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Unravelling the role of green entrepreneurs in urban sustainability transitions: a case study of China's Solar City.

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Abstract

This paper aims to understand the role of green entrepreneurs in urban sustainability transitions. We propose an analytical framework combining transition approaches and green entrepreneurship from a relational lens. It includes four processes: emergence of green entrepreneurs, multi-scalar interest coordination, empowering through anchoring, and struggling with the regime at the urban scale. This framework is illustrated through an empirical analysis of the role of green entrepreneurs in the development of the solar water heater industry in China's Solar City. The analysis

unravels how the local institutional contexts and multi-scalar relations empowered local green entrepreneurs to become system builders for urban transitions.

Keywords: green entrepreneurs, urban sustainability transitions, relational geography, latecomer cities, agency and power.

1 Introduction

Sustainability transitions is a burgeoning research field and political practice due to its focus on systemic and fundamental transformations towards more sustainable production and consumption (Markard et al. 2012). Transitions research has demonstrated great strength in analysing how the highly institutionalised and mutually reinforcing processes in existing regimes can be unlocked to create path-breaking transformations, and has provided rich understandings of system changes in sectors such as energy, transportation and buildings (e.g. Bridge et al., 2013; Geels, 2012; Gibbs and O'Neill, 2015). Recently, there is a growing body of literature examining the role of cities and regions in sustainability transitions (e.g. Affolderbach and Schulz, 2016; Bulkeley et al., 2013; Rohracher and Späth, 2013; Rutherford and Coutard, 2014). Urban sustainability transitions are more than sector-specific transitions, involving fundamental and structural changes in urban systems to realize sustainability goals (Frantzeskaki et al., 2017). Thus "urban areas are locations in which regime change is accomplished through changes to infrastructure, institutions, production and consumer behaviour within the boundaries of the urban area" (Holtz et al., 2018:849).

Sustainability transitions are often believed to mainly address public well-being and public authorities are expected to play a leading role (Smith et al. 2005). This, however, largely underestimates the role of the private sector (Burch et al. 2016).

Research on green entrepreneurship suggests that green entrepreneurs can have the transformative capacity to adapt and challenge existing institutional structures to favour emerging industries (Hörisch 2015; Zhang and White, 2016). Indeed, Gibbs and O'Neill (2014) argue that green entrepreneurs can contribute to sustainability transitions by acting as 'system builders' to advocate for wider system changes in regulations, standards and norms.

However, solely emphasising green entrepreneurs' individual strategic actions and impacts promotes the idea of 'lone heroes' and ignores the social contexts and supporting networks that give rise to them (Cohen 2006). Existing studies have also not differentiated the socio-economic-political impact of green entrepreneurs at different spatial scales. In concurrence with Hörisch (2015) and Burch et al. (2016), green entrepreneurs have great potential to positively influence sustainability transitions at the city level, but the extent to which they can act as system builders depends on place-specific power relations between human agency and social structures, both of which are conditioned and shaped by spatial contexts and multi-scalar relations (Coenen & Truffer 2012; Binz et al. 2014). The question, then, is under what conditions green entrepreneurs gain power to act as system builders in urban sustainability transitions?

In this paper, we develop an analytical framework combining transition approaches

and green entrepreneurship from a relational geography perspective, which places actors, actions, and the changes and developments resulting from their relations at the centre of analysis (Boggs & Rantisi 2003). This framework involves four processes: emergence of green entrepreneurs, multi-scalar interest coordination, empowering through anchoring, and struggling with regimes at the urban scale. The framework emphasises the flows of knowledge, resources, and legitimacy that empower green entrepreneurs through meeting the interests and priorities of various governance levels. We believe this analytical framework could go beyond the two extremes of social structures in transitions research and 'lone heroes' in green entrepreneurial research respectively, and provide a more in-depth understanding about the contingent role of green entrepreneurs in urban transitions.

To illustrate this framework, this paper uses an empirical case study of solar water heater (SWH) diffusion in Dezhou, China. Despite being a latecomer in urbanisation and industrialisation, Dezhou has become one of China's leading cities in the development of solar thermal energy, with a SWH cluster of national importance and an SWH installation rate among the highest in China. These achievements led to Dezhou being designated as China's Solar City and gaining wider international environmental recognition. During this transition, the private sector SWH industry and the largest firm Himin in particular, have played a pivotal role. Using this specific case study exemplifies how local contexts, multi-scalar relations, and green

entrepreneurs interact to influence sustainability transitions in urban China.

