic systems reportedly also run the risk of getting locked-in to an incremental innovation path which rather hinders the creation of new industries or regional branching (Asheim and Cooke 1998). Furthermore, with continuing globalization, it is increasingly argued that a shift in perspective is needed away from cumulative knowledge dynamics in territorial innovation models towards recombinatorial knowledge dynamics and anchoring of increasingly mobile knowledge (Crevoisier and Jeannerat 2009; Moulaert and Mehmood 2010). Especially endogenous approaches with their closed view on regional development show a tendency to favor local relations as an explanation for industry formation (Moulaert and Mehmood 2010; Lagendijk

2006). Even though there is growing recognition that non-local interaction in addition to localized cumulative learning is of key importance (Crevoisier and Jeannerat 2009; Bunnell and Coe 2001; Bathelt, Malmberg, and Maskell 2004), the question on how to embed multiscalar perspectives into endogenous regional development theories is not settled yet. One promising approach here are recently emerging knowledge-based approaches which point at the new context for innovation which is increasingly recombinatorial, mobile and embedded in multi-location innovative milieus (Crevoisier and Jeannerat 2009), global production networks (Coe, Hess, Yeung, Dicken, et al. 2004), open innovation networks (Chesbrough 2003) or global communities of practice (Wenger 1998; Coe and Bunnell 2003). In such perspectives, regions foster territorial embedded innovation processes, which are however increasingly meshed with extra-regional knowledge networks (Cooke 2004; Bathelt, Malmberg, and Maskell 2004). As such, the mobility and anchoring of knowledge dynamics becomes a central research area (Crevoisier and Jeannerat 2009).

2.3 Globalization and anchoring of mobile knowledge dynamics

In a globalizing knowledge-based economy, systematic and permanent mobilization of knowledge has become a key process for innovation and industrial growth (Foray 2004; OECD 1996). Also tacit knowledge is increasingly exchanged at long distances through highly mobile workers and experts (Berset and Crevoisier 2006). Knowledge thus more and more circulates and is constantly accessed and re-combined in interacting firms, universities or regions. As Crevoisier and Jeannerat (2009, 1225) put it very nicely, in this new setting, “there is a move from specialization within regional production systems to more specific regional knowledge and resources within multi-location networks of mobility and anchoring.” In such complex spatial interaction, the territorial focus on single regions has to be substituted with a relational approach, which positions innovative actors and processes not only in a geographic area, but in networked space (Crevoisier and Jeannerat 2009; Bathelt and Gluckler 2003; [redacted]).

Companies or regions consequently represent multiscalar entities that might be integrated into densely localized interpersonal networks and global communities of practice at the same time. In a relational perspective, the ‘elsewhere’ is thus not a uniform structure that is ubiquitously spread in space, but a network topology of connected actors which develops in very specific places. Depending on the portfolio of proximate or distant interaction in a field of technology, very different forms of territorial organization of a related industry can result. Innovative ideas and entrepreneurial actors are accordingly not bound to a specific place anymore. Their locational decision might rather be depending on their position in wider social networks and their perception of the development potential of a specific place. Research on ethical diaspora networks as a case in point shows that returning experts are key in very early phases of cluster evolution (Sonderegger and Täube 2010). Similarly, successful clusters can be crucially dependent on extra-regional network connections (Giuliani and Bell 2005; Giuliani and Rabellotti 2012). The decisive question for a region that wants to attract a growth industry is hence no more whether it can provide a regional production system that provides all critical resources to that specific industry, but whether it is able to mobilize specialized knowledge from elsewhere and *anchor* it sustainably in a local context (Crevoisier and Jeannerat 2009; De Propris and Crevoisier 2011).

Anchoring as a concept is not yet covered with much literature. One exception is the “regional anchor hypothesis” by Feldman (2003), a typical exogenous approach to regional development. Using concepts from real estate economics, Feldman argues that sufficiently large firms or universities can act as an anchor tenant, which attracts numerous related customers or suppliers. By attracting a set of related actors, the anchor tenant indirectly generates positive externalities (e.g. knowledge spillovers) that trickle down to all stakeholders in a region. As can easily be seen, this hypothesis is subject to the criticism on exogenous approaches formulated above. De Propris and Crevoisier (2011) point out that the presence of a single regional anchor is no sufficient condition for explaining sustained anchoring of emerging industries in a region. In addition to attracting anchor tenants, anchoring relies crucially on the subsequent *process* of enhancing and strengthening localized interactive learning which generates positive externalities for both the regional knowledge base and the anchored companies (De Propris and Crevoisier 2011). Anchoring should thus not be understood as a one-dimensional process of attracting foreign transnational companies (Feldman 2003; Liefner 2008), but as a much more differentiated and interactive process in which existing regional resources get coupled with external innovation dynamics in rich and diverse ways. Also anchoring can thus be understood as a systemic process through which a region manages to get connected to a global innovation system level and thereby mobilizes knowledge dynamics from other innovative centers.

3 Conceptualizing anchoring with technological innovation systems

Following [redacted] a spatially revised innovation system perspective is a promising way forward here. Especially the technological innovation system (TIS) approach could provide an interesting conceptual basis for the anchoring hypothesis, as it allows for a multiscalar take on new industries and has elaborated a structured view on the related social construction processes (Jacobsson and Bergek 2011; Carlsson and Stankiewicz 1991). As much of the empirical work in TIS literature has focused on emerging environmental technologies, it has furthermore built up rich empirical accounts of the early formation processes in new industries like wind power, biofuels or electric mobility (Bergek and Jacobsson 2003; Jacobsson 2008; Negro and Hekkert 2008). It has however not yet taken strong account of spatial innovation dynamics. Applying it in a multiscalar perspective thus also promises feeding back an interesting contribution to TIS research by scrutinizing how the relevant innovation dynamics play out in space.

