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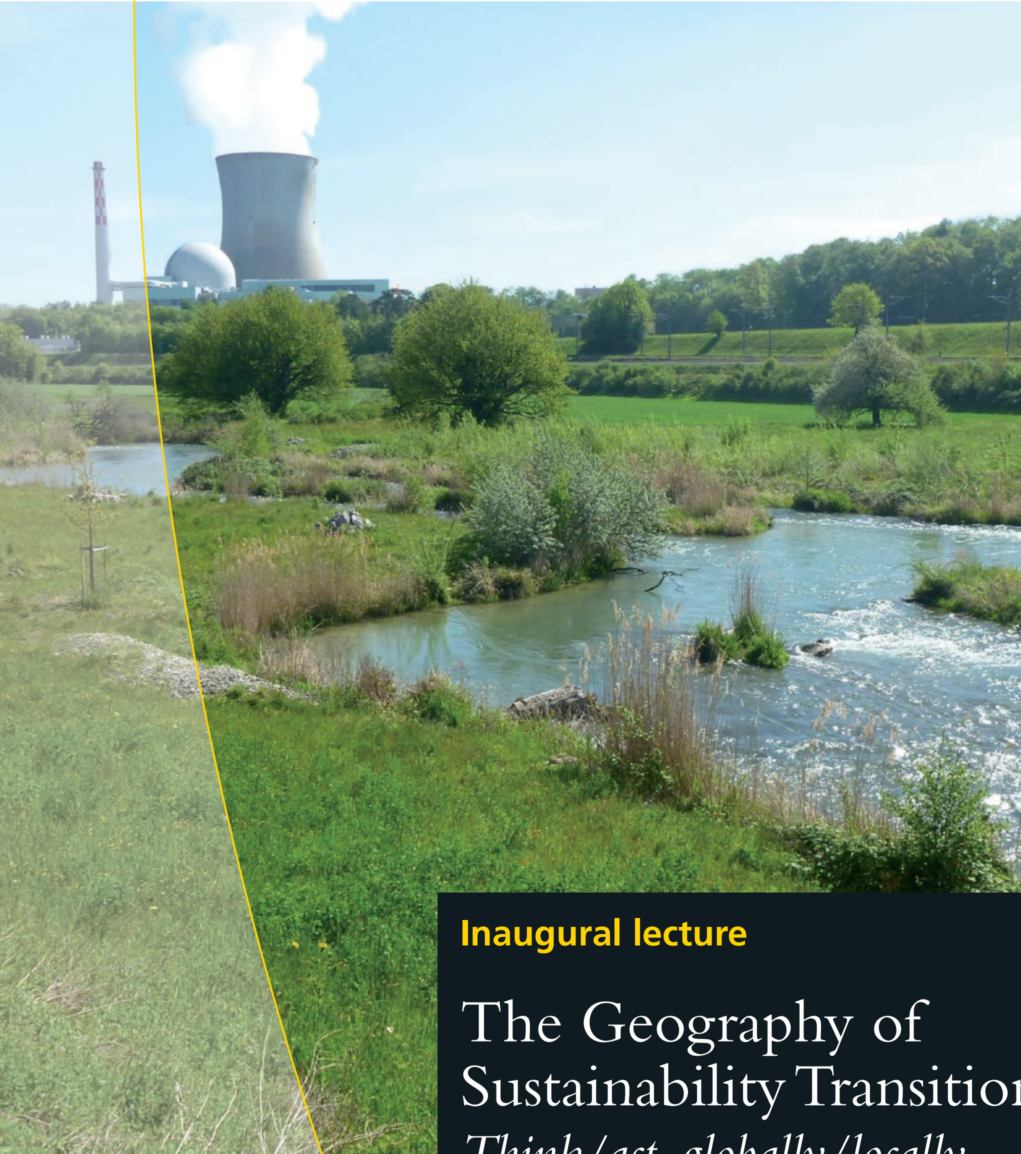

Inaugural lecture

The Geography of Sustainability Transitions
Think/act, globally/locally

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The geography of sustainability transitions

Think/act, globally/locally

Inaugural lecture, delivered upon acceptance of the Chair in Geography of Transitions in Urban Infrastructures, at Faculty of Geosciences of Utrecht University, on Friday, 20 May 2016 by Bernhard Truffer.

