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Creative Destruction or Mere Niche Creation? Innovation Policy Mixes for Sustainability Transitions

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Creative destruction or mere niche creation? Innovation policy mixes for sustainability transitions

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Abstract

Recently, there has been an increasing interest in policy mixes in innovation studies. While it has long been acknowledged that the stimulation of innovation and technological change involves different types of policy instruments, how such instruments form policy mixes has only recently become of interest. We argue that an area in which policy mixes are particularly important is the field of sustainability transitions. Transitions imply not only the development of disruptive innovations but also of policies aiming for wider change in socio-technical systems. We propose that ideally policy mixes for transitions might include elements of 'creative destruction', involving both policies aiming for the 'creation' of new and for 'destabilising' the old. We develop a novel analytical framework including the two policy mix dimensions ('creation' and 'destruction') by broadening the technological innovation system functions approach, and by expanding the concept of 'motors of innovation'. We test this framework by analysing 'low energy' policy mixes in Finland and the UK. We find that both countries have diverse policy mixes to support energy efficiency and reduce energy demand with instruments to cover all functions on the creation side. Despite the demonstrated need for such policies, unsurprisingly destabilising functions are addressed by fewer policies, but there are empirical examples of such policies in both countries. The concept of 'motors of creative destruction' is introduced to expand innovation and technology policy debates to go beyond policy mixes consisting of technology push and demand pull instruments, and to consider a wider range of policy instruments which may contribute to sustainability transitions.

Key words: innovation and technology policy, policy mix, sustainability transitions, energy efficiency, motors of innovation, technological innovation system (TIS)

1. Introduction

Recently, there has been increasing interest in the innovation studies literature in questions surrounding policy mixes. While it has long been acknowledged that the stimulation of innovation and technological change can include a number of different types of policy instruments and that the most appropriate type of instrument might depend on the stage of the innovation process or the respective sector (Pavitt, 1984), the issue of how such instruments form policy mixes has only recently be discovered as being of interest to this community (Borrás and Edquist, 2013; Magro and Wilson, 2013; Flanagan et al., 2011; Quitzow 2014) and policy makers from the European Commission (Nauwelaers et al., 2009).

We argue that policy mixes are particularly important in the field of sustainability transitions. This literature has received increasing interest in the context of technology and innovation studies and goes beyond single innovations, examining change at the level of socio-technical systems (cf. Markard et al., 2012). Transitions in the form of systemic changes in current structures for consumption and production are viewed as of paramount importance to reduce the overall environmental impacts of human activities. Much of the literature focusses on protective niche spaces for innovations which might overturn incumbent regimes (Smith and Raven, 2012) and facilitating the emergence of technological innovation systems, for example, to foster renewable energy technologies (e.g. Bergek et al., 2008). However, the literature also suggests that control policies are needed for change in socio-technical systems to occur (Rotmans et al., 2001; Kemp and Rotmans 2004). Recently, attention has also been paid to the processes of destabilising incumbent (industrial) regimes through "weakening reproduction of core regime elements" that are seen as necessary to create "windows of opportunity" for the upscaling of niche innovations (Turnheim and Geels, 2012, 2013). In this context, major policy change has been argued to be important, because "it shapes both the direct support for industries… and economic frame conditions" (Turnheim and Geels, 2012, p.46). Thus, transitions may not only require the development of disruptive innovations but also of disruptive policies aiming for systemic change (e.g. Kivimaa and Virkamäki, 2014; Weber and Rohracher, 2012).

Building on the seminal concept of creative destruction, proposed by Joseph Schumpeter (1942/1993), and the recent concept of regime destabilisation (Turnheim and Geels, 2012), we propose that policy mixes favourable to sustainability transitions need to involve both policies aiming for the 'creation' of new and for 'destroying' (or withdrawing support for) the old. We conceive of these kinds of policy mixes as not only comprising typical innovation and technology policies but all policies that potentially work in favour of transitions. This paper extends the work on the functions of Technological Innovation Systems (TIS) approach by proposing a novel conceptual framework for policy mixes for sustainability transitions, and introducing it as “motors of creative destruction” building on and extending Suurs and Hekkert’s (2009) concept of “motors of innovation”. The extension addresses the previous critique of the TIS approach (e.g. Smith and Raven, 2012) that it has little to offer in terms of analysing transitions (especially niche-regime interactions): it does so by combining attention to niche creation with attention to regime destabilisation and arguing that policy mixes need to attend to both processes in a mutually re-enforcing way. Empirical testing of the framework is provided by examining policy mixes influencing low energy transitions in Finland and the UK. Both countries have made significant efforts to promote energy efficiency but provide interesting contrasts in several ways (discussed later).