The remainder of this paper is organised as follows. Section 2 provides a literature review of transitions, green entrepreneurship, and relational geography research, foregrounding our analytical framework to understand the role of green entrepreneurs in urban sustainability transitions in Section 3. This framework is illustrated in Section 4 through a case study of SWH development and diffusion in Dezhou. Finally, Section 5 concludes the paper with reflections on the framework and the Dezhou case, and implications for future research.

2 Literature review

2.1 Agency and power in transition approaches

A socio-technical system consists of a set of actors, networks and institutions, as well as material artefacts and knowledge. These system components intensively interact with and depend on each other, resulting in stable and path-dependent regimes, that is, the set of rules embedded in artefacts, institutions, actors and cultural values (Geels 2011). The central concern of sustainability transitions is how to enable fundamental changes in socio-technical regimes.

The Multi-level Perspective (MLP) has been the most influential analytical framework in transition research due to its straightforward and simplified way to

depict complex socio-technical transitions through interactive processes at the landscape, regime, and niche levels (Smith et al. 2010). A niche is a protected space allowing radical innovations to be shielded, nurtured, and empowered (Smith & Raven 2012). The landscape is the collection of external factors that affect the dynamics of niches and regimes, but is unlikely to be influenced in reverse in the short run. A socio-technical transition happens when a) landscape changes exert pressure on regimes and provide legitimacy to niche activities; b) regimes destabilise as internal conflicts emerge, creating windows of opportunities for niche innovations; and c) niche innovations gain momentum to challenge and replace regimes through articulating expectations, social learning, and mobilising heterogeneous actors (Geels 2011) . However, the MLP has been frequently criticised for being too functionalistic and oversocialized (Smith et al. 2005) , and it neglects "how, why, and through whose agency these changes come about" (Lawhon and Murphy 2012:360).

The technological innovation system (TIS) approach is another influential framework in transition research. The overall function of TIS is to develop, diffuse and utilise new innovations through the interaction between actors, networks, and institutions. Much TIS research has focused on analysing system functions, e.g., entrepreneurial experiments, knowledge development and diffusion, guiding searches, market formation, resource mobilisation, and legitimation (Bergek, Jacobsson, Carlsson, *et al.,* 2008). This analysis of functions is a useful tool to assess TIS and locate system

weakness, but it is weak in explaining system change (Geels 2011).

Transition approaches, therefore, need to incorporate various types of agency and power. Geels (2014) introduces four forms of power into the MLP: instrumental power, discursive power, material power, and institutional power. However, these forms of power are mainly negative and resistant and only held by the powerful regime agents. This means that the MLP "continues to find itself in the analytical stalemate of having to explain how the *currently* 'powerful' can be unseated (by 'niches'), when they have all the power" (Tyfield 2014:592). Tyfield (2014) thus advocates a relational, dispersed, and productive conceptualisation of power in understanding system transitions, in which new forms of productive power drive the formation of niche assemblages and transform the regime configurations. Similarly, Avelino & Rotmans (2009: 560) argue for the existence of 'niche-regimes' defined as a network of "actors that exercise transformative power; niche-regimes have the capacity to replace old resources by new resources and to transform the current distribution of resources". Yet how, and under what geographical-historical conditions, do these productive and transformative powers emerge? Who are the actors exercising these powers to lead changes?

2.2 Green entrepreneurs

The current global environmental landscape and market failures provide great opportunities for the rise of green entrepreneurs (Cohen & Winn 2007), who aspire to

"restructure the corporate culture and social relations of their business sector through proactive, ecologically oriented business strategies" (Isaak 1998:88). Though green entrepreneurship suffers from the liability of newness and a lack of legitimacy among other actors (Zahraie et al. 2016), it possesses considerable potential to address environmental problems by exploiting opportunities inherent in environmentally-related market failures and thereby facilitating global economic systems moving toward sustainability (Gibbs & O'Neill 2012).

Existing research has developed typologies of green entrepreneurs based on the green firms' sizes, the timing and extent of engagement with a green agenda, as well as green entrepreneurs' motivations (Isaak 1998; Hockerts & Wüstenhagen 2010; Nikolaou et al. 2018). However, a focus on the psychological motivations of green entrepreneurs overlooks the messy and complex institutional process that explains their capability to seize opportunities (Gibbs 2009). In addition, the fixed typologies fail to capture the fluid and blurred state of green entrepreneurs, who may move between 'green' and 'conventional' business (O'Neill and Gibbs 2016). In this respect, Walley and Taylor (2002) developed an approach to classify green entrepreneurs by considering the mutually producing relationship between internal motivations and social structures, which includes hard forces such as economic incentives and environmental regulations, and soft forces such as family and personal networks.