TISs are 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” ([redacted]). A TIS consist of an actor base (companies, universities, government agencies, intermediaries, users, advocacy coalitions), formal networks (regional innovation networks, industry alliances, technical committees, working groups, etc.), and a supportive institutional context (rules that enable and constrain actor behavior, e.g. laws, routines, markets). Technological innovation is assumed to emerge out of the co-evolution of these components.

TIS research typically distinguishes between the structural elements (actors, networks and institutions) and the key processes that facilitate their buildup. In its current form, it analyzes the construction of innovation systems with a list of seven key processes (formerly called 'functions', see Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008; Hekkert, Suurs, Negro, Kuhlmann, et al. 2007), which are listed in Table 1. These process can be interpreted as an emergent property of the activities in the system, which form a resource for the involved actors as well as for the future evolution the TIS as a whole (Markard, Musiolik, and Worch 2011). Protected market niches, technological standards, professional norms or technology specific collective expectations are examples of such resources that emerge out of the systemic interplay in a TIS and benefit all involved actors (Markard, Musiolik, and Worch 2011). The performance of a TIS (e.g. how well it is developing, diffusing and utilizing an innovation) can thus be analyzed by the strength or weakness of each of these processes (Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008; Hekkert, Suurs, Negro, Kuhlmann, et al. 2007) and the way they co-evolve (Suurs and Hekkert 2009). New industries accordingly develop most easily if they are embedded in a well performing TIS.

Table 1: Key processes in technological innovation system build-up

Key process	Definition	Indicators
Knowledge creation and diffusion	Activities that create new knowledge, e.g. learning by searching, learning by doing; activities that lead to exchange of information among actors, learning by interacting and learning by using in networks	R&D projects, no. of involved actors, no. of workshops and conferences, network size and intensity, activities of industry associations, websites, conferences, linkages among key stakeholders
Influence on the direction of the search	Activities that positively affect the visibility of requirements of actors (users) and that have an influence on further investments in the technology	Targets set by the government, no. of press articles that raise expectations, visions and beliefs in growth potential
Entrepreneurial experimentation	Emergence and decline of active entrepreneurs as a prime indication of the performance of an innovation system, concrete activities to appropriate basic knowledge, to generate and realize business opportunities	No. of new entrants, no. of diversification activities of incumbents, no. of experiments
Market formation	Activities that contribute to the creation of demand or the provision of protected space for the new technology, e.g. construction of market segments	No. of niche markets, specific tax regimes and regulations, environmental standards
Creation of legitimacy	Activities that counteract resistance to change or improve taken-for-grantedness of new technologies	Rise and growth of interest groups and their lobbying activities
Resource mobilization	Activities related to the mobilization and allocation of basic inputs such as financial, material or human capital	Availability of competence/human capital, financial capital, complementary assets for key actors
Development of positive externalities	Outcomes of investments or of activities that cannot be fully appropriated by the investor, free resources that increase with number of entrants, emerge through firm co-location in TIS	Emergence of pooled labor markets, intermediate goods and service providers, information flows and knowledge spill-overs

Source: Compiled from (Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008; Hekkert, Suurs, Negro, Kuhlmann, et al. 2007; Musiolik and Markard 2011)

TIS research has so far largely ignored tackling the spatialities of the key processes and TIS structure. The concept was mostly applied to national case studies, arguing that a national TIS is performing well if all the structural elements and key processes are provided inside national borders. This focus was readily criticized as the actual strength of the approach and its process view is that it also allows for multiscalar perspectives beyond national borders ([redacted]

[redacted]). Recent studies indeed show that a TIS is probably very seldom a mono-scalar entity ([redacted]). In most cases a national or regional TIS is a node in a network of more or less densely connected other innovative subsystems which in their totality form a 'global TIS' ([redacted]). In addition it is usually also influenced by institutional contexts that manifest themselves from a local (city regulation) or national (culture, R&D support programs) to a global (rules of the world trade organization) scale. This implies that only some of the structural components and processes might be evolving in a densely localized setting. Yet, others might evolve in other territorial subsystems of the global TIS and then be coupled to a given region. Others again might develop in transnational companies or global communities in a strongly internationalized way.

Accordingly, anchoring as a process can be understood as a multiscalar TIS build up in a region. In most cases, this process incorporates getting coupled to (and mobilizing) actors, networks or institutions in external territorial subsystems of a global TIS. Through interactive learning and the increasing integration of local and extra-regional actors and processes, emergent properties of a TIS (or system resources) develop, which remain at least partly bound to a given region and thereby build a sticky anchor for mobile innovation dynamics. Over time, the relevant actors, networks and institutions stabilize and after some time, agglomeration economies kick in and the formative TIS evolves into a self-sustaining territorial innovation and production system. Anchoring in this understanding does thus not mean that a full-fledged TIS with all its structural elements and key processes locates and develops in a region. It rather means that these elements and processes emerge either locally or by coupling with global TIS structures ([redacted]).

