Approaches for Transitions Towards Sustainable Development

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Approaches for Transitions towards Sustainable Development: Status Quo and Challenges

ABSTRACT
With the aim to facilitate the long-term transformation towards a sustainable future, the research field of sustainability transition has gained growing attention. A number of approaches have been proposed to understand or even manage the complex societal transition processes towards sustainable development. There are four popular approaches for sustainability transitions, i.e. the multi-phase concept, multi-level perspective, strategic niche management, and transition management. However, there is a lack of studies to systematically review and critically reflect on these various approaches in this emerging field. This paper presents a holistic review of the four most common approaches, and more importantly, identifies four critical challenges for the future studies on transition approaches. Consequently, the associated future research agenda is presented.

Keywords: sustainable development; sustainability; challenges; transition; approaches
Introduction: Sustainability through socio-technical transitions

Sustainable development, a political catchphrase for almost three decades, has many different interpretations and, therefore, provokes various responses towards changes for sustainability (Hopwood et al., 2005; Davidson, 2014). Among these responses, the methodology of green economists currently dominates policy discussions on sustainability (Geels, 2012). However, there has been extensive debate that the price mechanism advocated by green economists is not adequate for promoting radical sustainability innovations which are featured with a high level of uncertainty (e.g. Geels et al., 2008), and coping with the complexity nature of various sustainability issues e.g. climate change (Hoffmann, 2011).

More fundamentally, many existing systems are stabilised through various lock-in mechanisms. This means once adopted, an activity provides growing benefits and generates increasing inertia. Thus, over time, it becomes increasingly difficult to “transform the pattern and select previously available alternatives” (Mahoney, 2000). For instance, previous studies have shown that not only industrial economies but also rapidly industrializing countries like China and India are becoming locked into fossil fuel-based technological systems (Unruh and Carrillo-Hermosilla, 2006). Green economists offer little insights into how existing systems stabilised by various lock-in mechanisms can be reconfigured, transformed or even replaced to become more sustainable. Consequently, a genuine transformation towards sustainability has not yet begun (Helne and Hirvilammi, 2015).

Originated in Dutch, the research field of socio-technical transitions aims to respond to the deficiencies of, and thus complement the green economy approach by digging into historical transitions, e.g. from horse-drawn carriages to automobiles, to explore how these shifts take place, thereby providing insights into contemporary sustainability issues. It highlights multi-dimensional interactions among the industry, technology, markets, policy and culture, capturing the complexity of systematic changes towards sustainability (Geels, 2012). There are various definitions of socio-technical transitions. One definition is that transitions are shifts from one socio-technical system to another (Grin et al., 2010). A more detailed definition is that a transition is “…a gradual, continuous process of change where the basic character of society (or a complex sub-system of society) transforms” (Rotmans et al., 2001, p.16).

A sustainability transition takes place if the direction of a certain socio-technical transition is sustainability. Sustainability transitions are defined by Markard et al. (2012, p.956) as “…long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable alternatives”. Common characteristics of sustainability transitions include:
1. involving profound changes along different dimensions, e.g. technological, organizational, political, economic, behavioural, and socio-cultural (Markard et al., 2012; Rotmans et al., 2001);
2. requiring interactions among multiple actors such as the industry, the government, users and social groups (Grin et al., 2010);
3. long-term processes which take decades to unfold (Geels, 2012; Rotmans et al., 2001);
4. requiring the development and diffusion of a wide range of innovations, including new technologies, policies, standards, and social practices (Geels et al., 2008).

During the last two decades, various approaches emerged for sustainability transitions. There are four most common approaches as employed in sustainability transitions related studies, namely the multi-phase concept, multi-level perspective, strategic niche management, and transition management. However, very few studies attempted to review these approaches systematically. This paper contributes to existing body of knowledge on sustainability transitions by comparing these four dominant approaches and more importantly, identifying the fundamental challenges associated with applying these approaches. Consequently, the associated future research agenda is discussed for transition research.

Research methodology

To systematically compare these four approaches and identify the challenges, the conceptual theory-building method was adopted in this study (Meredith, 1993). The essence of conceptualization is to firstly identify unique commonalities, patterns and differences from the existing works, which were consequently integrated into a unique perspective of understanding (Meredith, 1993). This study involves the first part of conceptual theory-building, i.e. the identification of unique connections and differences of the existing works, as well as the illustration of the commonalities and difference through a conceptual framework. The development of the conceptual framework follows the work of Meredith (1993), Lynham (2002) and Wacker (1998). The research procedure of this study is illustrated in Fig 1.