Another major line of research focuses on the strategic actions and business models of green entrepreneurs (Schaltegger et al. 2016; Gast et al. 2017). Besides integrating sustainability values into their business practices and daily management, green entrepreneurs actively network with external stakeholders to gain access to a variety of resources such as capital, information, low-cost services and infrastructure (Kimmel & Hull 2012). Green entrepreneurs also strive to create favourable institutional environments, which usually involves collective actions in articulating sustainability visions, legitimising green development, lobbying for government support, developing new standards, influencing civil discourses and constructing new norms (Zahraie et al. 2016; Pinkse & Groot 2015). Pacheco et al. (2010) compare existing market rules to a 'green prison', "wherein… sustainable actions are punished, rather than rewarded" (p455-466). To escape from green prisons, other than by discovering opportunities under existing rules, green entrepreneurs may create new rules by proactively influencing the establishment of new industry norms, property rights, and government legislation that reward their green businesses.

In the process of furthering their individual interests, green entrepreneurs can exert both market and sustainability impacts through their green products destroying existing unsustainable production methods, market structures and consumption patterns (Hörisch 2015). At the social level, green entrepreneurs, as role models and

future wealth generators, may be able to impose their visions upon other actors and change their mindsets (Beveridge & Guy 2005). At the disruptive level, sustainable entrepreneurs can act as social engineers to change, reconfigure or provide a new system to impact upon global-level social and environmental problems (De Bruin 2016).

Green entrepreneurship research so far, however, has not provided adequate insights into how, and under which socio-spatial conditions, green entrepreneurs can build capacity and power to alter existing game rules or create new reward systems. A focus on individual green entrepreneurs risks overstating their role in transforming the economy at the cost of obscuring the role of other actors and support networks (Gibbs & O'Neill 2012). While some research has shifted attention to the socio-spatial contexts that may foster green entrepreneurs (Outsios & Kittler 2018), this still fails to reveal "the practices and processes through which change is realized, how economic activities are materially transformed in specific contexts" (Beveridge and Guy 2005:673). Research therefore needs to pay more attention to the interaction and symbiotic relationship between the individual behaviour of green entrepreneurs, other actors and social structures, i.e. "how they use strategies to change their business environment and how their environment provides opportunities and threats for their actions" (Zahraie et al. 2016:39).

2.3 A relational geography approach

Relational geography, with its focus on the relations between agency and structure under a multi-scalar perspective, is ideally placed to link the above two lines of research. Relational geography conceptualises space as an open meeting place of interrelations that "run through differing spatial scales from the very local to the global and all points in between" (Massey 2005:9). The relational approach acknowledges that agents and economic actions are embedded in, and subject to, social structure and relations, but it also argues that they are shaping social relations and institutional structures for future economic actions (Murphy 2003). The presence of localised relational assets or institutional thickness in a region is not sufficient to explain its rise and fall. Instead, much causal weight should be given to "the spatial configurations of heterogeneous relations among actors and structures through which power and identities are played out and become efficacious" (Yeung, 2005: 38). In this sense, space is constantly under construction by the tensions between external relations and internal territorial interests and constraints (Jonas 2012). Raven et al., (2012:70) thus advocate that adding a relational space to MLP helps to understand transitions as an outcome of "tensions created in multi-scalar interactions between spatially distributed actors embedded in multi-level structures with different temporal dynamics".

At the city level, agency is not simply conditioned by local contexts, rather, it involves the influence of both intentional and unintended actions by actors across

regional, national, and supranational scales (Hodson & Marvin 2010). Therefore, to understand the role of green entrepreneurs in urban sustainability transitions we need to examine not only green entrepreneurs' strategic actions, but also the spatial embeddedness and multi-scalar interactions that shape urban contexts and influence green entrepreneurs' emergence, and empowerment. Some factors at the urban scale, such as infrastructure, user practices and vested interests, can impose a harsh selection environment for sustainable niche development. Green entrepreneurs thus need to ally actors across scales through interest coordination and to anchor external knowledge, resources, and legitimacy to empower their local system building.

3. An analytical framework

Articulating these theoretical approaches together, we propose an analytical framework to understand the role of green entrepreneurs in urban sustainability transitions from a relational perspective, including four processes: emergence of green entrepreneurs, multi-scalar interest coordination, empowering through anchoring, and struggling with regimes at the urban scale (Table 1).