Assessing the performance of the key processes at different points in time can accordingly help to assess if and how well emergent properties of a TIS get imported to or evolve in a region. The better the performance of the key processes in a region, the more system resources get mobilized for local actors, the stronger the anchor for mobile innovation dynamics and thus the better the conditions for an emerging industry. Doing a 'functional analysis' (Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008) of the TIS can thus provide a measure of how well the anchoring process is working, which can in turn inform policy makers trying to support such a process (see Bergek, Jacobsson, Carlsson, Lindmark, et al. 2008). De Propris and Crevoisier (2011, 172) suggest that "if regional growth is pursued through the anchoring of a new industry, this means transforming mobile factors into immobile factors to sustain a local process of firm agglomeration and knowledge accumulation." Applying a TIS understanding further differentiates this. Anchoring means transforming globally mobile structural TIS elements (actors, networks) into locally sticky (Asheim and Isaksen 2002) factors (here: emergent properties of TIS) through activities that can be described with the key processes.

4 Case selection and methods

This perspective will now be applied to a case study on on-site water recycling (OST) technology, a case in point for a recently emerging clean-tech industry in the water sector.

4.1 On-site water recycling as a case study

OST systems are a disruptive, decentralized alternative to incumbent centralized wastewater treatment technology. Existing wastewater technology builds on large pipe networks, huge treatment plants and government or utility controlled operation. OST in contrast is based on small, flexible treatment plants which can be installed quickly into buildings wherever needed. OST systems are expected to considerably improve the cost structure of urban water management and at the same time significantly reduce freshwater consumption of households (Fane and Fane 2005). OST represent a disruptive innovation with transformational potential to the development logic of the wastewater sector. It is not based on new to the world technologies, but on radically new ways of combining existing components, business models, service and maintenance concepts and therefore particularly dependent on systemic innovation ([redacted]). So far, mainly Japan, the USA and Western European countries have developed an OST industry, which predominantly serves rural and industrial niche markets. Innovative activity in the field is accordingly dispersed in several countries and over three continents ([redacted]). The global TIS for OST accordingly consists of subsystems in America, Asia and Europe, which are integrated at a more international level mainly through international research and development communities ([redacted]) and international water associations and initiatives which are increasingly pushing OST.

4.2 Case selection in China

China was chosen as a case study area because decisions on infrastructure sectors are much more flexible in emerging economy contexts than in OECD countries with well-established (and often locked-in) centralized supply and discharge systems (Berkhout, Angel, and Wieczorek 2009). Also environmental problems are often more pressing in emerging economies. Combined, an emerging economy context thus promises a much more dynamic context for scrutinizing industry formation processes in clean-tech industries. The cases for in-depth investigation inside China were selected based on theoretical sampling, looking for both successful and failure cases of OST industry location. Desk research showed that a considerable industry emerged mainly in Beijing, which hosts eight small to medium-sized OST companies and has 2’000 to 3’000 OST systems installed. Its success story was chosen for the most detailed investigation, whereas Shanghai and Xi’an provide contrasting failure cases with varying initial characteristics (see Table 2).

Table 2: Initial development potential of the three case studies in China

Location	Connection to global TIS	Exogenous development potential	Endogenous development potential
Beijing	++	0	+
Shanghai	++	0	+++
Xi’an	+	++	0

0=none, +=weak, ++=strong, +++=very strong

Connections to a global TIS were available in all three cases to some extent. Variation is thus mainly included in the remaining two initial conditions. Development potential seen from an endogenous perspective was arguably most abundant in Shanghai. This city developed very quickly into the industrial and commercial center of China after the initiation of an opening and reform period in the mid-70ies. When first experiments with OST technology happened, Shanghai therefore already had related industries (like machinery components or water technology) in place. Beijing and Xi’an in contrast had a much weaker industrial basis, Beijing as the scientific center could however provide a related knowledge infrastructure. Xi’an in contrast was best endowed with exogenous development potential as it attracted a very active entrepreneur that was pushing OST already at a very early point in time. At the outset, Shanghai thus represents a case where endogenous explanations would expect an OST industry to emerge most easily, whereas Xi’an represents a case in point for exogenous explanations. Beijing in contrast appears to be the least favorable place for an OST industry to emerge.

4.3 Methods

As the key processes in early TIS formation depend strongly on social construction and sense-making of the involved actors, the suitable tool to assess them in-depth are expert interviews and qualitative content analysis. In this study, such data was triangulated with intensive desk research of relevant reports, internet databases, publications and company's annual reports in both English and Chinese. In total, 40 interviews and five field visits to on-site treatment projects were conducted during an extended field stay in China between November 2010 and May 2011. Interviews covered experts from several key stakeholder groups except government (see Table 3). As government officials were reluctant to give interviews, the influence of policy and regulation was assessed through seven interviews with academic policy experts and retired politicians.

Table 3: Interviews in China

Stakeholder group	Interviews Beijing (BJ)	Interviews Shanghai (SH)	Interviews Xi'an (XA)	Sum
Academia (AC)	Chinese Academy of Sciences (6), Qinghua, Beijing S&T University, Beijing Forestry University, Renmin University	Tongji University (2)	Xi'an University of Architecture and Technology	13
Domestic Companies (DC)	Beijing Origin Water, Beijing Tooling, Beijing Hujia-Hanqing, Beijing Qingyuan	Shanghai 4F, Shanghai Zizheng, PACT Shanghai		7
Foreign companies (FC)	Siemens, Veolia, GE, Kubota, Hydranautics, Huber, Inge AG, DHV	Grundfos, Norit, ITT		11
Policy experts (PE)	Renmin University, Chinese Academy of Sciences (2)	China Construction Design Institute, Tongji University, Korea University	Xi'an Municipal Design Institute	7
Associations (AS)	International Water Association, Global Water Intelligence			2
Sum	27	11	2	40

To guarantee anonymity, interviewees will be cited in the results section according to this table's abbreviations. E.g. an academician from Beijing would be named (ACBJ) and numbered. Interview guidelines were structured according to scheme of analysis by Bergek et al. (2008) and adapted to each stakeholder group. All interview recordings were fully transcribed, translated and analyzed using qualitative content analysis as introduced by Glaser and Laudel (2006).