<Insert Figure 1 here>

Figure 1. Research procedure

Specifically, an iterative analysis and synthesis process was adopted in this study (Meredith, 1993), which involves defining goals and purpose, reading literature, identifying commonalities and differences, synthesizing, proposing an initial framework which
summarizes the four approaches, collecting additional literature, and revising or confirming the framework. In this study, the goals are to: 1) identify the linkages and commonalities between the four most common approaches on transitions; 2) identify the differences between the four approaches; and 3) identify the critical challenges associated with applying these four approaches.

Qualitative content analysis was adopted in analysing the literature and identifying commonalities and differences. Content analysis is a method of analysing written, verbal or visual communication messages, with the purpose of providing a condensed description of the phenomenon. The outcome of content analysis is usually various concepts or categories describing the phenomenon, which could be then used to build up a model or conceptual framework (Elo and Kyngäs, 2008). Content analysis could be used in either an inductive or deductive way. In this study an inductive content analysis was adopted, which involves the process of reading literature, open coding, and abstraction (Elo and Kyngäs, 2008). After the goals were determined, the literature related to these four approaches was read through to identify as many headings (keywords) as necessary, and the headings could be generated freely at this stage. After this open coding process, the headings were grouped into higher-order categories to reduce the number of categories by collapsing those that are similar (abstraction). The result of this content analysis is a list of themes and categories that describe the linkages and differences of the four transition approaches, and the critical challenges associated with them. Subsequently, a synthesizing process was conducted, with the aim to organize the various identified linkages and differences between the approaches into an overarching framework, as shown in Fig 2. Consequently, the critical challenges were presented.

**Different approaches for sustainability transitions**

**Multi-phase concept**

The multi-phase concept of transition (MPC) was systematically illustrated by Rotmans et al. (2001). They argued that an ideal transition process can be represented by the S-shaped curve, which contains four different phases, namely the predevelopment phase, take-off phase, breakthrough phase, and stabilization phase. In the predevelopment phase, there are no visible changes in the status quo but many sustainability experiments. In the take-off phase, changes occur, and the current system begins to shift. In the breakthrough phase, visible structural changes in various dimensions take place (e.g. cultural, economic, ecological and institutional changes). During the stabilization phase, the change slows down while a new equilibrium emerges (Loorbach 2007). However, transitions of socio-technical systems may
not achieve the planned stabilization or even fail entirely. Van der Brugge and Rotmans (2007) proposed other possible pathways for the MPC.

According to Van der Brugge and Rotmans (2007), the key for the take-off phase to occur is that sustainability innovations strengthen each other and align into stable innovation networks, which succeed in maintaining and reproducing their own organizations. Therefore in the take-off phase, there are three possible outcomes: 1) the innovation networks share a similar goal and they reinforce each other to become strong enough to compete with the existing systems (stabilization), 2) the innovation networks compete with each other which result in less satisfactory outcomes (lock-in), and 3) the innovation networks are all not capable of becoming self-sustaining and therefore the transitions fail (system breakdown).

Even if the take-off phase has occurred, there is still no guarantee that the transition will be successful. It is possible that the promoted sustainability innovations in the take-off phase have fatal drawbacks that were not well understood and are only revealed in the acceleration phase. Choices made early on can also reduce the diversity of options which may help to make up for the deficiencies (Grin et al., 2010). As a result, a backlash may take place in the acceleration stage.

It is important to clarify that the MPC is not intended as a deterministic concept and cannot be used to predict the course of transitions. Rather, it is a descriptive framework for describing the certain generic patterns of transitions, and to influence the transition, scholars may need to understand these patterns first (Grin et al., 2010). Some scholars have recognised the usefulness of the MPC. Frantzeskaki and de Haan (2009), for instance, explained that the MPC distinguishes the transition process in distinct phases with different dynamics, thereby enabling scholars to identify different transition processes in the various phases. Similarly, Nevens et al. (2013) employed the MPC of transition to explain the scenarios of creating sustainable cities in Belgium.

**Multi-level perspective**

Despite capabilities to identify the four phases of transition, MPC does not explain why transitions occur. The multi-level perspective on transitions (MLP) provides a useful approach to explain why transitions occur. The initial idea of the MLP was proposed by Rip and Kemp (1998), while the MLP framework which is widely researched today is developed by Geels (2002). The MLP views transitions as non-linear processes that results from the interactions among developments at three levels: the niche, regime, and landscape.