（Table 1 about here）

3.1 Emergence of green entrepreneurs

Building upon Walley and Taylor's (2002) typology of green entrepreneurs, we understand the emergence of green entrepreneurship as an outcome of the interplay between individual entrepreneurial actions and particular socio-spatial contexts under

the global landscape of the green economy. Global landscapes are critical because they are reshaping both the interests and expectations of individual entrepreneurs and the priorities of multi-scalar governance. Driven by either financial motivations or sustainability values, green entrepreneurs take risks and seize market opportunities or create market niches in places with favourable social structures. This process entails performing several TIS functions such as knowledge development and diffusion, resource mobilisation, legitimation, and market formation, which could possibly lead to a noticeable cluster of green businesses in a particular place.

3.2 Multi-scalar interest coordination

Interest coordination among different governance levels is the key mechanism whereby local niches gain legitimacy or are empowered (Hodson et al. 2016). The rise of green business coincides with the interests and priorities of multiple governance levels, enabling green entrepreneurs to build multi-scalar supporting networks. It is reasonable to expect that actors at the different governance levels have heterogeneous interests and expectations towards environmental innovations. These interests are shaped and conditioned by place-specific economic, political and cultural contexts. At the user level, it is pivotal that environmental innovations can meet consumers' economic or environmental values. At the local level, those green businesses benefiting the local community with economic growth are likely to receive support from local governments. At the national and global level, the environmental merits of green businesses could be valued as a way to address global environmental changes,

and thus build political, economic, and even cultural relations.

3.3 Empowering through anchoring

With the development of multi-scalar relations, green entrepreneurs not only have access to external networks, knowledge, and resources, but can also anchor these to sustain and legitimate local niche development. Anchoring is 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" (Binz and Truffer 2017:21). Through this process, extra-local innovation elements and actors are anchored into specific local innovation systems and become spatially 'sticky' resources for green niche development, empowering green entrepreneurs and their supporting networks.

3.4 Struggling with regimes at the urban scale

The above processes are shifting the power balance between niche development and the structure of regimes in urban areas. Empowered green entrepreneurs can challenge the existing form of a regime in cities through three impacts: market impact, discursive impact, and political impact (Hörisch 2015). The popularisation of green products will have a direct contribution to urban environmental improvement. Green entrepreneurs also can exert influence in changing other actors' mindsets through their discursive power. Finally, by allying with other actors, green entrepreneurs may lobby

for institutional change to favour their growth. This process may lead to fundamental realignment of the urban society, technologies, infrastructure, lifestyle, as well as governance and institutional frameworks (Frantzeshaki et al., 2017).

These processes do not work in sequential or linear order, but undergo constant interaction, reinforcing each other. Thus, this framework does not simply stress the agency of entrepreneurs in lobbying for system change, but also highlights the key mechanism whereby they are empowered through multi-scalar relations, which is built through interest coordination in particular socio-spatial contexts under the global landscape of green development.

4 A case study of China's solar city

Located in the west of Shandong Province, Dezhou was traditionally an important agricultural city in China. Following rapid industrialisation since the 1980s, the manufacturing industry has become the main pillar of Dezhou's economy, although its GDP per capita and urbanisation rate remain lower than the national average (Dezhou Statistics Bureau, 2015). In particular, the SWH industry has emerged as a key economic sector. In the 1990s, China's SWH was regarded as a low-cost household appliance for bathing water and largely driven by the market in rural areas and small cities. Since the early 2000s, China has been committed to the development of renewable energy and in consequence, many local governments began to support

SWH diffusion in urban areas thanks to its environmental merits. To date, China accounts for more than two-thirds of the world's solar thermal collector production and utilisation (Weiss *et al.,* 2017). Dezhou's SWH cluster, at its peak, accounted for 16% of China's SWH manufacturing capacity and its SWH installation rate amongst residents is over 70% (Li *et al.,* 2011).

In order to investigate the development of the SWH industry in Dezhou, between November 2014 to March 2015, 36 semi-structured interviews were conducted with respondents from solar enterprises, municipal government, research institutes, industry associations and estate developers in Dezhou and Beijing. These interviews focused on the factors which facilitated and obstructed SWH industry development in the city and the interaction between the industry and other urban institutions and actors. In addition, document analysis, site observations, and attendance at industrial conferences were utilised as data collection methods in order to triangulate the interview sources.