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1 Introduction

Dear rector magnificus, dear colleagues, dear guests, friends and family. It is a great pleasure and a big honor to do this oratie. The title of my inaugural lecture corresponds to the title of my university chair. The geography of sustainability transitions is a field that is gaining traction both in academia and in policy making. The subtitle might however sound rather awkward. To already give away the take-home message of this talk: I maintain that the current challenge of achieving sustainability transitions is to increasingly think and act, both at the local and the global level. This indicates that we have to go beyond the very mobilizing slogan of environmental movements formulated in the 1970ies, which was "think globally, act locally".

I can seamlessly build on the talk given by Rob Raven as mine is firmly rooted in the sustainability transitions literature. Sustainability transitions are fundamental transformations of entire industrial sectors towards less impacting future structures. An example are ongoing changes in electricity sectors which build increasingly on renewable energies. The argument will be developed in four steps: First, I will elaborate on the origins of the public debate on sustainability transitions and introduce a salient theoretical framework to analyze emerging industries. In a second step, I will provide empirical illustrations on how "local action" has importantly contributed to the development of green industries. More recently, and this will be the third step, we see that global relationships play an increasingly important role and I will elaborate what it takes to grasp this conceptually. Concluding, I will look at the future of sustainability transitions research and beyond.

2 Sustainability transitions: a historical program and some salient frameworks

If one tries to pinpoint a historical start of broadly shared societal concerns about the environment, I guess two books from the early 1960ies stand out: the "silent spring" by Rachel Carson (1962) and "the life and death of great American cities" by Jane Jacobs (1961), who would celebrate her 100^{th} birthday this year. They sort of condensed an emerging critique against the dominating trust in engineers and other experts that their advice would automatically lead our societies towards progress and happiness. Both argued that the dominant forms of progress actually led to quite horrible impacts on both social and natural environments. And they both hinted at a geographical problem, namely that one had to shift the focus of analysis away from the national level to the global and local scale, where negative outcomes of technological progress were more likely to become tangible. In this vein, the early environmental movement coined the slogan "think globally, act locally" as a call for citizens to distrust experts and to mobilize them to proactively take care of the future.

This appeal got greatly amplified by two disasters with established large scale technologies: the nuclear accident in Tchernobyl in 1986 and more recently the tsunami induced nuclear meltdown in Fukushima in 2011. Both events mobilized a considerable number of citizens to proactively engage in technology development. It was a sort of democratic upsurge of laypeople wanting to shape the technologies of the future. In the beginning, these citizen movements – local action, so to speak – were ridiculed by experts because they returned to old technologies that had since long thought to have been overcome. Think of the electric vehicle movement in countries like Switzerland or Norway or wind energy as originally developed in Denmark. So, people engaged in activities that some have called nurturing "hopeful monstrosities". Could this ever lead to anything serious or were these local initiatives bound to fail from the start?

If we fast-forward to the current situation in many of these technology fields, we see that quite astounding developments took place. Today we have five MW wind power plant that have little in common with the original bricolages of Danish farmers. Another remarkable indicator is that cost for photovoltaic power has decreased by a factor of ten over the past twenty years. Meanwhile it has reached grid parity, which means it starts to pay to take your electricity from a panel instead as from the grid. A recent report from the EU furthermore states that the renewable energy sector today hosts more than 2 million jobs. We therefore witnessed the emergence of a veritable industry over the past quarter of a century.

In order to answer the question of whether and how the early local initiatives were connected to the later industry emergence, we have to adopt a "socio-technical" understanding of industry development. This means that we have to conceptualize how social change processes interact and align with technological developments in order to form "configurations that work", as Arie Rip and René Kemp have called it already twenty years ago (Rip and Kemp, 1998). Transitions studies have developed a number of conceptual frameworks to analyze the dynamics of socio-technical systems in sectors like electricity, transport or urban water into more sustainable directions(Markard et al., 2012).