According to MLP, the existing socio-technical systems may change because innovations emerge and challenge the existing systems. Niches are the ‘protected spaces’ of sustainability
innovations, e.g. subsidised demonstration projects (Geels, 2011). Niches are incubation rooms where innovative activities take place and where time-limited protection is offered to help novelties sustain against selection pressures from the market (Grin et al., 2010; Lachman, 2013). Niches, in essence, provide the seeds for transitions. The actors in niches aim to spread their novelties in the existing system or even to replace it (Geels, 2012).

Even though niches may challenge the current systems, transitions do not come about easily, since existing systems are stabilized by many lock-in mechanisms, i.e. deep-rooted rules (Geels, 2004). This concept builds on the idea of technological regime proposed by Nelson and Winter (1977), who argued that there are cognitive routines shared in a community of engineers. Geels (2002) furthered widened it by taking more social groups into consideration such as policy makers, social groups, suppliers, and scientists, explaining that the activities of these groups are all guided by rules. Due to these established rules, i.e. socio-technical regimes, the existing systems have stability, which makes it hard to be changed.

The landscape is the wider context which influences niche and regime dynamics (Rip and Kemp, 1998). According to Driel and Schot (2005), there are three types of landscape: (1) factors that do not change (or change very slowly), e.g. natural climate, (2) rapid external shocks, e.g. wars, and (3) long-term changes in a particular direction, e.g. climate change. These factors can be analysed in a single “landscape” category because they form the macro context that actors cannot influence in a short run (Grin et al., 2010), and thus, the landscape represents the greatest degree of structuration beyond the control of individual actors (Geels, 2012). However, this does not mean that landscape is not associated with the human agency. It is the aggregations of multitudes of actions that bring about urbanization, globalization, and cultural changes (Grin et al., 2010).

The key mechanisms of transitions proposed by the MLP are: (1) niche-innovations accumulate internal momentum, through learning processes, performance improvements, and support from powerful groups, (2) landscape level creates pressure on the regime, tensions in the regime appear and the regime become destabilised (3) destabilized regime open windows, i.e. opportunities for niche innovations, which then diffuse into the regime (Geels, 2002). To offer a more specific understating of different scenarios of transitions, Geels and Schot (2007) further enriched the MLP by developing a typology of four transition pathways based on different multi-level interactions. These include the transformative path, reconfiguration path, de-alignment and re-alignment path, and technological substitution.

MLP approach was proposed based on the analysis of many historical case studies of transitions (Geels, 2002; Rip and Kemp, 1998). However, it has great potential to be employed in studying sustainability transitions in contemporary or future contexts, e.g.
electricity systems (Foxon et al., 2010; Yuan et al., 2012), science system (Schneidewind and
Augenstein, 2012), and transport system (Geels, 2012). For instance, Yuan et al. (2012)
adopted the MLP framework to investigate the low-carbon transition of the electric power
sector in China, and proposed various transition pathways and policy suggestions. Similarly,
Foxon et al. (2010) analysed the transition pathways to low-carbon electric systems in the UK.
Geels (2012) used the MLP to analyse the driving forces and barriers to the transition towards
the low-carbon transport systems. These contemporary studies usually adopt the MLP
approach to explain the ups and downs of niche-innovations and struggles against existing
regimes on multiple dimensions (Geels, 2011).

Even though the MLP approach explains why transitions happen, it mainly operates as a
research tool and does not intend to investigate how to influence or even manage transitions.
This issue is addressed by the strategic niche management approach (SNM) and the transition
management approach (TM).

Strategic niche management

Proposed by Kemp et al. (1998), SNM aims to identify the features of successful niches.
Kemp et al. (1998, p.186) defined SNM as “the creation, development and controlled phase­
out of protected spaces for the development and use of promising technologies by means of
experimentation, with the aim of (1) learning about the desirability of the new technologies
and (2) enhancing the further development and the rate of application of the new technology.”
The work by Kemp et al. (1998) and the later SNM literature distinguished three internal
processes for developing a technological niche successfully, i.e. articulation of expectations,
the building of social networks and multidimensional learning process.