The next section reviews the literature before section 3 turns to the proposed analytical framework and the methodology. Section 4 presents the empirical analysis followed by a discussion of the key insights in section 5 and conclusions in section 6.

2. Innovation policy mixes and sustainability transitions

2.1 Policy mixes in innovation studies

Recent interest in innovation policy mixes has been justified on the grounds that real world policy contexts involve several policy instruments in different policy domains and with different rationales, dispersed governance structures and many levels of administration (Borrás and Edquist, 2013; Flanagan et al., 2011; Magro and Wilson, 2013; Quitzow 2014). Policy mixes are not merely used to refer to intended combinations of policies but rather the existing complexity and variety of policies influencing innovation and technological change. Flanagan et al. (2011) argue that policy mixes can at best be coordinated by a process of mutual adjustment between a variety of actors and systems. This means that there are no ‘optimal’ (Neuwalaers et al., 2009; Borras and Edquist, 2013; Quitzow 2014) or even ‘good’ (Flanagan et al., 2011) policy mixes in a general sense.

Many scholars use the concept of ‘policy mix’ similarly to Borras and Edquist (2013, p.1514) who refer to ‘a set of different and complementary policy instruments to address the problems identified’ in a national or regional innovation system. However, broader interpretations have been suggested by Magro and Wilson (2013) and Rogge and Reichardt (2013), adding to the mix also policy goals and rationales as well as processes of policy making and implementation. While we see merit in the broader concept of the policy mix, for purposes of empirical illustration in this paper, we focus on what Rogge and Reichardt (2013) would define as instrument mixes. We do, however, extend from

Borras and Edquist in that we examine policy mixes for transitions over several policy domains, not merely ‘classic’ innovation policy instruments.

Our contribution complements many recent studies on innovation policy mixes (e.g. Borras and Edquist, 2013; Rogge and Reichardt, 2013; Flanagan et al., 2011), that are predominantly conceptual (the exception being Quitzow 2014), by applying the concept to an empirical context. We also address other shortcomings in this literature: the consideration of innovation fairly narrowly in the context of R&D support, firms and individual technologies (e.g. Nauwelaers et al., 2009; Rogge and Reichardt, 2013; Quitzow, 2014) and the lack of attention to policy mixes fostering ‘directed’ transitions towards more sustainable socio-technical systems. The need for such transitions is a crucial policy challenge and an increasing focus of academic research, reviewed below.

2.2 Sustainability transitions and innovation policy

Considerable recent literature on sustainability transitions has emerged to study the transformation of socio-technical systems (incl. technologies, infrastructures, institutions, industrial sectors, user behaviours) towards environmental sustainability. The multi-level perspective (MLP) has developed as the key meso-theory to explain such processes (Markard et al., 2012). The principal idea of the MLP is that transitions come about through interactions between three different levels: landscape (macro-economic and macro-political trends, significant environmental changes, demographic trends, etc.), regime (the deep structure of the socio-technical system involving alignment between technologies, infrastructure, rules, institutions, practices, behavioural patterns, markets, industry structures, etc.), and niches (spaces where various technical, social and organisational innovations are created and tested) (Geels, 2002, 2004, 2011; Geels and Schot, 2007). The MLP posits that top-down landscape pressures and bottom-up developments of emerging niches can lead to the destabilisation of incumbent regimes offering opportunities for niches to break through and overthrow the incumbent regime. Closely connected to the MLP, the literature on Strategic Niche Management (SNM) has emerged as a call to extend technology policy to facilitate the development of technological niches through experimentation-oriented policy tools, potentially stimulating transitions towards new regimes (Hoogma et al., 2002; Kemp et al., 1998).

A related theoretical trajectory is that of Technological Innovations Systems (TIS), developed to study the emergence of new technologies and the formation of technology-specific innovation systems around them, and particularly to identify “system weaknesses that should be tackled by public policy” (Jacobsson and Bergek, 2011, p.46). Many recent TIS studies are focused on system functions that are defined as activities influencing the development of an innovation system around a particular technology (Suurs and Hekkert, 2009; Jacobsson and Bergek, 2011). The central idea behind the TIS functions approach is that, through cumulative causation, the different functions strengthen one another and together lead to a positive, self-reinforcing dynamic ('motors of innovation') allowing a technology-specific innovation system to develop (Suurs and Hekkert, 2009). Suurs and Hekkert (2009) have found national policy to support mainly the 'science and technology push' motor and to have hampering effects on market and entrepreneurial motors. The motors are argued to enable the build-up of TIS; they emerge over a long period of time and comprise a broad variety of activities (Suurs and Hekkert, 2009).