In line with many colleagues here at Utrecht University, I have mostly researched how new clean-tech industries emerge. The conceptual framework of Technological Innovation Systems, or TIS as we call it, has proven very generative for this purpose (Bergek et al., 2015; Carlsson and Stankiewicz, 1991). Adopting this framework means that we look not only at companies that run innovation processes in-house but also at networks among these companies and with many other actors that promote a specific technology and which are embedded in different institutional contexts. Citizen movements can be analyzed as part and parcel of an emerging technological innovation system. The performance of innovation systems can be assessed by scrutinizing core processes through which innovations are developed like how knowledge is generated, how resources are mobilized, how legitimacy can be raised for the future technology and finally how markets get formed. Conjointly these key processes drive the up-scaling of new technologies into mature industries (Bergek et al., 2008; Hekkert et al., 2007).

The original TIS literature analyzed many different cases of "alternative technologies" such as biogas, photovoltaics, wind, fuel cells, organic food, electric mobility and so on. These analyses however mostly focused on specific countries, like the Netherlands. This was primarily because researchers assumed that industrial policy was primarily implemented on a national scale. As you might expect from the title of my talk, we have criticized this state of affairs from a geography point of view (Coenen et al., 2012; Murphy, 2015). This is, in a nutshell, the meaning of the geography of transitions: It asks "where" new developments are likely to happen, and which sort of local contexts are amenable to the creation of novel configurations that work. However, focusing on the local is not enough. We observe that resources, which actors bring in from distant places are increasingly important for the success of new technologies (Sengers and Raven, 2015; Truffer and Coenen, 2012; Wieczorek et al., 2015). Also transition oriented innovations are increasingly taking place outside of European countries. One indication is that China is gaining a dominant role in the global investment of renewable energy and countries like India or South Africa are following suit just a number of ranks lower. We therefore have to ask how local and global activities are interlinked and how they contribute to the maturation of technological innovation systems (Dewald and Fromhold-Eisebith, 2015; Quitzow, 2015; Truffer et al., 2015).

3 Evidence for the effectiveness of local action

Let me start with elaborating the relevance of local processes. One of the most remarkable technological developments in the field of sustainable transitions was the rapid growth of photovoltaic markets in Germany over the past two decades. In figure 1, you see the growth in the five major national markets in the world over the course of twenty years. Please be aware that the y axis is put in a logarithmic scale, which shows how rapidly this technology has diffused. Germany has become the world market leader since the early 2000s. This remarkable development is mostly explained by the introduction of a strong national support policy in Germany in the early 2000s: the so-called feed-in tariff for renewable electricity sources. It therefore looks as if we are in a classical situation where national policy defines how and which industries will develop. And this is all the more to