5 Emergence of an OST industry in China

In all three cases, the OST story started in the early nineties, at a time when wastewater infrastructure was still largely missing in most parts of China (Browder, Xie, Kim, Gu, et al. 2007). This notwithstanding, the development trajectory of OST varied strongly in the three case study regions.

5.1 OST in Shanghai and Xi'an

Shanghai was the place in China that could provide the best endogenous development potential through its industrial structure. The city was also well connected internationally and even hosted some leading transnational water companies (PESH1). Nevertheless, it turned out to be unsuccessful in locating an OST industry. According to our interviewees, this failure is due to the fact that it never created a viable market for OST systems and its local industry got locked-in to developing solutions for centralized wastewater plants (DCSH1). In the early 80ies, the local government was confronted with very pressing water pollution problems, so together with international donor agencies, TNCs and consultants they implemented a massive infrastructure build-up strategy focusing on large-scale end of pipe solutions (PESH1). OST consequently got pushed into very small experimental niches (PESH2), entrepreneurial experimentation was limited to large scale and mass-producing component suppliers and also knowledge creation and the local science system was not involved in the networks of OST technologies for a long time (ACSH1, DCSH2). Systemic interaction thus never kicked in in Shanghai and incumbent companies and spin-offs took up the OST idea and started serving rural and industrial markets only in the last ten years (DCSH2, DCSH1).

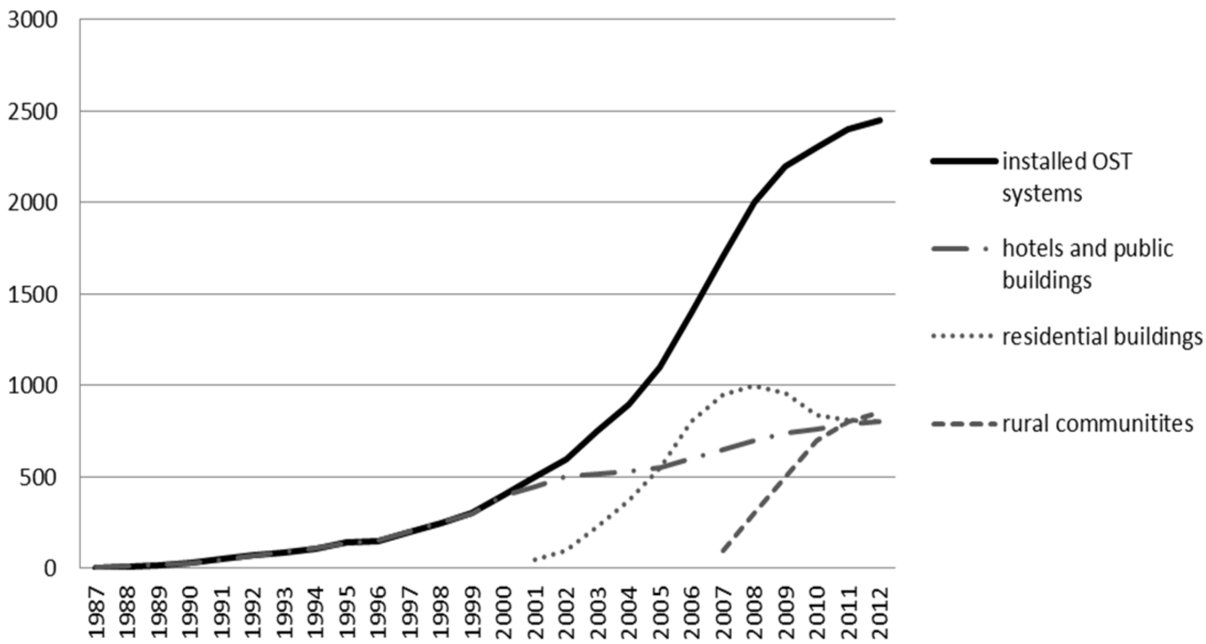
Shanghai's OST industry therefore missed the early phase of development and has consequently just started building up a proto-TIS that could provide internal momentum or anchor mobile innovation dynamics. Especially the tight extra-regional connections of Shanghai to TNCs and donor agencies apparently led to an import of dominant solutions from the centralized wastewater technology paradigm which considerably hampered the development of a local OST industry (PESH1, ACSH1).