In comparison to MLP/SNM, little insight has been provided on how an emerging TIS can overturn incumbent regimes, a shortcoming pointed out by Markard and Truffer (2008) and Smith and Raven (2012). They argued that the TIS approach is myopic with regard to the explanation of transitions that is seen to mainly rest on the success of the performance of the corresponding innovation system of alternative technologies (inward-looking) but pays less attention to the system's environment, including the incumbent regime. Our contribution is to extend the TIS framework to shed light on the functions needed not only for the creation of new innovations but also for the destabilisation of existing regimes: the argument is that policy mixes need to attend to both processes in a mutually re-enforcing way.

Recently, a few studies have discussed the role of innovation policy in the context of socio-technical transitions (Alkemade et al., 2011; Kivimaa and Virkamäki, 2014; Meelen and Farla, 2013; Weber and Rohracher, 2012). They postulate a need for policies that take into account transitions from the perspective of 'directed' change towards improved sustainability. While, for example, Weber and Rohracher (2012) argue in favour of policy mixes as single policy instruments do not provide sufficient guidance and direction to innovation for transformative change due to the 'directionality failure' of traditional innovation policy, these recent studies pay little attention to processes destabilising existing regimes and how policy mixes could address this dimension.

2.3 Policy mixes for creative destruction?

The idea of sustainability transitions as being partly enabled by the destabilisation of established socio-technical regimes (e.g. Turnheim and Geels, 2013) links to the concept of creative destruction, as coined by Joseph Schumpeter, and particularly the explanations of creative destruction through competence destroying (Tushman and Anderson, 1986) or disruptive innovations (Christensen, 1997;

Turnheim and Geels, 2012). Creative destruction has been conceptualised as a process, in which an innovative entrepreneur challenges incumbent firms and technologies in a way that makes the existing technologies obsolete, forcing incumbents to withdraw from the market (Soete and ter Weel, 1999). At the heart of the entrepreneurial action is disruptive and destroying innovation that "changes the technology of process or product in a way that imposes requirements that the existing resources, skills and knowledge satisfy poorly or not at all. The effect is thus to reduce the value of existing competence, and in the extreme case, to render it obsolete" (Abernathy and Clark, 1995, p.6). However, critics also point to empirical evidence which shows that, through processes of creative accumulation, incumbents may be able to absorb new technologies and integrate them within their existing capabilities and thereby prevent the destruction of existing industries as a consequence of discontinuous technological change (Bergek et al., 2013). We suggest that a similar kind of thinking could be applied to policy in that some new policies could be disruptive in the institutional context shaking the regime in a way that reduces the value of existing practices and technologies, thereby creating momentum for transitions. We further specify this thinking by developing a novel analytical framework in Section 3.1 extending the TIS functions approach.

3. Analytical framework and methodology

3.1. Analytical framework: policy mixes for sustainability transitions through 'creative destruction'

Building on the literature reviewed above, the focus of our analytical framework is on policy instruments targeting two different types of processes that have been highlighted to be of importance for sustainability transitions: the creation of niche innovations and the destruction of incumbent regimes (Table 1). On the 'creation' side, we mainly use the existing TIS functions as a basis (Bergek et al., 2008; Jacobssen and Bergek, 2011) as it gives a rather comprehensive list of innovation-inducing processes that policies can potentially address (Kivimaa and Virkamäki, 2014), and we make slight amendments influenced by the SNM literature (particularly Smith and Raven, 2012).[1] We added 'price-performance improvements' as an additional category, because the SNM literature argues that price-performance improvements are an important process that help stabilise a niche and enable it to compete with incumbent technologies (Geels and Schot 2007).

[1] Positive externalities has been identified as one of the seven TIS components, and may, for example, hinder private R&D investments due to 'free' knowledge spill-overs to other actors (e.g. Jacobsson and Bergek, 2011). It is, however, not included in our analytical framework as it mainly involves public R&D funding, which is well covered in the categories for knowledge (C1) and resource mobilisation (C5) and, apart from that, it is seldom specifically addressed by policy interventions, being rather integrated as a premise in a wide variety of innovation and environmental policies seeking to minimise externalities.