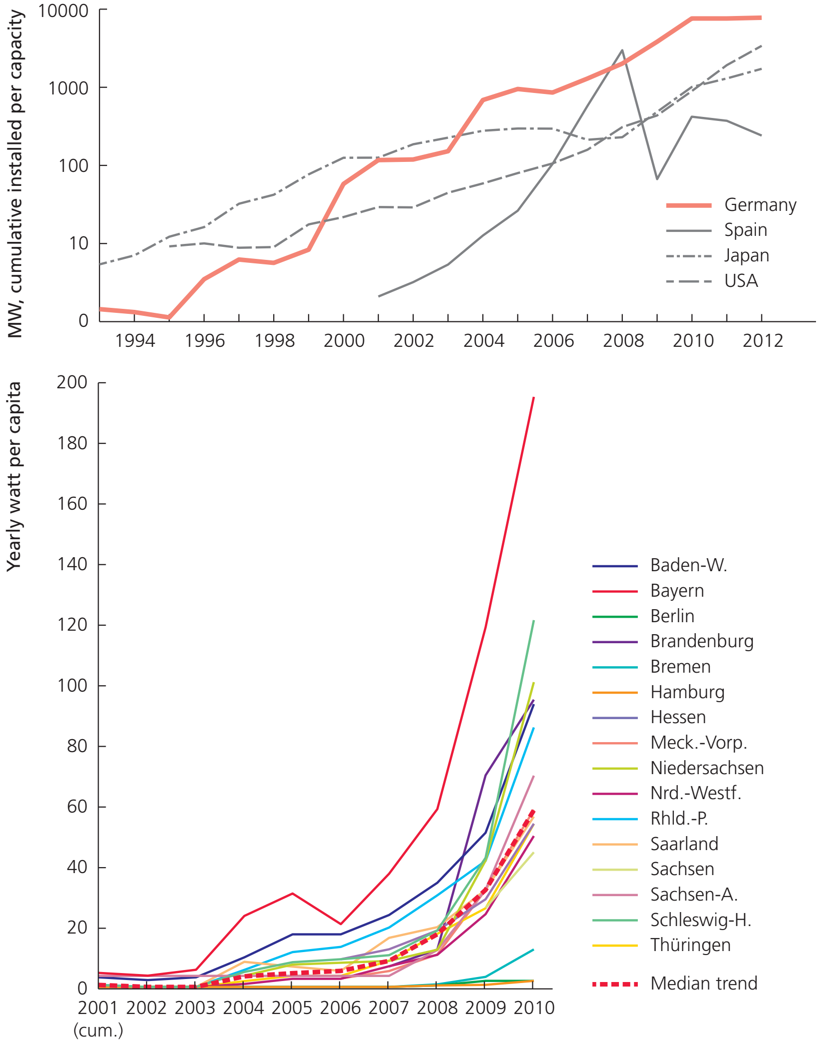

Figure 1: *Market growth in photovoltaics globally and within the German Federal states (Dewald and Truffer, 2012)*

be expected in a field with a strong public policy component like infrastructure sectors aiming for sustainable development.

However on further scrutiny, we see a high variety of market developments inside of Germany. The second part of figure 1 depicts the diversity of growth rates at the level of federal states. The curves depict per capita added capacity of each year. Without going into the details, you may see that some federal states like Bavaria and Baden Württemberg grew by a factor two to three more rapidly than the average of all federal states. An immediate candidate for explanation would be sunshine, as irradiation is higher in the South than in the North. However, this explanation still does not fully account for the geographical variation.

Through a detailed analysis of the early formation processes of the German PV TIS, we were able to show that one specific actor group was key for early market development: so-called Solarbürgerinitiativen (solar civic initiatives). Normal citizens got mobilized after Tchernobyl to transform the energy system in their local communities (Dewald and Truffer, 2012). However, neither the technology was available in a robust form yet, nor were user expectations fixed and also regulatory frameworks were badly suited for the new technologies. To become effective, the civic initiatives had to play the role of system builders, of sorts (Hughes, 1987). They bought components and integrated them into products, which they sold to their fellow citizens. They also had to overcome resistance by local trades like plumbers, or roofers, who did not see any serious market prospect. Finally, they lobbied their local parliaments to change laws and to introduce new promotional programs. In a sense, they went for an energy transition in their local communities.

In 2010 when we conducted the empirical study, we identified 330 initiatives in Germany of which 75% were concentrated in three federal states: Bavaria, Baden-Württemberg and Northrhine-Westfalia. These were also the regions that had experienced the strongest growth subsequent to the introduction of the national feed-in law. Based on these analyses, we could show that the work of the local initiatives had been crucial for the introduction of the national feed-in tariff. For this to understand you have to know that local community representatives were very actively lobbying for political support first in the respective federal states and finally also at the national level. Furthermore, early forms of feed-in tariffs had been introduced and tested in various local contexts long before the introduction of the national support policy and served as demonstrations that the "configurations work". To summarize, we claimed that without the work of these local initiatives, Germany would never have been able to become the global market leader for photovoltaics and as a consequence, it would have been difficult to reap the learning economies that massively drove down costs for photovoltaic energy by several orders of magnitude (Dewald and Truffer, 2011).

Therefore: Local action made a huge difference to the emergence of new and potentially more sustainable technologies. It enabled to overcome development barriers by aligning technological designs and institutional conditions in specific local contexts. This local context reduced complexity of the alignment process, actors could build on relationships of trust and by this they could demonstrate actual "configurations that work".

Meanwhile we have many more examples in the literature that point into similar directions (Hansen and Coenen, 2015; Späth and Rohracher, 2012). A classical case is the explanation by Garud and Karnoe (2003) why Denmark became a world market leader in the wind energy industry and not the US, despite of the latter having had spent much more resources and building on world class universities. Also in the Danish case, local lay actors – farmers in this case – tried out different designs, had arm-length interactions with early users and policy makers, which provided support for broadly based learning processes over extended periods of time.