Specifically, regarding articulation of expectations, Kemp et al. (1998) stated that in the
early years of development, the advantages of a new sustainable innovation are usually not
apparent, and there are many barriers to it. Expectations of the new technology from the
interested actors are very crucial if they are shared, specific and linked to particular societal
problems which the existing technology is not able to solve (Kemp et al., 1998). The
construction of social network is another important process. Considering the development of
a new technology may be slowed down or even stopped by regime actors, i.e. actors
promoting the traditional technologies, new networks should be developed to ensure that the
new technology can function as desired (Kemp et al., 1998). Finally, SNM scholars argue that
to eliminate various barriers, learning processes at multiple dimensions are needed, such as
the constraints of the innovation and suitable regulation policies (Caniels and Romijn, 2008),
The approach of SNM has been employed to understand the situations of niche-innovations in reality. For instance, based on the SNM approach, Hansen and Nygaard (2014) identified that the proliferation of the palm oil biomass waste-to-energy niche in Malaysia has been triggered by three key factors, namely the strong pressures from environmental groups, the rising oil prices and a persisting waste disposal problem. Similarly, Van der Laak et al. (2007) adopted SNM to analyse three biofuel experiments in Netherland, among which two are relatively successful and one is less successful. Their study showed that the less successful one has unrealistic expectations, narrow social networks and only technical learning process without learning in user practices, infrastructure and psychological aspects (Van der Laak et al., 2007).

Kemp et al. (1998) stated that SNM differs from the old “technology-push” approach, by bringing knowledge of users and other actors into the innovation process and generating interactive learning processes and institutional adaptation. However, some scholars argue that SNM focuses too much on technological innovation, neglecting a broad visioning process for sustainability. Harborne et al. (2007), for instance, argued that to have a more radical impact, demonstration projects may need to be driven by a clearer guiding vision. Baumgartner and Korhonen (2010) expressed a similar concern that current approaches used in sustainable development research are often reductionist, and thus strategic thinking needs to be enhanced. Advocated by Rotmans, Loorbach and others, the transition management (TM) approach responds to this deficiency of SNM approach, emphasizing the importance of creating visions prior to niche experiments.

Transition management

TM has gained a rapid growth in last decades as an innovative method to tackle complex societal problems (Rotmans et al., 2007). By means of integrating long-term thinking with short-term action, it attempts to manage transitions towards sustainable development (Lachman, 2013). With an interdisciplinary approach to address sustainable development (Lam et al., 2014), it combines the studies of socio-technical transitions with insights from complex systems theory and governance approach (Markard et al., 2012).

The core of TM is a cyclical process model. This model consists of four components: 1) structuring the sustainability problem and establishing the transition arena; 2) developing a transition agenda, i.e. a vision of sustainable development and deriving possible transition pathways; 3) establishing and carrying out transition experiments and mobilizing the
resulting transition networks; 4) monitoring, evaluating and learning lessons from the experiments, and making adjustments in the vision, agenda and coalition” (Loorbach, 2010; Rotmans and Loorbach, 2009). In essence, TM creates a social movement about sustainability through new alliances and networks (Loorbach and Rotmans, 2010).

The last decade witnessed a growing attention on TM at regional and local levels (Markard et al., 2012). There are some examples of implementing TM, such as the roof transition program initiated by ESHA Group (Loorbach and Wijsman, 2013), and the healthcare transition program initiated by the Dutch Ministry of Health, Welfare and Sports (Loorbach and Rotmans, 2010). For instance, guided by the TM approach, ESHA Group initiated the roof transition scheme to gradually transform all roofs in the Netherlands to achieve substantial CO₂ reduction and promote the use of renewable energy (Loorbach and Wijsman, 2013). To achieve the transition goals, ESHA group has established the first 100% bitumen recycling plant and initiated various green roof projects in the city of Rotterdam (Loorbach and Wijsman, 2013). The possibility of applying TM in different domains is also explored, such as higher education (Stephens and Graham, 2010), energy (Meadowcroft, 2009), and water resources (Voß et al., 2009).

Comparison of the different approaches

By comparing the literature related to these four approaches, it was found that these four approaches examine sustainability transitions from different perspectives. MPC and MLP have been primarily used as research tools describing and analysing various historical and contemporary transitions. Specifically, MPC identifies the four phases of transitions and MLP uses three levels to explain why transitions take place. By contrast, even though SNM and TM have been used as research frameworks, they were proposed primarily as policy instruments to proactively manage transitions. Specifically, SNM has identified three key processes of successful niche experiments, and TM provides a framework to govern transitions. Thus, these four approaches could be grouped into two categories, i.e. research frameworks and policy tools. After several attempts of synthesizing, the linkages and differences between the four approaches were visualized as Fig 2. Research frameworks provide a deeper theoretical basis for the policy tools and the empirical studies on the policy tools help to refine the research frameworks.