Xi'an appears to have failed in locating an OST industry for very different reasons. It is a provincial capital in central China and suffering from equally pressing water shortages as Beijing. In contrast to Beijing, Xi'an's OST scene was from the outset strongly dominated by a special kind of external anchor tenant: a visionary and internationally very well connected professor returned to Xi'an from Japan and thereafter tried to push OST with its research group at a local university (ACXA1). This professor got interested in OST systems during his studies in Japan and wanted to introduce an adaptation of the successful Japanese concept in Xi'an and the rest of China (ACXA1). His group became very active in building pilot plants and networks with authorities and design institutes (PEXA1), and successfully implemented OST systems in local residential districts (Wang, Chen, Zhang, and Li 2008; Zhang, Wang, Xiong, Chen, et al. 2010). However, despite his enthusiasm and encouraging research results, also Xi'an never developed a vibrant OST industry as almost all of the key TIS processes remained dependent on activities of his research group. This team was deliberately building up legitimacy for OST, influencing guidance of the search through networks with local design institutes and authorities (PEXA1, ACXA1), and strongly pushed knowledge creation and diffusion, even by training local OST operators (ACXA1). Nevertheless, these key processes didn't get self-sustaining either in regional market segments and entrepreneurial experimentation, nor in supportive couplings with the global TIS level. As such, Xi'an contributed a lot to knowledge creation (which also fed back to other Chinese regions) and created legitimacy for the OST concept beyond the borders of the city (ACXA1, ACBJ1), but its proto-TIS never scaled up, leaving Xi'an as a lighthouse for OST, but without a competitive OST industry.

5.2 OST in Beijing

The OST industry in Beijing, in contrast, developed in a much more dynamic way. Figure 1 shows that the diffusion of OST systems followed a typical S-curve and evolved in three consecutive market segments.

Figure 1: Number of installed OST systems in Beijing (cumulative)



Source: estimates from interviewees

5.2.1 Beijing 1990-2000: OST gets introduced in a hotel market segment

The first *actors, networks and institutions* in Beijing emerged in the late 80ies (DCBJ1), at a time when local wastewater treatment infrastructure and technology was still very embryonic (DCBJ3). In 1987, driven by increasingly pressing water scarcity, Beijing's local government formulated a regulation mandating hotels with a construction area exceeding 20’000m^2 and public buildings with a construction area exceeding 30’000 m^2 to introduce on-site water recycling facilities ((Mels, Guo, Zhang, Li, et al. 2007), DCBJ1, DCBJ2, DCBJ3). This regulation kick-started a market in a region with very few actors or knowledge on OST technology in place.

Market formation

At the time, the indigenous technological know-how even for centralized wastewater treatment was still limited, so hotels in order to comply with this regulation had no other choice than to refer to international companies (mainly from Japan, Germany and France) for help with project planning and implementation (DCBJ2). Until the mid 90ies, the new market in hotels did thus not enter the consciousness of most Chinese project developers and remained a strongly internationalized structure, served mostly by foreign companies (DCBJ1). In addition, many large hotels in the city were run by international hotel chains, so not only was the first OST market in Beijing served by foreign companies, but also the first customers originated from outside the region (DCBJ2).

Creation of legitimacy

Nevertheless, this fragile market structure was performing quite well (DCBJ3, ACBJ2, DCBJ2). Thanks to international management, professional operation and economic profitability of the on-site systems in large hotels, legitimacy for the concept was generated which made local engineers and practitioners first realize the full potential of the idea (DCBJ2). Legitimacy was thus firstly imported from other places in the global and only later disseminated based on the positive experience in large hotels (DCBJ2). This proved to be crucial also in later development stages of the TIS.

Knowledge creation

In parallel, also Beijing's academia was firstly taking up OST as an interesting field of study (ACBJ2, ACBJ1). In the early nineties, a research group from Qinghua University got included in a global research network of a transnational water company and developed quickly into a globally leading group in membrane bioreactor technology, a core process for many OST systems (ACBJ1). Also other universities and research institutes started first experiments with their own OST pilot plants (ACBJ3, ACBJ2). However, such activities were still rather explorative, aimed at scientific discoveries and not connected to any local industrial partners (ACBJ4, ACBJ3).

Entrepreneurial experimentation

Entrepreneurial experimentation was indirectly imported from the global TIS, mainly by introducing products of Japanese and European companies ([redacted]). At the beginning, many foreign firms competed in Beijing's small hotel market, but none of them could tackle a dominant market share. Managers of foreign OST firms complained about unclear regulation and corrupted business practices in the Beijing market, so many of them only stayed for a short time (FCBJ2). A Japanese company as a case in point complained that when they tried to expand their market presence in the mid 90ies, their technologies were quickly counterfeited (FCBJ2), so they disenchanted left the Chinese market completely (FCBJ2). Only at the end of this first period, some first domestic actors emerged: Small Chinese companies started copying products of their international competitors and supplying the OST market with very cheap but also largely dysfunctional own products (DCBJ1).

Resource mobilization, guidance of the search, positive externalities

As the hotel market in Beijing was strongly driven by external TIS structures, also the remaining three processes were mainly provided by foreign actors and imported into Beijing through foreign companies, in the form of pre-fabricated OST systems. No guidance, resource mobilization or positive externalities could emerge locally at the time, so localized TIS processes still had to form. In sum, the only key process which can be attributed to a regional scale in Beijing is market formation: By introducing the hotel regulation, local actors started for the first time perceiving OST systems' market potential. At the end of the nineties, OST in Beijing was thus a regulation-driven market niche, which was nearly completely coupled to TIS structures developing outside China. Nevertheless, the legitimacy, knowledge creation and first entrepreneurial experimentation induced at that time proved to be decisive in later development phases.