4.1 The emergence of green entrepreneurs

Dezhou's solar industry began with the entrepreneurial story of Huang Ming, the founder of Himin, the city's leading SWH firm. Initially, Huang Ming worked in Dezhou as a researcher for a state-owned oil drilling research institute of China's Ministry of Mineral Resources. In 1987, a book about solar engineering of thermal processes introduced Huang Ming to the field of solar energy and he began to make

SWH, exploring the potential market by presenting SWH to his friends and relatives as gifts to see how they worked (interviews SE01, SE03)[1]. In 1992, Huang Ming joined the '*tide of going to business*' by setting up Xinxing company, which paved the way for the establishment of Himin in 1995. In 1997, Himin cooperated with Tsinghua University (a Beijing-based university) as a regional manufacturing branch of Tsinghua Solar, which possessed the most advanced evacuated tube SWH technology at that time. Subsequently, Himin started to develop its own innovations by setting up its own international R&D teams (interview SE09). External technology learning and substantial R&D investments made Himin not only the world's largest SWH supplier, but also one of China's technology leaders in the SWH industry. Meanwhile, Himin made great efforts in promoting the SWH market by popularizing knowledge of solar energy in Dezhou and nationwide. Himin's fast growth created an expanding market for related solar products and equipment and opportunities for Dezhou's local entrepreneurs, resulting in other local solar firms gaining national influence (interviews SE04, SE05, SE07, SE08, SE14). By 2010, the city was home to more than 120 enterprises engaging in solar-related industries.

> *"Visitors from all around the world come to Dezhou mainly for Himin, but when they are here, they find there are many more solar enterprises other than Himin providing different advanced technology and products...Himin did play an important role, it attracts a lot of attention to Dezhou, and we benefit from this".*

[1] Interviews are numbered by combining interviewee types (e.g. solar enterprises (SE), municipal government (MG), estate developers (ED), research institute (RI) and industry association (IA)) and sequential number (01~36).

[interview SE08]

The growth of this SWH cluster is closely associated with both Dezhou's and China's socio-economic context. SWH meets the economic rationale of reduced energy bills for hot water during China's fast urbanization. Close interpersonal networks in Dezhou also played an important role. As there are many acquaintances working in the industry, mutual trust between producers and consumers has been enhanced to facilitate SWH adoption. Many SWH firms were established or spun-off with help from relatives and friends who were already operating businesses in the industry (interviews SE04, SE12). In 2005, Dezhou's government officially implemented its *Solar City Strategy* and introduced a series of preferential policies and plans to provide comprehensive technological and financial support to the solar industry (interviews MG 11, MG19).

4.2 Multi-scalar interest coordination

The development of Dezhou's SWH industry illustrates a tripartite win-win-win for the environment, city marketing, and industry. The industry has aligned with interests and priorities at the local, national, and global levels, resulting in wide multi-scalar relations. Global climate change has exerted landscape pressures which resonate with China's endogenous challenges in energy security and environmental improvement. China's framing of the sustainable development problem has gradually shifted from an initial focus on energy security to concern about global climate change and domestic environmental pollution. More importantly, many institutions have been

changed at the national level to facilitate low carbon development - '*energy saving and carbon mitigation*' has become a prevailing discourse in China's media, government, and business（interviews RI10, IA32）. Not only have the national Five-Year-Plans (FYPs) prioritised renewable energy development, but the Renewable Energy Law (2006) provides a supporting institutional framework. In addition, China is making efforts to shift its GDP-oriented cadre performance evaluation system (CPES) towards a greater weighting for environmental performance. The rise of the SWH industry coincided with this global interest and national priorities in green development and, consequently, gained legitimacy and resources from the global level and national level. Due to Himin's contribution to the renewable energy industry, Huang Ming was elected as a delegate of the National People's Congress (NPC) in 2003, where he proposed China's Renewable Energy Law. Himin has not only become a well-known green enterprise in China, but also has been widely cited by international media as a key mover for the sustainable development of renewable energy. In 2008, Huang Ming was also elected as vice president of International Solar Energy Society.