The relevance of local embedding is however not limited to lay people and motivated citizens. In a recent research project that we ran jointly with a group from the environmental engineering department at UC Berkeley, we could show how a cautious local embedding process was instrumental for creating legitimacy for a rather strongly disputed technology: namely direct potable reuse of wastewater. California, like many other regions in the world are increasingly suffering from water shortages (Binz et al., 2016a). Running water in short cycles is among the promising approaches to get the needed services out of the available water. One extreme form is to recycle treated wastewater and directly inject it into the drinking water reservoirs. Obviously, this is an option that many people find disgusting. What do you have to do to create widespread acceptance for such a technology?

We reconstructed the development trajectory of the corresponding Technological Innovation System over fifty years. One of the local water companies, the water utility of Orange County, managed to install first direct potable reuse systems, already in the early 1980ies. They chose a high involvement strategy with their local communities to garner support. They worked on a broad variety of technological designs, developed safe operation and maintenance procedures, they interacted with all sorts of local stakeholders to explain their approach and identify early problems. Over all these years, they maintained a high profile of trust from their local communities and were considered a best practice example in the whole state of California.

Impressed by this success, several other local utilities tried to copy the model of Orange county. However, replications were limited to the technical setups and some glossy information brochures for their customers. One after the other of these initiatives ran into heated opposition. Citizen groups like the "revolting grandmothers" or a local brewery stood up against these schemes and brought them to a standstill. The problem was that the copiers failed to understand the broad and systemic approach that Orange county had been following and missed some of the essential parts for creating local legitimacy.

More recently the sector seems to have learned its lesson and direct potable reuse is increasingly accepted as a potential source of drinking water in California. Through our research, we could show that an innovation system perspective helped industry actors to develop a deeper understanding of what is needed to introduce and scale-up a novel technologies that are initially confronted with strong resistance. Acting at the local level has also here proven to be very important. It provided a place where new "configurations that work" could initially be developed and their feasibility be demonstrated before they could be taken up at a regional and national scale.

4 Incorporating the global perspective

We conclude from these examples that local processes can play a decisive role for industry emergence and that even supposedly "unqualified" actors can mobilize the needed resources and run the relevant system building processes. This is, however, not the end of history and this leads me to the fourth part of my talk. Put in somewhat broader conceptual terms, I tried to show that successful innovation does not only depend on technical expertise but equally on the ability of actors to conduct institutional alignment processes. Proximities among actors are very important for the latter. They provide contexts for short learning cycles, they enable the mobilization of trust under conditions of uncertainty and they allow to reduce complexity by limiting variation in context conditions. Local spaces are often very suitable containers where proximities materialize (Coenen et al., 2010). However, proximities may also play out beyond local contexts. This is one of the original contributions made by another two of my colleagues at Utrecht University, Ron Boschma (2005) and Koen Frenken (Hardeman et al., 2015).

Outside of local contexts, proximities may materialize along cognitive, institutional, professional, organizational or cultural lines. These proximities may enable actors to access resources from distant places that would otherwise not be available to them. We therefore have to analyze how actors get access to resources and competencies outside of their local contexts. The national focus has therefore not only to be questioned "from below", i.e. from the local spaces, but also "from above", i.e. transnational relationships. At times, the national level even gets sidelined by direct local-global relationships. Let me illustrate this with an another example from our recent research.

Onsite water treatment is one of the hopeful monstrosities of our times. It promises to soon supplant the heavy infrastructure based way we deal with our urban water. Since the early 20th century, the incumbent regime had been extremely successful to convert cities into livable places. Cholera and other communicable diseases, which were endemic in former centuries have more or less disappeared in those urban areas that have implemented it. However, considering future challenges, it becomes increasingly unclear whether this socio-technical regime will still be appropriate, particularly if we look at developing countries (Larsen et al., 2016).

Onsite treatment options have many potential advantages. In particular they require much lighter investments in civil engineering infrastructure. However, these alternative systems are still not very well developed and lack many of the needed socio-technical alignments to make them serious challengers for the incumbent regime. As a consequence, only a few sizeable markets have developed internationally. It is a technological innovation system at a very early stage of development, so to speak.