Table 1: The analytical framework

Potential innovation/system influence of policy instrument	***Basis in literature***	***Description of policy instruments*** *(influenced by Kivimaa and Virkamäki, 2014)*
Creative (niche creation)		
Knowledge creation, development and diffusion (C1)	Strengthening the knowledge base and how that knowledge is developed, combined and diffused is a key TIS function and a key process within the SNM literature (learning). This implies not only R&D but support for networks as network weaknesses can hinder knowledge development (Jacobsson and Bergek, 2011). Different types of knowledge, e.g. scientific, technological, production, market, logistics and design, and sources of knowledge, e.g. R&D and learning, are included (Bergek et al., 2008).	R&D funding schemes, innovation platforms and other policies aiming to increase knowledge creation and diffusion through networking; subsidies for demonstrations; educational policies, training schemes, coordination of intellectual property rights, reference guidelines for best available technology.
Establishing market niches/ market formation (C2)	Strengthening market formation by creating new customer demand, e.g. through institutional change, is also a TIS function. It comprises niche markets, e.g. in the form of demonstration projects, bridging markets and mass markets (Jacobsson and Bergek, 2011). Also in SNM, niche markets are considered important for the further development of new socio-technical configurations (Hoogma et al., 2002). They can be created through policy action but also might pre-exist in the form of green consumers who buy products with sustainability credentials despite higher prices or lower performance (Smith and Raven, 2012).	Regulation, tax exemptions, market-based policy instruments such as certificate trading, feed-in tariffs, public procurement, deployment subsidies, labelling
Price-performance improvements (C3)	According to the SNM literature, sustainable innovations often are not competitive within normal selection environments because their performance is weaker compared to incumbent technologies (e.g. electric cars in terms of range) and/or their price is higher (e.g. solar energy compared to natural gas) (Schot and Geels, 2008). Through achieving price-performance improvements, niches can over time become competitive with incumbent technologies and this process can be aided by policy (Kern, 2012).	Deployment and demonstration subsidies enabling learning-by-doing; R&D support (cost reductions through learning).
Entrepreneurial experimentation (C4)	In TIS, this involves the reduction of uncertainties to facilitate the testing of new technologies, applications and markets to enable piloting, the creation of new opportunities and learning (Bergek et al., 2008; Jacobsson and Bergek, 2011). It also involves support for entrepreneurship addressing partly the formation of new actors and networks in SNM.	Policies stimulating entrepreneurship and diversification of existing firms, advice systems for SMEs, incubators, low-interest company loans, venture capital.
Resource mobilisation (C5)	Mobilisation of human and financial capital, and complementary assets such as network infrastructure are included in this TIS function (Bergek et al., 2008; Jacobsson and Bergek, 2011). In SNM, this is subsumed under the process of building of social networks (Smith and Raven, 2012).	Financial: R&D funding, deployment subsidies, low-interest loans, venture capital. Human: educational policies, labour-market policies, secondment of expertise.
Support from powerful groups / legitimisation (C6)	"Legitimacy, i.e. social acceptance and compliance with relevant institutions; is needed for many of the other functions to work, e.g. for resources to be mobilized, for markets to form and for actors to acquire political strength. Legitimacy also influences expectations among managers and, by implication, the function "influence on the direction of search"" (Jacobsson and Bergek, 2011, p.51). In SNM, shared positive expectations legitimate the continuation of	Innovation platforms, foresight exercises, public procurement and labelling to create legitimacy for new technologies, practices and visions.