At the user level, SWH products catered to the rising demand of Dezhou's and China's urbanising residents for an economic source of hot water. In Dezhou, SWH was widely seen as a cost-saving and convenient technology that improved residents' living quality. The growth of the SWH industry significantly contributed to Dezhou's

GDP growth and city branding, as well as employing around one-third of the city's workforce (Tyfield et al. 2010). Interviewees suggested that it is precisely because Dezhou is a small less developed city without other dominant industries that the SWH industry has played a pivotal role (interviews SE12, MG19, RI22, IA32). This key role in local economic growth fitted with the city government's development priorities. As a SWH entrepreneur illustrates:

> "In the past, people knew Dezhou because of braised chicken, but it was a low-end product… Dezhou government wanted to promote Dezhou to the word, so they needed a recognised star enterprise. Eventually, they believed Himin could be the best city label of Dezhou …The government's expectation was that the leading enterprises Himin, together with those supporting solar enterprises, would make a difference to Dezhou". [interview SE12]

4.3 Empowering through anchoring

It is through these multi-scalar relations that external knowledge, resources, and legitimacy are anchored to Dezhou's local SWH cluster, whereby large firms have played a central role in bridging local and external networks. With the fast-growing SWH market nationwide, Himin's financial size has grown rapidly and it has attracted investment from domestic and international investors, such as Goldman Sachs and Ding Hui Investment, who together invested US$100 million in Himin in 2009. Furthermore, it has developed a strong innovative capacity by drawing in talent internationally and taking advantage of cooperation with leading universities in China. Initially, Himin benefited substantially from local technology spillovers through Tsinghua Solar, but after 1997, resorted to Australian solar experts to develop

its indigenous evacuated tube technology. It subsequently established China's first private research institute in the solar thermal industry. While Himin has become one of the leading firms in SWH technology innovation, it retains intensive connections with Beijing's research institutes:

> *"Himin was very small at the beginning, so it needed strengths-borrowing. Tsinghua Solar belongs to Tsinghua University, Himin could benefit from association with this well-known brand …this drove Himin's market growth".* [interview SE12]

Most of the other large SWH firms in Dezhou also chose to cooperate with Beijing's universities and research institutes, because Dezhou lacks research universities and R&D talent (interviews SE02, SE05, SE09). They have taken advantage of Beijing's talent resources to promote technology development through outsourcing, technical cooperation, training, and inviting experts for short periods of time to guide their research.

These big firms play the role of global pipelines in importing advanced knowledge and diffusing this to the local cluster through local networks. A number of firms were established as equipment providers for Himin in the early stages, but many of them went on to become SWH manufacturers as a result of benefitting from technology spillover. Many solar firms' founders and employees had work experience in Himin (interviews SE 01, SE02, SE04, SE07, SE12, RI10). The outflow of talent led to spin-off activities and also enhanced technology and tacit knowledge spillover to other firms. As Himin moved up the value chain to provide high-end SWHs, this left market

room for small SWH firms in Dezhou (Li et al. 2011). Firms in other industries also diversified into solar business. For instance, the air-conditioning industry used to be a leading industry in Dezhou, but some air-conditioning firms shifted to the solar industry, partly because they realised the unsustainability of their polluting industry, but also to take advantage of Dezhou's new momentum as a solar city (interviews SE05, SE08).

Furthermore, increasing reputation and legitimation were embedded into Dezhou's place identity building. In 2005, the city was awarded 'China's Solar City' by China's Solar Association and in 2009 designated as one of China's first Renewable Energy Demonstration Cities by the Department of Housing and Urban-Rural Development, receiving RMB 60,000,000 annually to subsidize demonstration projects. Dezhou boosted its international reputation when it hosted the International Solar City Congress in 2010. The solar city has become the prevailing discourse and daily practice in the local community, building and enhancing a sense of place identity among Dezhou's residents, media, industry, and local authority, and reinforcing the mobilization of more resources and participation (interviews MG17, RI 22).

4.4 Struggling with regimes at the urban scale

As the industry became more financially and politically powerful, it was able to lobby and ally with other actors to reconfigure regime institutions, norms, standards, and discourses within the city, a key strategic objective in transitions involving the

development of a critical mass of entrepreneurs and other actors (Bergek, Jacobsson & Sanden, 2008). While individual SWH installations had become an established social phenomenon in the early 2000s, institutional actors involved in Dezhou's building infrastructure initially inhibited further SWH-building integration. At the early stage , Himin sought to cooperate with estate developers to develop SWH-building projects but failed (interviews SE01, SE12), because estate developers did not trust the quality of SWH systems and lacked know-how about incorporating SWH into buildings (interviews RI 22, RI32, SE03, MG06). The building design institutes also lacked expertise in SWH-building integration. To counter this situation, Himin built several demonstration SWH-integrating buildings and developed an estate project 'Future City' as a model project to show how solar energy could be integrated with residential buildings. In 2004, together with Dezhou Architect Design Institute, Himin developed and promoted the first design standard for SWH-building integration projects in Dezhou and Shandong province (interview RI22). In 2006, together with Shandong's Department of Construction, Dezhou's SWH industry created China's first standard schematic handbook for the integration of building and solar energy. The SWH industry has thus actively engaged in what Zhang & White (2015) term 'enacting legitimacy' through their actions and engagement with other actors.