<Insert Figure 2 here>

**Figure 2.** Comparison of the different approaches

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Another core issue is the different emphasis of the approaches on the three levels, i.e. the niche, regime and landscape (see Figure 2). It is the MLP approach that explicitly denotes the interplay between the three tiers determines the transition processes, and thus MLP emphasize all the three levels. It is also evident that the SNM focuses on the niche dynamics and thus only emphasizes on the niche level. By contrast, the existence of the three structural levels and how they relate to the transition phases were implied by the MPC approach. For instance, when illustrating the MPC, Rotmans et al. (2001) explained that every domain has its own dynamics, with culture only changing slowly (landscape), economy changing fast (niche), and institution and technology changing in between (regime). In terms of the TM approach, it seems to emphasize all the three levels since it aims to influence the broad transition process. However, TM particularly focuses on nurturing new sustainability coalitions and networks that are actually situated at the niche level.

Although these approaches inform each other, it remains highly unclear in the literature whether these four dominant approaches are largely complementary to each other and thus could be used jointly; or have significant differences and thus, should be treated separately. Some studies have jointly employed many approaches in one study. For instance, Raven et al. (2010) argued that both SNM and TM contribute an important role to experiments even though TM have proposed other instruments. Consequently, they proposed a competence kit of sustainability transitions for practitioners based on both SNM and TM. By contrast, some scholars indicate these approaches have significant differences. For instance, major proponents of the MLP e.g. Geels do not acknowledge the ideal S-curve with distinct phases indicated by the MPC and instead, they believe transition processes are highly non-linear and complex (Grin et al., 2010).

**Critical challenges and recommendations for the transition approaches**

The research field of sustainability transitions has experienced rapid growth over the last decade and attracted growing attentions. As a result, a series of critical challenges have been identified for the research field of transition. However, these challenges have barely been systematically analysed and discussed. This paper proposes that the transition research field faces four critical challenges that need to be seriously considered in the future research agenda.

**Theme 1: How to operationalize the niche, regime and landscape levels?**
Geels (2011) argued that MLP reflects a heuristic perspective of theory building. As a result, it is difficult to draw interactions among variables in such frameworks rigorously. Therefore, the MLP itself does not provide rigorous guidelines for the delineation of the three levels, i.e. the niche, regime and landscape. This, however, presents a significant challenge for empirical analysis of transitions. Jørgensen (2012), for instance, identified this major weakness of the MLP by asking “how are the levels distinguished by themselves in MLP?”

Due to lack of guidelines for distinction among the levels, MLP related studies run the risk of the ambiguity of analysis (Lachman, 2013). Frantzeskaki and de Haan (2009), for instance, proposed the concept of niche-regime, which denotes powerful niches that can be a competitive alternative to the regime, indicating that niche and regime do not have explicit boundaries. Proponents of the MLP e.g. Geels and Schot (2007) also suggested that structures of niches are similar to those of regime, and niche-innovations could become regimes, when social networks of niches grow and become stabilized. From the transition perspective, this is arguably reasonable since the transition process is the process that the niches today gradually grow to become the regime tomorrow. However, this presents another challenge for transition analysis, i.e. to what extent that growing niches with different levels of stability, power and scale could be regarded as regimes?

Rigorous guidelines for delineation of the three levels need to be based on precise definitions of them. However, currently, there are various conceptual issues associated with the three levels waiting for resolutions. For instance, even though the MLP defines niches as the protective space for sustainable innovations (Geels, 2011), the concept of “protection” and the functions of “protective spaces” received little attentions in the literature (Smith and Raven, 2012). Similarly, whether the regime is a set of stabilised rules or a socio-technical system remains debatable in the literature (Markard and Truffer, 2008). The landscape concept has also been criticized for not producing a coherent sphere of its own and often operating as a “garbage can” in empirical analysis containing many kinds of contextual factors (Jørgensen, 2012). The lack of guidelines and definitions of the three levels has led to ambiguous interpretations of the factors influencing transitions. For instance, Geels (2012) analysed low-carbon transitions in transportation system based on MLP. In this study, some cultural factors such as “a cultural preference for private property rather than collective ownership”, “the cultural preference for speed and time” and “cultural values such as freedom, choice, progress, wealth and status” were classified as landscape factor, while other cultural factors such as “culture values and positive discourse around the joy of driving”, “user patterns and life styles” and “consumer preferences that benefit cars” were regarded as regime factors (Geels, 2012). In this study, the criteria based on which these various factors related to “culture” were classified seems highly ambiguous. The boundaries between the
three levels need to be delineated in a more rigorous manner in future studies so that greater clarity of the MLP could be achieved.