5.2.2 2000-2007: Gold rush in a new residential building market

Actors, networks, institutions and market formation

At the beginning of the new millennium and based on the positive results of the hotel market segment, Beijing's government decided to extend its on-site water recycling regulation to residential development areas (DCBJ1, ACBJ2). Starting from 2003, new residential developments exceeding a total floor surface of 50'000 m^2 were forced to install on-site water recycling facilities (DCBJ1 4, DCBJ4, DCBJ5). As real estate construction was in a large boom at the time, this legislation meant that most new residential projects in Beijing had to include an on-site system (ACBJ2). This small addition to existing regulation thus opened a completely new and considerably large market segment, which lead to a surge in local actors and networking (DCBJ1).

Entrepreneurial experimentation

As the demand for on-site systems skyrocketed, new companies got founded to serve this market. All of the interviewed companies were established around the year 2000, either as spin-offs from local universities (DCBJ5, DCBJ6), or by entrepreneurs returning from Europe, Japan or Australia (DCBJ4, DCBJ3, DCBJ6). Thus, even though Beijing started building up its own suppliers at the time, the underlying knowledge base of half of the industry still largely originated from external locations in the global TIS. According to the interviewees from local companies, in the first few years, their main activity was “learning by doing” (DCBJ3, DCBJ1). The startups developed and installed their own OST systems very quickly and then learned on the spot about the technological and organizational challenges (DCBJ1). In this process, local actors increasingly also took over the hotel market segment from international companies which continued pulling out of the now strongly competitive market (DCBJ1).

Knowledge creation

Together with learning by doing in the industry also scientific knowledge creation in local universities intensified (ACBJ1). Now many research institutes started getting in cooperation with local companies, either because some of their graduates founded their own companies (DCBJ5) or because start-ups needed scientific expertise in the configuration and early operation of their OST plants (DCBJ4). Localized knowledge creation thus got an increasingly systemic character with start-ups and research organizations involved in intensive reciprocal learning. As much of academia was at the same time strongly linked internationally, this setup also facilitated the constant translation of international best practices into the emerging TIS in Beijing (ACBJ1).

Creation of legitimacy

However, despite this increasingly vibrant development, after five years it got clear that the market segment in residential buildings was a massive failure, mainly due to institutional shortcomings, like unadapted regulation, missing law enforcement, economic disincentives or missing trust from end-users (DCBJ1, DCBJ3, DCBJ5, ACBJ2, ACBJ3). Professional operation and maintenance of OST plants could not be guaranteed in this segment, so most systems broke after a few years (DCBJ3, DCBJ5). Also the price structure in Beijing’s water sector was such that residential OST plants could not be operated profitably (ASBJ1, ACBJ5). Interviewed experts estimate that nowadays, only about 5 to 10% of the systems in residential districts are still operational (DCBJ1, ACBJ2, DCBJ3). This failure strongly delegitimized OST in Beijing. Even though by the mid-2000’s the local industry had built up basic technological and organizational know-how, the dire institutional context in the residential market made the OST concept increasingly look like a very undesirable option for urban water management (ACBJ6). Had there not been the still successful market segment in hotels and a quickly growing local industry, the OST story would probably have ended in complete de-legitimization at this point in time (DCBJ4).

Resource mobilization, guidance of the search, positive externalities

Resource mobilization was no issue for local TIS actors, as the market was based on an obligation of real estate developers to integrate OST systems into their projects. They accordingly integrated the cheapest possible OST systems (DCBJ1) and shifted additional costs to the tenants through higher apartment rents (FCBJ1). Direction of the search did not happen in a public process, but increasingly in regular meetings and interpersonal networks in the local industry and research groups (DCBJ1, DCBJ3, ACBJ7). Positive externalities, finally, emerged for the first time in the tightly interacting local universities and companies which educated a small specialized labor force (ACBJ7).

In sum, in the second phase a proto-TIS started emerging in Beijing and external knowledge that had entered the region in the first phase got increasingly anchored locally in a dynamic entrepreneurial experimentation process. One crucial anchoring process in that time appears to be the repatriation of highly skilled experts, which used their knowledge to establish companies in a fast growing market. Still, other pipelines to the global TIS also remained crucial, especially through the internationally well connected regional science system.

5.2.3 2007-today: Consolidation in a rural market segment

Despite the problems in the residential market, starting from 2007, OST systems in Beijing extended to another new market segment and took on increasingly localized systemic character. As national policy increasingly pushed infrastructure buildup in rural areas, actors from Beijing's proto-TIS could successfully lobby the local government to implement their OST solutions in the rural fringe of Beijing.

Actors, networks institutions

Also in the last phase, OST systems still had to be installed in hotels and new residential developments (ACBJ2, PEBJ1). However, the real estate market started slowing down and regulations still left major gaps in the control, maintenance and operation system for OST plants (DCBJ3, FCBJ2, DCBJ5). The actor base now stabilized and interpersonal guanxi[1]-ties between industry, academia and the local authorities got denser (DCBJ1). Concomitantly, the experience of Beijing started radiating to other places and advocacy coalition for rural OST systems developed increasing visibility throughout China (ACBJ7, ACBJ8).