One of the notable exceptions where we could identify instances of socio-technical alignment is the city of Beijing (Binz et al., 2016b). It all started with the introduction of a law that the city government implemented in 2008. It required international hotel chains to treat their wastewater in-house. The hotel chains mobilized international technology firms to develop suitable solutions. After a number of years, a sizeable niche market developed, which was seen as a considerable success by the local government. This led local technology firms and university startups to copy system designs and successfully lobby the city government to extend the regulation to newly built apartment blocks, in 2010. This led to a strong growth of local companies. However, performance of the solutions remained below expectations and legitimation for onsite treatment started to dwindle. As a consequence, some companies shifted their target markets to peri-urban and rural contexts, where the systems proved to work much better because they developed encompassing operation and maintenance concepts and adopted a broad legitimation strategy. Based on these new markets, an industrial export base could be developed to sell these systems all over China and beyond.

This example illustrates how local processes have again been decisive for success. However, the crucial driver in this case was the ability of actors in the innovation system to access global resources. Proximities were therefore not limited to local contexts. They encompassed organizational proximities within international hotel chains and professional proximities with transnational technology companies. Even though the Beijing companies initially had problems achieving quality standards, they ultimately managed to build up an industrial core by anchoring globally available resources in their local environment. It is therefore the combination of local embedding and transnational networks that was decisive for achieving socio-technical alignment.

Analyzing some other forms of proximity, we discovered entirely new "geographies" of relevant innovation system processes. In one paper, we looked at cognitive proximity by analyzing co-authorship networks in the field of membrane bioreactor technology, a core component of onsite water treatment systems (Binz et al., 2014). As you see in figure 2, the pattern that appeared is far from trivial. Apparently, knowledge production takes place in largely globalized networks. However, these patterns are not without geography. We see for instance that there are strong interactions between European and Asian authors, while American authors seem to be rather isolated. The situation is not equal everywhere, though. As you might see, for the case of South Korea, quite a distinct interconnection pattern exists within the country. In Europe instead, we see strong interconnections, with Germany as an important hub, but also including manifold transcontinental

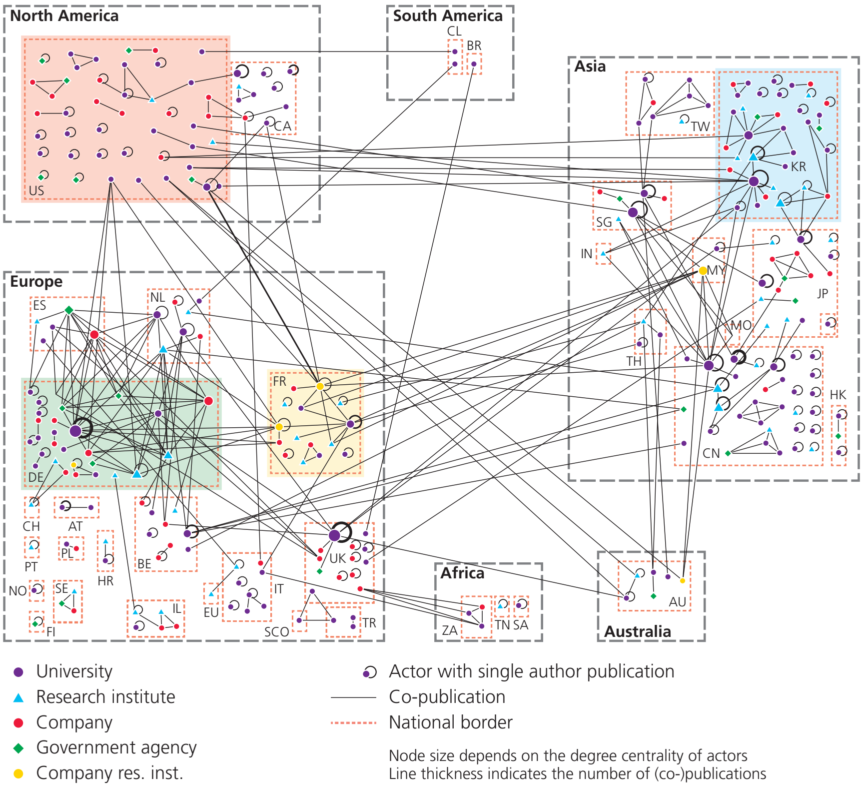

Figure 2: *Co-authorship networks in MBR 2003-2006 (Binz et al., 2014).*

interconnections. France instead, despite being the home of two of the largest transnational companies in the water sector, shows very weak interconnections.