**Theme 2: How could sustainability transitions be explored under a flat ontology rather than the hierarchical ontology which has been dominant in transition-related literature?**

Geels (2002) proposed the MLP based on the work by Rip and Kemp (1998). Since then, the MLP attracts increasing level of attentions. Gradually the transition dynamics theorised by the MLP has become somewhat standardized interpretations of transitions (Geels and Schot, 2007). The dominance of the MLP in transition studies has motivated scholars to rethink its capability to explain transitions and several critical deficiencies of the MLP have been identified.

A critical issue is that since slow and incremental changes could exhibit radical changes over the longer term, it is hard to distinguish fundamental sustainability transitions from ongoing system renewal (Genus and Coles, 2008). Rotmans et al. (2007) indicated that sustainability transitions are open-ended and continuous processes without a real closure. This contrasts with historical transition studies, which usually assume an end, i.e. stabilisation phase of sustainability transitions. It is arguable that due to constraints on the scope of analysis, in an individual study the choice of time periods for transitions are always unavoidable. However, the criteria for selecting boundaries of transition periods are rarely explicitly illustrated in existing MLP studies.

According to MLP, with a higher degree of structuration than the niche, the regime and landscape usually change slowly. This contrasts with some empirical studies which revealed that some regime or landscape factors (e.g. visions and regulatory frameworks) are changing rapidly (Jørgensen, 2012). The MLP also tends to simplify the functions of various actors involved in transitions. In a typical MLP analysis, there are always some actors being the “niche actors” by promoting the niche-innovations while others being the “regime actors” by prohibiting the growth of the niches. However, it is not necessary that players involved in transitions are attached to only one level, e.g. regime actors or niche actors since in reality actors could engage in all levels (Jørgensen, 2012). For instance, a construction enterprise could employ the traditional techniques (acting as a regime actor) in some projects while adopting more sustainable methods e.g. off-site construction in other projects (acting as a niche actor). An energy developer could develop thermal power plants (acting as a regime actor) and also wind power plants (acting as a niche actor).

The above deficiencies of the MLP suggest that an alternative approach to sustainability transition may need to be developed. A key feature of the MLP is that it interpret transition
processes in a hierarchical way, with the niche, regime and landscape being the micro-, meso- and macro-level descriptions of societal processes (Markard et al., 2012). To respond to the deficiencies of the MLP, Shove and Walker (2007) argued for “backing off from the nested, hierarchical multi-level model as the only model in town, and for exploring other systematic theories of change”. Jørgensen (2012) fundamentally challenged the MLP by preliminarily developing an alternative arenas of development (AoD) approach as a framework to study transitions based on the relationism ontology, which conceptualises the world as “flat” refuting the notion of structural levels (Geels, 2010). It challenges the idea of selection environments implied by MLP by flattening distinctions between agency and structure, based on the notion that actors involved in transitions are simply part of ongoing entanglements (Garud and Gehman, 2012).

The flat ontology has several advantages over the MLP in terms of theorising transitions. For instance, under the flat ontology, sustainability transitions are no longer a matter of shifting from one equilibrium state to another, as suggested by the MPC, but a far more fluid transformation process where the old and new become entangled (Garud and Gehman, 2012). The flat ontology also prevents the difficulties of assigning actors to different levels by understanding actors in a dynamic actor network perspective. The actor network theory (ANT) is specially developed based on the flat ontology (Latour, 1987), and Genus and Coles (2008) argues that ANT could provide a useful approach to examine sustainability transitions. Future studies could be undertaken to explore how transitions could be explained by the ANT or other methods based on the flat ontology.

Theme 3: Are SNM and TM really effective in facilitating sustainability transitions?

SNM has been used primarily for ex-post evaluations, i.e. retrospective analysis rather than ongoing transitions, and thus it is hard to assess whether SNM actually works in practice (Ieromonachou et al., 2004; Lachman, 2013; Schot and Geels, 2008). Based on the retrospective analysis, SNM has been used to generate policy advice aiming to promote the development of niche-innovations, but these policy suggestions do not result in straightforward recipes and, by contrast, they identify some policy dilemmas (Schot and Geels, 2008). For instance, regarding learning, SNM reveals that variety is needed to facilitate broad learning, but too many varieties dilute precious resources and prevent accumulation (Schot and Geels, 2008). Similarly, Hegger et al. (2007) suggested learning process is often prevented in practice despite been recognized by SNM. They argued that in SNM research, more efforts should be made on developing concepts and guiding principles of sustainability rather than technological innovations (Hegger et al., 2007). It seems SNM
may have a technology-driven bias of transitions and need to be used in practical experimentation in society to justify and further improve its explanations on niche dynamics (Caniels and Romijn, 2008).