However, although a number of estate projects adopted SWH-building integration for

promoting sales, it did not become a common practice among estate developers until the government implemented a mandatory installation policy, which had been lobbied for by the SWH industry (interviews SE03, SE04). The mandatory installation policy required new building projects to integrate SWH in design and construction. Though many estate developers initially attempted to avoid the regulation, the resultant loss of market competitiveness eventually forced them to incorporate SWH into building construction (interviews ED 20, ED21, ED24, ED25, RI22).

> *"When the mandatory policy was the first initiated，inspection was not in place, and estate developers did not really follow the design, but this situation changed as soon as property buyers do not want to buy properties without SWH being incorporated. Through this market selection and increasingly strict government inspection…the situation improved a lot".*[interview RI22]

From this point, institutions and actors involved in the general building infrastructure were no longer hostile to SWH-building integration in Dezhou, and 95 percent of new residential buildings in its central urban area had SWH systems incorporated by 2014 (Dezhou Government, 2014). The actions of government thus influenced what is deemed legitimate in the local institutional context, creating a 'legitimacy space' within which the SWH industry could develop (Zhang & White, 2015).

As the city's industrial interests and territorial priorities are closely aligned, the SWH industry successfully lobbied the Dezhou government to initiate the *Solar City Strategy* in 2005 as part of Dezhou's development vision and to implement favourable policies towards the industry, including the promotion of solar industry as Dezhou's

leading industry and positioning Dezhou as a leading solar city both within China and globally. This included municipal government funding and preferential land use for solar enterprises and organising cultural events such as the International Solar Expo and Solar Thanksgiving Day (interviews MG12, MG17, MG19).

This solar city vision is supported by residents, who are proud to be part of China's Solar City and are willing to accept solar thermal products, albeit that they are less aware of specific targets or policies. These attitudes have to a large extent been shaped by the SWH industry, which has exerted a strong discursive power in influencing the way the issue should be discussed. While electrical water heaters (EWHs) are viewed as a safe and convenient product by urban residents elsewhere in China, it is not considered as safe or convenient as SWH in Dezhou (interviews SE01, SE04). This attitude is largely attributed to the influential promotion by the local SWH industry, enabling the use of SWH as a taken-for-granted routine for local residents.

The diffusion of SWH in Dezhou thus became a self-sustaining process when a positive feedback loop was established among the SWH industry, local government, estate developers, and urban residents (Yu & Gibbs 2018b). The SWH industry is the key actor in allying these actors to promote regime change in urban building infrastructure, policies, mindsets, and user practices. The success of Himin in this

emerging renewable energy industry also enabled it to exert political influence at the provincial and national levels. The consequent introduction of China's Renewable Energy Law and the subsequent policies towards the renewable energy industry altered regime conditions, which imposed direct pressures on actors at both national and local levels to champion the production and consumption of renewable energy.

5 Discussion and conclusions

This paper responds to the recent call for interactions between human geography and transitions studies (Murphy, 2015; Hansen & Coenen, 2015). The framework we have developed in this paper highlights that the coordination of interest and expectation, which is being shaped by the socio-spatial institutional structure and landscape pressure, is the key mechanism for green entrepreneurs to build multi-scalar relations to empower their local actions. Using the example of Dezhou's SWH industry, the framework shows how green entrepreneurs emerge, develop, and exert impact in a multi-scalar context, rather than simply focusing on what is mobilised (Avelino & Rotmans, 2009). We have demonstrated that the agency of green entrepreneurs to struggle against institutional structures is not simply by virtue of possessing resources, rather, it is "as the result of a collective and embedded capacity and hence developed and reproduced through actor networks" (Smith and Raven, 2012: 1031). The Dezhou case shows an explicit local network comprising the SWH industry, local government, estate developers and civil society, with the dominant firm Himin at the centre

interacting with trans-local networks, drawing knowledge from global pipelines, attracting international financial investments, influencing the national institutional structure and earning a pioneering green image. These key actors thus play the role of intermediaries between the local node and global network (Späth & Rohracher 2014). Although the industry had to overcome opposition from developers, Dezhou has not experienced the kinds of "antagonistic power dynamics and relations" that Avelino and Rotmans (2011: 799) suggest as a necessary condition for transitions to occur. This may reflect the continued key role of local governments in China which act as "instigators, regulators, and participants" in urban growth (Sun & Huang, 2016: 918).