This illustrates that proximities may exhibit complex geographical patterns that defy any simple characterization as national, local or global. We have to disentangle these relationships in order to better understand who plays a central role in the core processes and how policies may be defined that are able to intervene in these complex interaction patterns. Network analysis methods as those developed by the economic geography group here in Utrecht therefore show high analytical promise for a geography of transitions perspective.

A last and very current example of my research relates to the perhaps most challenging case for transitions research: transitions in development contexts. I see here many overlapping interests with colleagues at the human geography department (Morrison and Cusmano, 2015; Zoomers and Van Westen, 2011). A geography of transitions perspective enables to highlight a number of interesting points here: first, the innovation systems in which development interventions are generated seem to consist of global networks of development organizations. However, also these networks shows distinct geographies. We reconstructed the network associated with sustainable sanitation options and see that strong links exist between research and development organizations from industrialized countries and include only very few actors from the Global South. Secondly, development interventions need to be implemented in specific local contexts. To this avail, international development organizations team up with local actors (mostly local NGOs). A geography of transitions perspective will analyze, which sort of systemic resources are mobilized or what forms of network failures could possibly appear in this interaction. Finally, we may ask how socio-technical alignments are managed in specific local contexts and what it takes to achieve "configurations that work". The rather mixed record of many development cooperation projects may be due to mismatches in all of these three levels. We currently work with two PhD students on a project on sanitation innovations in slums of Nairobi, Kenya.

5 Outlook on the future geography of transitions research and beyond

Summing up, we can provide a generalized perspective on how innovation processes interact across spatial dimensions. In an ongoing publication, we are elaborating an integrative framework for global innovation systems (Binz et al., in preparation). In figure 3, you see a schematic representation of a possible ideal-type global innovation systems. Essentially it says that different aspects of a technological innovation system can

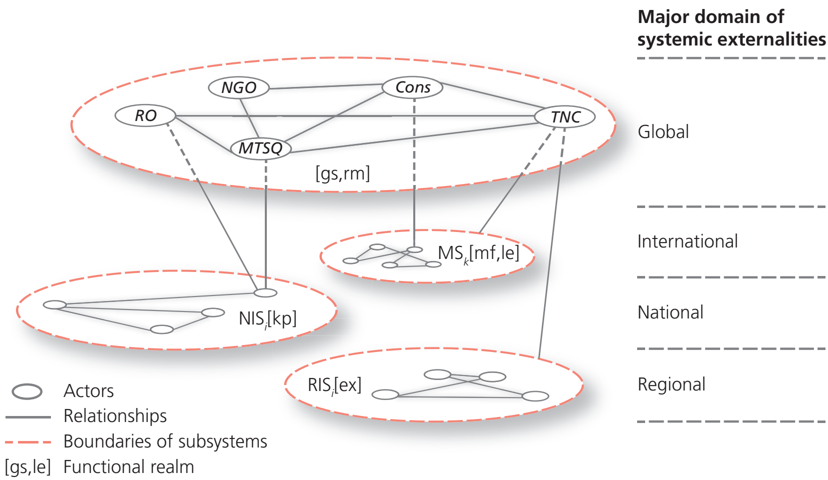

Figure 3: *Schematic representation of a Global Innovation System*

be organized at different levels building on different forms of proximity. This implies in particular that we cannot assume that some actors, like consumers, are bound to the local scale, while others like transnational companies act exclusively at a global scale. Rather, all actors may both be locally anchored and globally connected. The illustrative case depicted in the figure describes a system, in which processes of standard formation and resource mobilization are mostly happening in networks among transnational companies, globally operating NGOs and consultancies. Other aspects like entrepreneurial experimentation may instead take place in specific regions, where spatial proximity advantages can be reaped. And finally, some processes may build on cultural proximities, for instance, as in the case of pilot markets addressing globally mobile, young people in large cities all across the world. For a well-functioning system it is crucial that these different subsystems are well interconnected (Balland et al., 2013; Ter Wal and Boschma, 2009).