Similarly, proponents of TM indicated that the theory of TM is in a hypothetical stage, and it might take one or two decades before it can be fully validated (Rotmans et al., 2007). Contrast to SNM that has been primarily used in the retrospective analysis, TM has been adopted to influence some contemporary transitions. However, even though the modern cases of TM illustrates the application possibilities of this approach, they do not show that it is sector-wide applicable or useful (Loorbach and Wijsman, 2013). Stephens and Graham (2010), for instance, indicated the dynamics of power and their roles in sustainability transitions has not been given adequate attention within the TM literature. In addition, it is far from clear what TM means for different types of firms in various sectors and to what extent the dominant culture within a business could influence the space for sustainability transitions (Loorbach and Wijsman, 2013).

Apart from the lack of validation, SNM and TM are also inadequate to answer which sustainability experiments can ultimately contribute to a sustainability transition. Van Eijck and Romijn (2008) argued it is likely that some experiments are more important than others. Thus, it is important to make sure that valuable resources are allocated to the experiments that are more liable to enable sustainability transitions. However, assessment of the transformative potential of sustainability experiments can only be partially rational and predominantly irrational because it involves uncertainty, power struggles, interests and manipulations (Rotmans et al., 2007). This presents a significant challenge for transition policy tools i.e. SNM and TM since without knowing which sustainability niche to promote, it is unlikely that sustainability transition could be efficiently facilitated.

More fundamentally, it is apparent that both SNM and TM focus on nurturing the sustainability niches to enable larger societal transitions. The MLP implies that niches are important, but niche developments are rarely able to bring about sustainability transitions without the help of other forces from the regime and landscape levels (Schot and Geels, 2008). Most scholars in the debate on sustainability transitions focus on the emergence and empowerment of niche while the destabilisation of existing regimes is assumed to happen along the way and has received far less attention (Turnheim and Geels, 2012, 2013).

To better conceptualise how the regime could be gradually destabilised thereby providing opportunities for niche-innovations, Geels (2014) proposed the approach of Triple Embeddedness Framework (TEF) with a focus on industry regimes. According to TEF, the destabilisation of industry regimes is enabled by the dynamic interactions between industries and the economic and socio-political environments. The economic environment is composed
of suppliers and customers, and it selects firms through economic competitiveness. By contrast, the socio-political environment (e.g. social movements, wider publics, media, policymakers) select firms through legitimacy and social fitness (Geels, 2014). Built on Grinyer and McKiernan (1990), Geels (2014) propose that regime destabilisation has three key elements: increasing pressures from economic and socio-political environments; industry fight-back and resistance to external pressure; and strategic reorientation of firms towards sustainability (Geels, 2014a). Both external forces and endogenous enactment are needed to facilitate regime destabilisation. Turnheim and Geels (2012) have used the TEF approach to analysed two historical cases about the British coal industry, namely the transition from coal dominance to the four-fuel economy (1913-1967), and the destabilisation of coal in the electricity sector (1967-1997). Currently, this approach is still in a development process and was mainly used as a research tool rather than a policy instrument. It remains unclear whether TEF could operate as an effective policy tool complementing the existing SNM and TM approaches. Future studies could be undertaken to gather empirical data to further examine the validity of the current SNM and TM approaches, or to develop alternative policy tools for managing transitions, e.g. the tools based on the emerging TEF approach.

Theme 4: Could a robust theory of sustainability transitions be developed catering for the messy reality?

The discussions in previous sections reveal there are various critical issues with the current transition approaches. Garud and Gehman (2012) argue scholars have yet to develop a robust approach to conceptualizing sustainability transitions. Such a reliable approach must survive the tests of the messy reality.

It appears the MLP is being presented mainly as a global model, but it actually struggles to cater for the complexity of the reality in sustainability transitions (Genus and Coles, 2008). Despite the heuristic nature of the approach which is designed to suits various empirical domains, there is a tendency to neglect substantial differences in contexts of transitions. Markard et al. (2012, p.962) has pinpointed this issue and stated “the spatial and institutional contexts in which sustainability transitions unfold have not received much attention.”