Entrepreneurial experimentation

The local industry consolidated in the last phase and Beijing Origin Water emerged as the leading company in the field (DCBJ5, DCBJ4, ACBJ2). This company also started exporting its OST systems to Asia, Australia and Eastern Europe, won prestigious national innovation and management awards and thereby gained attention from investors and the top national leadership (DCBJ4, ACBJ1). Especially the good relationship to authorities enabled this company to convince the local government to install several 100 OST systems in environmentally sensitive rural areas around Beijing (DCBJ4). Learning from the experience in the residential market, a comprehensive operation and maintenance system was set up with

[1] Interpersonal ties, based on reciprocity, a very important structural element of Chinese society, (see e.g. Xin and Pearce 1996)

costs completely covered by municipal governments (DCBJ4). Other companies in Beijing were similarly looking for alternatives to the challenging residential market and diversifying into rural or industrial projects (DCBJ5, DCBJ1). In addition, in this last phase, Japanese OST companies entered China again, this time targeting the promising rural market segment (FCBJ2).

Market formation

In the last phase, actors of the Beijing OST TIS for the first time actively constructed a new market segment in the rural fringe of the city (DCBJ4, DCBJ3). At the same time, OST markets now also started springing up in other regions of China, especially in Southern rich rural areas and in water scarce cities in Northern and Western China (ACBJ8, DCSH1, DCSH2). Even though OST systems in rural areas often use a more low-tech approach, Beijing’s actors also successfully created and supplied market niches in rich environmental protection zones and the urban fringe of other cities in Southern China (DCBJ5, DCBJ4).

Guidance on the direction of the search

With the growing institutionalization of OST, also guidance of the search was increasingly pushed by academia and idealistic entrepreneurs (ACBJ7, ACBJ8, DCBJ3, ACBJ2). The Chinese Academy of Science established a competence center for rural OST systems, running large scale field studies that tried to find suitable technologies and maintenance schemes for OST systems (ACBJ7, ACBJ8). Some successful experiments got published as cover stories in highly prestigious national technology magazines (ACBJ8). Also international advocacy coalitions for OST system, such as the EcoSan initiative or sustainable sanitation alliance started having influence in China, mainly through highly devoted academicians and entrepreneurs (ACBJ2, DCBJ3). Equally, the international Water Association organized a conference on OST systems in Xi’an, further linking scientist in the field both inside China and with different parts of the global TIS (ASBJ2).

Other key processes

Knowledge creation further intensified in the last phase, still predominantly through university-industry ties (ACBJ1, DCBJ4). As the government started subsidizing rural OST systems, also financial resources were for the first time mobilized in a local context. Legitimacy was still contested due to the fiasco in the residential market, so all of the interviewed company managers claimed that they still invested heavily in making presentations at conferences and symposia in order to legitimize OST (DCBJ3, DCBJ5, DCBJ4, DCBJ1). Positive externalities, finally, were increasingly evolving in the small specialized labor force and the newly constructed rural market segment.

In the last phase, the small OST TIS in Beijing thus stabilized; some of the industry got consolidated whereas one company developed into a national (and increasingly international) leader. After a complex process lasting for about 20 years, anchoring came to a successful end: Through its increasingly institutionalized local and external connections, Beijing's TIS started providing growing positive externalities and spillover effects to its local actor base.

5.3 Discussion

Table 4 summarizes the performance assessment of Beijing's OST TIS in the three consecutive development phases. As shown above, its setup changed from a strongly external dominated structure to a more and more regionally anchored setup: Whereas most of the key processes were imported from the global TIS in a first phase, they were gradually turned into sticky resources in later development stages. In a nutshell, Beijing's success lies in a three step anchoring process: First it attracted actors and knowledge from other places through opening a small market to foreign companies. Then it transformed this cutting edge know-how through entrepreneurial experimentation in a localized learning-by-doing process, and finally retained learning and capability buildup in a regional, yet multiscalar TIS. Beijing's

OST industry thus emerged out of the co-evolution of industrial and academic actors, market segments and institutional contexts which were constantly building systemic interaction ties both locally and internationally. Interestingly, this process was not intended or planned from the outset but emerged out of the conducive mix of endogenous and exogenous elements.

Table 4: Summary of the performance of key TIS building processes in Beijing

		Knowledge creation	Market formation	Entrepreneurial experimentation	Creation of Legitimacy	Guidance of the search	Resource mobilization	Pos. Ext.
Hotels 87-00	External	++		++	++	+	+	+
	Regional	+	++					
Resi-dential 00-07	External	+		++		+		
	Regional	++	+++	++	---		+	+
Rural 07-12	External			+		+		
	Regional	++	++	+	+	++	+	+

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

Applying the same analysis to Shanghai and Xi’an in Table 5 reveals that OST developed there in a significantly less systemic way, which did not mobilize all key processes and which did not provide constructive anchoring of global TIS structures and processes. Shanghai in principle had some innovation system structures and connections to the global TIS in place, but no supportive processes developed out of it. Xi’an in contrast could provide only weak endogenous TIS structures, but activated considerably more key processes through a dedicated exogenous entrepreneur. However, its TIS buildup remained centered on this single key actor and never initiated regulative change, market segments or a wave of start-ups like in Beijing. Xi’an thus shows a case in which an (initially exogenous) anchor tenant was unable to provide all the critical resources for industry build-up. The comparison with Beijing reveals that demand-side effects and the succession of a set of differing market segments might have been a crucial missing factor in Xi’an.