	protecting and nurturing a niche (Schot and Geels, 2008).	
Influence on the direction of search (C7)	TIS defines this as incentives and/or pressures for organisations to enter the technological field influenced by visions and expectations articulated by companies and in policies (e.g. Jacobsson and Bergek, 2011), by landscape changes, and by legitimisation (Bergek et al., 2008). Links also the articulation of expectations and visions in SNM (e.g. Smith and Raven, 2012). Conflicting policy goals and instruments are likely to diminish this influence.	Goals set and framing in strategies, targeted R&D funding schemes, regulations, tax incentives, foresight exercises, voluntary agreements.
Destruction (regime destabilisation)		
Control policies (D1)	The transition management literature argues that 'control policies' are required to put pressure on the regime. For example internalising the environmental costs of carbon emissions is argued to be key to create an 'extended level playing field' for niches and incumbent technologies to compete on fair terms (van den Bergh et al., 2006). Kemp and Rotmans argue that without such policies the fostering of niche innovations will not lead to transitions (Kemp and Rotmans, 2004, p.164).	Policies, such as taxes, import restrictions, and regulations. Control policies, for example, may include using carbon trading, pollution taxes or road pricing to put economic pressure on current regimes. Banning certain technologies is the strongest form of regulatory pressure (e.g. phase out of fluorescent light bulbs).
Significant changes in regime rules (D2)	The 'deep structure' of socio-technical regimes consists of semi-coherent set of rules directing and coordinating the activities of the social groups reproducing the various elements of socio-technical systems; one element of destabilisation can be reconfiguration in the institutional rules which are favourable to the status quo/path dependent evolution of the regime (Geels, 2011). Particularly, radical policy reforms, where policies substantially change economic frame conditions, may accelerate destabilisation (Turnheim and Geels, 2012, p.44).	Policies constituting, for example, structural reforms in legislation or significant new overarching laws. Historic examples of major rule changes include the privatisation and liberalisation of electricity markets in the 1990s which completely changed the selection environment within which utilities were operating.
Reduced support for dominant regime technologies (D3)	Support for incumbent technologies can become institutionalised within the rules of the regimes which make it difficult for innovations to break through (Smith and Raven, 2012). For example fossil fuel technologies are heavily subsidised and "their removal would greatly contribute to their destabilisation"(Turnheim and Geels, 2012, p.48). Historical examples show that the loss of support can have serious consequences (Turnheim and Geels, 2012).	Withdrawing support for selected technologies (e.g. cutting R&D funding, removing subsidies for fossil fuel production or removing tax deductions for private motor transport).
Changes in social networks, replacement of key actors (D4)	Close relationships between government and key regime actors is often seen as a major source of lock-in (Unruh, 2000; Walker, 2000). Regime destabilisation may involve replacement of incumbents by new actors (Turnheim and Geels, 2012). Deliberately breaking up established actor-network structures or developing different fora to bypass traditional policy networks could provide windows of opportunity for niche innovations and is one of the strategies recommended by transition management scholars (Rotmans et al., 2001).	Balancing involvement of incumbents for example in policy advisory councils with niche actors (as attempted in the Dutch energy transition programme through the transition platforms (Kern and Smith, 2008); formation of new organisations to take on tasks linking to system change.

Our analytical categories on the 'destruction' side are developed drawing particularly on the concepts of regime (Geels, 2010; e.g. Hoogma et al., 2002) and regime destabilisation (Turnheim and Geels, 2012, 2013). We also link these to creative destruction and disruptive innovation (Abernathy and Clark, 1985) and some of the ideas of transition management (Rotmans et al., 2001; Kemp and Rotmans, 2004).

What do we know about how existing regimes can be unsettled? Technological regimes have been conceptualised to be about rules, i.e. the cognitive and normative framework connected to functional relationships between technical components and actors (Hoogma et al., 2002, p.19). It is both the technology and the rules in the regimes that have frequently been identified to be path dependent and, therefore, difficult to change (Unruh, 2000; Pierson, 2004). The struggle between niches (creation of the new) and regimes (stability of the old 'dominant design' (Anderson and Tushman, 1990) supported by incremental innovation (c.f. Abernathy and Clark, 1985)) has been argued to happen around dimensions such as markets, regulations and infrastructure and being enacted by various actors building 'coalitions, when navigating transitions' (Geels, 2010). In the literature linked to creative destruction, the struggle has been described to occur particularly after disruptive innovation has emerged as competition between old and new technical regimes during the 'era of ferment'; this happens until a new dominant design has emerged from competition between actors, leading to and supported by the build-up of standards and optimised organisational processes around it (Anderson and Tushman, 1990). Thus, the concept of regimes implies rules, technologies and actor-networks as the main components that can enforce stability or, when they change, create instability of the regime. Therefore, we propose our regime destabilising functions to be linked to changes in rules, technologies and actor networks (drawing on Kern, 2012, and Verbong and Geels, 2007).

In our analytical framework (Table 1), rules are divided into two functions: control policies implying efforts to control the environmental impacts of the existing regime (D1) and significant changes in regime rules referring to structural reforms in legislation and significant new overarching laws that are not necessarily directly or solely targeting environmental impacts (D2). The transition management literature has long argued that 'control policies' (D1) are required to put pressure on the regime. For example, internalising the environmental costs of carbon emissions is claimed to be crucial in creating an 'extended level playing field' for niches and incumbent technologies to compete on fair terms (van den Bergh et al., 2006). Kemp and Rotmans (2004) argue that without such policies the fostering of niche innovations will not lead to transitions. An example of such a policy instrument is the EU Emissions Trading Scheme.