Countries are taken for granted as the primary context for many transition analysis (Coenen et al., 2012). However, in reality, there are many other contexts e.g. regions, cities, and even the globe in which sustainability transitions could also unfold. By assuming countries as the transition context, the current approaches could be less convincing as means to understand transitions happened in other contexts. More importantly, developing and developed countries differ on social, behavioural, environmental and political grounds
For instance, technology is often not domestically developed in developing countries, and the knowledge often stays in the countries of origin, i.e. usually developed countries (Lachman, 2013). Shove et al. (2014) have argued MLP is inadequate in understanding how air conditioning has spread from the US to other parts of the world. Many developing countries are going through industrialization and urbanization, e.g. China and India, and thus have other priorities e.g. economic development. The cultural and political diversities between the East and West may also have significant implications for understanding sustainability transitions. For instance, regarding the rating tools of green buildings, the Leadership in Energy & Environmental Design (LEED) originated in the U.S. and Building Research Establishment Environmental Assessment Methodology (BREEAM) originated in the UK were established by organizations independent from the government, while the Three Star system in China and the Green Mark in Singapore were both developed by relevant governmental departments (Chang et al. 2016). Due to the deep involvement of the government, the users of the Three Star system has experienced exponential growth in the Chinese construction industry. These indicate context-specificity is critical for understanding the tools, theories and approaches for facilitating sustainability transitions. However, most studies fail to explain explicitly what the context of the studied transitions is and how it may affect the generalizability of the results (Markard et al., 2012).

The current approaches on sustainability transitions were originated in Dutch. The majority of empirical studies on sustainability transitions have also been conducted in Europe (Coenen et al., 2012). To what extent the Dutch context has influenced the theory development of sustainability transition? Loorbach (2010) expressed the similar concern by asking to what extent TM can be translated to other socio-political contexts and cultures. Apparently, current approaches to sustainability transitions should be tested in other settings to achieve greater robustness (Lachman, 2013). Further researches should employ the various approaches in different socio-political contexts with various forms, e.g. industries, regions, communities, cities, countries, and the globe, to empirically test and further refine the approaches.

Conclusions

The various approaches on sustainability transitions have offered new perspectives for understanding the systematic changes needed to move our society towards sustainability. The MPC and MLP aim to theorise the complex transition dynamics by discerning four distinct phases and three interacting levels of transitions respectively. The SNM and TM have been used as research tools, but primarily as policy tools to proactively influence and manage
sustainability transitions, with SNM proposing three niche processes and TM suggesting four steps nurturing new networks for sustainability.

Fundamental challenges of these approaches and the associated future agenda for transition research are identified and discussed. The MLP has been suffering from the poor conceptualization of the proposed three levels (i.e. the niche, regime and landscape), which leads to great difficulty in operationalizing the levels in empirical research. The hierarchical view of transitions indicated by the MLP has been dominant in the literature, but approaches based on the “flat ontology” may provide a better conceptualization of transitions in some aspects than the hierarchical view. Disadvantages of SNM and TM relate to the lack of validation and testing, and thus, it is difficult to judge whether these policy tools actually works in reality. Finally yet importantly, the theory development of sustainability transitions might be affected by the Dutch origin and the proposed approaches have been primarily used in developed country context, which may affect the applicability of the approaches in developing countries.

The four approaches discussed in this paper have been dominant in the debates on sustainability transitions. As a research field, sustainability transition has received a growing attentions from scholars (Markard et al., 2012), and new approaches are continuously emerging, e.g. the TEF proposed by Geels (2014) and the AoD approach suggested by Jørgensen (2012). The newly emerged approaches address some weaknesses of the previous methods and emphasize some particular aspects of sustainability transitions. The growing number of approaches on sustainability transitions is an indication of the prosperity of this research field, but at the same time, researchers are facing increasingly level of difficulty in comparing the various methods and forming a complete understanding of sustainability transitions. This study has contributed to this holistic understanding by critically analysing the four dominant approaches. However, with the growing number of emerging approaches, it could become increasingly difficult for researchers to understand sustainability transitions in the future.

Therefore, a core issue for the transition research field is: should an overarching theory be developed illustrating the full picture of sustainability transitions? With similar evolutionary thinking, the currently dominant approaches might be synthesized into an overarching scheme in which different approaches form specific subsets. However, it may be harder to synthesize the MLP with the newly emerged approaches based on the flat ontology e.g. the AoB, since the ontologies are too different. The future research territory of sustainability transition could be the co-existence of several major schemes with distinct philosophies on transitions, formed by the various groups of specific approaches. Still, no matter how
exquisite the approaches and schemes look like, they need to be tested by the empirical studies, i.e. the messy reality to justify their positions in the transition research territory.

References


Research procedure
Figure 1
196x93mm (120 x 120 DPI)
Comparison of the different approaches
Figure 2
165x105mm (200 x 199 DPI)