I hope, I could convince you that there is a considerable potential for a geography of transitions agenda to address pressing challenges of sustainability transitions. I would therefore like to come back to the slogan of the 1970s of thinking globally and acting locally. As I showed in the first half of my talk, the conviction expressed by this appeal was not unfounded. Local initiatives laid the ground for the emergence of a number of new industries. The contribution of these initiatives was not limited to providing moral support. Rather many of them engaged in very material ways in the alignment of new socio-technical configurations. As a consequence, I conclude that local initiatives have to be taken seriously and in that regard, I fully support one of the core claims by Rob Raven about the importance of cities as laboratories for fundamental change. However, as the second part of my talk illustrated, we also have to move beyond the local action perspective. Increasingly action happens both at the local and the global level, as well as in between. In the example of cities as transition actors, we saw that international networks of cities become increasingly important. Hence my somewhat awkward slogan to think/act, locally globally.

As an outlook on future challenges in transitions research, I would state that sustainability transitions have partly been mainstreamed both in academia as well as in the public discourse. Some of the wild speculations twenty five years ago have turned into every day occupations of major societal actors. This is not to say that we will be living in sustainable societies, anytime soon. But we have learned a lot on how to deal with environmental problems. Our record is arguably less strong in tackling social problems on a global scale. The recent dramatic increase of migration flows towards Europe is a troubling indicator for that assessment. This will be one of the big challenges to tackle over the next twenty-five years. It is hard to predict how well we will be able to deal with this challenge. But I am confident that one proposition will remain valid throughout: Think/act, local/globally.

6 Epilogue and acknowledgements

Before closing, I would like to express my thanks to the many people that supported me on the long journey to this position. First of all, I'd like to thank Marko Hekkert and Ron Boschma for approaching me initially and for having been so supportive throughout the whole process. I appreciate your friendship and the high scholarly quality of your work. Furthermore, I would also like to thank my colleagues at the two institutes where I am affiliated: in particular professors at the innovation studies group from the Copernicus institute, Rob Raven, Koen Frenken, Ellen Moors, and my colleagues from the human geography department Andrea Morrison and Pierre-Alex Balland as well as all other Utrecht colleagues for providing such an inspiring and welcoming academic environment.

From my Swiss background, at the Swiss Federal Institute of Aquatic Science and Technology (Eawag), I have to thank many people. First of all, Rik Eggen our deputy director along with the directorate of Eawag, which agreed to support my professorship here at Utrecht University. In my everyday research, I had the privilege to work with a number of extremely talented people. In particular, I'd like to thank Lars Coenen,

Jochen Markard, René Kemp, Christian Binz, Lea Fünfschilling, Damian Dominguez, Ulrich Dewald as well as the current Postdocs and PhD students. I also have to thank my colleagues at the environmental social science department for making my life as a department head so easy that I still can afford to spend most of my time on my own research. And finally, I gratefully acknowledge my former colleague and promotor Prof. Paul Messerli from the University of Berne. I lectured there for twelve years, and he enabled me to maintain strong roots in both innovation studies and economic geography.

Finally, I want to express my gratefulness to my parents, my wife Mariette, my two sons Johannes and Oliver and my godson Simon. They have always been a supportive to my professional ambitions. As some of you might appreciate, it is not always easy to live with an academic. We are often obsessed with the next funding application, the next conference talk, the next publication or then we are absorbed with the countless vagaries of academic life. Without their support, I would not stand here. Let me finish by slightly varying an African proverb, which says "it takes a whole village to raise a child". I would add: "It takes a whole family and an extensive network of good friends to raise a professor".

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Bernhard Truffer had been appointed to the chair of 'geography of transitions in urban infrastructures' at Utrecht University by the 1st of August 2014. He has a 20% appointment, which is equally split between the Copernicus Institute and the Department of Human Geography and Spatial Planning. Besides he serves as a head of the environmental social science department at the Swiss Federal Institute of Aquatic Science and Technology (Eawag).

Originally trained as an economic geographer, from the university of Fribourg in Switzerland, he has since worked on sustainable innovations at Eawag. In parallel, he served as a lecturer and adjunct professor in economic geography at the University of Bern, and lectured at the Swiss Federal Institute of Technology in Zürich for many years. He was also a visiting professor at the Harvard Kennedy School, a fellow at the Social Science Research Center (WZB) in Berlin and the Daimler-Chrysler Research unit 'Society and Technology'.