Table 5: Summary of the TIS building processes in Shanghai and Xi'an

		Knowledge creation	Market formation	Entrepreneurial experimentation	Creation of Legitimacy	Guidance of the search	Resource mobilization	Pos. Ext.
Shanghai	External			+				
	Regional	+						
Xi'an	External	+						
	Internal	+++		+	+	+		

The presented evidence furthermore shows how decisively industry formation in a region depends on mobilizing a mix of internal and external actors and processes. Half of the success of Beijing is explainable with the fact that it was able to attract foreign technology and companies and later knowledgeable experts and entrepreneurs. The other half of the success is then attributable to the fact that it was able to *retain* these elements and continuously mobilize them regionally. However, in response to Crevoisier and Jeannerat (2009) the observed anchoring process did not only refer to knowledge, but to more generic innovation system structures which got mobilized through key processes. In a TIS perspective, knowledge creation is only one among seven key processes which might all be equally important for industry formation. Applying the TIS concept thus opens the rather restricted view of recent knowledge-based approaches to other important constituent elements of innovation and industry formation processes like demand side effects, institutions or actor strategies. Xi'an as a case in point depended mainly on anchoring external knowledge and did so quite successfully. Nonetheless, it was unable to further mobilize this knowledge in an industry build-up process, as the other key processes of TIS build-up remained underdeveloped.

It is important to also qualify our results here. Based on the presented evidence it remains difficult to explain why systemic anchoring happened only in Beijing. This process could doubtlessly have started also in Shanghai or Xi'an. It might indeed kick in more easily in places that have some related industries or knowledge infrastructures in place. The presented case study might thus describe a special case in which the region with relatively weak initial conditions managed to most successfully locate an emerging industry. More studies would be needed here to further assess the relationship between initial resource endowments and the probability of a successful anchoring and TIS build-up process. As it stands, our approach can thus not predict in which region a new growth industry is most likely to locate, but it provides an analytical framework for this question that accounts for more complexity than existing endogenous or exogenous approaches. Secondly, water recycling technology in China as a case is limited in its generalizability. It was chosen as a case in point for recently emerging clean-tech sectors. As such, we sustain that the developed framework could be applied with minor adaptations to other infrastructure-based clean-tech sectors. Locational dynamics in other sectors and countries might however look very different. Yet, we sustain that the anchoring hypothesis could be valid also beyond clean-tech sectors, especially in other latecomer countries that can tap into existing innovation systems to create local industries. Contrasting case studies in other institutional and sectoral contexts are thus strongly encouraged.

6 Conclusions

This paper aimed at improving the understanding of the locational dynamics of new clean-tech industries in a globalizing economy. By combining concepts from economic geography and innovation system studies, it argued that anchoring of global innovation processes in an emerging technological innovation system could add important conceptual elements to existing explanations on early industry formation. The case study on on-site water recycling technology in China demonstrated that such a systemic anchoring approach can give detailed accounts of why regions succeeded or failed in localizing a new industry. Beijing as a successful example was able to anchor global innovation dynamics in a local TIS by combining "rich proximity learning with intense medium and long-term interaction"

(Crevoisier and Jeannerat 2009, 1234). Shanghai and Xi'an in contrast, were unsuccessful in the very same attempt, even though they had better initial conditions seen from existing endogenous or exogenous approaches to regional development. We thus conclude that either of the existing approaches in isolation could not explain this outcome. Rather, the success or failure of a region in forming a local growth industry depends on their broader, systemic interplay: When exogenous and endogenous structures and active construction processes are combined in innovation system build-up, emergent properties of a TIS disperse locally and thereby form a strong anchor for global innovation processes. Such a systemic approach thus opens the spatial perspective of theories on industry formation to extra-regional and multiscalar dynamics as well as beyond mere knowledge perspectives and supply-side driven innovation concpets.

As such this paper offers a new answer to the fundamental question: "Do new industries need the local presence of related industries?" (Boschma and Martin 2010, 29). Based on our analysis we can answer at least for clean-tech industries with a qualified: "Not necessarily". We argue that they need a conducive context in the form of co-evolving territorial and socio-technical embedded innovation processes and - arguably increasingly important – multiscalar couplings to other regions of a global innovation system. Boschma and Frenken (2011a) furthermore argue that the sectoral evolution of regional economies can be predicted, albeit imperfectly, from data on the technological relatedness underlying structural change. Our results qualify this assumption: In today's globalizing world, radically new locational dynamics might spring up: The example of Beijing shows how systemic anchoring of global innovation processes could also introduce new industries into a region which at the outset has very limited technological relatedness in place.

In addition, this paper also contributes to innovation system studies in showing how TIS dynamics play out in multiscalar space. Especially the anchoring hypothesis is a new addition to this literature as it explains how socio-technical embedded innovation processes (which are emphasized very strongly in this literature) interrelate with territorial embedded processes. A lot of interesting questions remain open in this regard. Our results as an example hint that the science system and science-industry relations of very talented scholars appear to play a decisive role in the anchoring process. This finding resonates very nicely with recent insights in cluster studies (Giuliani and Rabellotti 2012) and could be further scrutinized in related research.

The presented results furthermore have direct implications for regional policy making: If a region wants to attract emerging growth industries, it needs a multi-dimensional, *systemic* policy approach which goes far beyond attracting a single anchor tenant or supporting its local industrial structure. Fostering anchoring of external TIS structures would require a broad set of interventions like stimulating a variety of market segments (which was crucial in the Beijing case), supporting local start-ups, connecting them to global knowledge networks (through e.g. conferences, local content requirements etc.), providing interaction platforms (associations or interpersonal ties), as well as formulating and adapting institutions (especially regulation) to support an emerging industry.

In summary, this study shows that a combined economic geography and technological innovation system framework could profit both strands of literature. We thus strongly encourage further research at this highly interesting disciplinary intersection.

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