Nonetheless, we are not advocating that agency and power are invariably critical in sustainability transitions regardless of spatial and temporal contexts. On the contrary, their role is contingent. Green entrepreneurs and their trans-scalar networks are still "operating within a context of institutions, norms, and rules which condition their choices and relations" (Boggs and Rantisi 2003:111). The resources and relations that empower green entrepreneurs are usually acquired from the very same multi-scalar institutional structure. As the Dezhou case exemplifies, it is through coordinating with the institutional interests at the different levels that the SWH industry has been empowered to make a difference.

The transition process is inherently political at various levels, involving power

struggles among different actors to define the landscape, sustain (or destabilise) regimes, and protect (or expose) niches (Meadowcroft 2011). No single actor has sufficient power to generate transitions, but there are usually certain influential actors dominant in directing the process, positively or negatively. Geels (2014) argues that incumbent big businesses are able to influence policy-making in many ways due to local economic dependency on them. We have demonstrated that this role of big business is not necessarily bound to incumbent actors, rather, emerging green businesses may also fulfil such a role in influencing local policy-making as long as they are 'big' enough in the local context. In Dezhou's case, the key role in local economic development and city branding enables the SWH industry to have structural power in directing local path-creation.

This contrasts with cities such as Beijing, where SWH entrepreneurs also lobbied hard for a mandatory policy, but received a slow response. As Bork et al. (2015: 40) indicate, the legitimacy of technologies can vary depending on local contexts and the actions of actors in "a socio-political process of legitimation". While Beijing's SWH industry is bigger than Dezhou's in terms of firm numbers and economic output, its relative importance in the local economy is much less than its counterpart in Dezhou, explaining the power differences of green entrepreneurs between the two cities. As green entrepreneurs have a comparatively bigger role in smaller cities' economic development, they possess higher potential to act as system builders. Dezhou's SWH

firms have not only diffused SWH widely, but have also built a new technological system, which encompasses many networked actors and supporting institutions, to make the diffusion a self-sustaining process and legitimated solar energy (Zhang & White, 2016).

This analysis also points to the role of the relative size of cities in urban transitions. Existing urban transitions research has focused on the leading cities in the developed world and sustainability transitions in small and ordinary cities have rarely been researched (Hodson & Marvin 2010). In fact, global environmental imperatives are repositioning the role of peripheral regions in global production networks (Murphy & Smith 2013) by challenging the economic criteria that used to be viewed as the key to regional development and offer another pathway where latecomers may have a better chance to lead due to less regime resistance in adopting green solutions and their place-specific endowments in, for example, renewable energy resources and interpersonal networks (Späth & Rohracher 2014; Yu & Gibbs 2018a). Scholars have thus argued that green niche development could be combined with local economic development in non-core regions because linking environmental sustainability to regional path creation not only strengthens local industry's competitiveness, but also delivers the economic benefits that less developed regions aim for, and thus ally more strategic actors to empower niche development (Essletzbichler 2012). Success in the environmental realm does not merely place them at the forefront of ecological

sustainability, but in turn, helps to promote local economic development through building a green image and attracting green investment (Outsios & Kittler 2018). Green entrepreneurs thus may have a bigger role to play in leading the local transition in such places. Future research can contribute with a more specific categorisation of cities and explore the corresponding roles of green entrepreneurs in their urban transitions.

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Table 1 Four processes in the framework

Process	Literature sources	Main activities
Emergence of green entrepreneurs	e.g. Walley and Taylor (2002); Cohen and Winn (2007); Gibbs and O'Neill (2012)	Entrepreneurial actions engaging in green businesses due to individual motivations and particular hard and soft social structures in certain places.
Multi-scalar interest coordination	e.g. Hodson and Marvin (2010); Hodson et al. (2016); Essletzbichler (2012)	Alignment with multi-scalar interests and expectations that are shaped by global landscape and national institutional structures.
Empowering through anchoring	e.g. Bathelt et al. (2004); Binz et al. (2016); Binz and Truffer (2017)	Green entrepreneurs bridge local and external networks and embed external knowledge, resources, and legitimacy to local innovation systems.
Struggling with regimes at the urban scale	e.g. Pacheco et al. (2010); Geels (2014); Gibbs and O'Neill (2014); Hörisch (2015); Burch et al. (2016); Tyfield (2014); De Bruin (2016)	Allying with other urban actors, green entrepreneurs exert market impact, discursive impact, and political impact to struggle for changes to socio-technical regimes within cities.