In addition to internalising externalities, it has been suggested that transitions require significant changes to regime rules (D2) in ways favourable to niches, because existing rules normally hinder path-breaking innovations (Smith and Raven, 2012). Turnheim and Geels (2012, 2013) argue that, as part of regime destabilisation, the 'weakening reproduction of core regime elements' is seen as necessary to create 'windows of opportunity' for the upscaling of niche innovations. Particularly, radical policy reforms, where policies substantially change economic frame conditions, may accelerate destabilisation (Turnheim and Geels, 2012). Such examples are the UK electricity market reform which gave priority to low carbon electricity generation options (Kern et al, 2014) and the coal market reforms in the 1980s and 1990s showing that "industries can be *deliberately* destabilised" (Turnheim and Geels 2012, p. 48).

In terms of changes in technologies, creative destruction through disruptive innovation involves processes by which resources, skills and knowledge held by incumbents become obsolete; in an industrial context, implying that, for example, the value of existing expertise and other factors of production reduce significantly (Abernathy and Clark, 1985). This is a rare event (Anderson and Tushman, 1990) as support for incumbent technologies is often institutionalised within the rules of the regimes making it difficult for innovations to break through (Smith and Raven, 2012; Turnheim and Geels 2012). Historical evidence shows that destabilisation normally entails weakening flows of resources into the reproduction of regime elements including core technologies (Turnheim and Geels, 2013). For example fossil fuel technologies are heavily subsidised and "their removal would greatly contribute to their destabilisation"(Turnheim and Geels, 2012, p.48). Thus, policy mixes for destabilisation may involve weakening flows of human and financial resources to established technologies and practices in the form of withdrawn subsidies or the shut-down of education programmes for engineers focused on particular technologies (D3). For example, in Germany, as part of the phase-out of nuclear power, federal research funding has been withdrawn from nuclear fission research (apart from safety related research, e.g. on nuclear waste disposal).

In terms of changes in actor-networks, a core process within transitions is the entry of new players who challenge established regime practices. People able to think 'outside the box' can make important contributions to radical innovation (Bower and Christensen, 1995). The interests that these 'outsiders' have in existing production and consumption systems tend to differ from the vested interests of incumbent firms, who carry more 'sunk costs' and are consequently more tied to perpetuating the existing way of doing things. This is why "[d]isruptive technologies rarely 'make sense' to incumbents, so that their development tends be left to small, outsider organisations" (Winskel et al., 2006: 367). New entrants are more likely to develop radical innovations in niche markets which, if successful, can disrupt and displace the mainstream way of doing things (e.g. Christensen, 1997). However, close relationships between the government and key regime actors is often seen as a major source of lock-in (Unruh, 2000; Walker, 2000). Destabilisation at the level of actor-networks may therefore involve the replacement of incumbents with new entrants or the reorientation of incumbents to new markets and regimes (Turnheim and Geels, 2012, p.35). Incumbents' existing competences might be rendered obsolete (Abernathy and Clark, 1995) or they may be able to absorb new technologies and practices to prevent their destruction (Bergek et al., 2013) but both processes involve significant activity of new players. Deliberately breaking up established actor-network structures or developing different fora to bypass traditional policy networks can provide windows of opportunity for niche innovations and is one of the strategies recommended by transition management scholars (e.g. Rotmans et al., 2001). From this we deduct for our framework that previously dominant and influential governance organisations or networks may be dismantled, replaced with new networks, merged or otherwise altered decreasing the legitimacy of and commitment to the old regime (D4). An example is the Dutch energy transition programme which by setting up transition platforms explicitly tried to bypass 'normal' policy making processes (Kern and Smith, 2008). Alternatively, the setting up of systemic intermediaries (Kivimaa, 2014) could be regarded as an action aiming to change social networks.

Overall, the proposed framework seeks to capture what we see as two sides of the same coin: the creation of innovations (C-functions) and the destruction of incumbent regimes (D-functions). This analytical framework will be used for empirically mapping policy instruments to assess whether existing policy mixes have the potential to drive sustainability transitions. The logic is to ascribe each instrument to contributing to one or more of these 'creative destruction' processes to reveal whether or not the existing policy mix addresses the stipulated functions (C1-7 and D1-4). The detailed methodology will be discussed in the next section.

3.2. Methodology

The empirical illustration of the utility of the framework focuses on national-level policies (including instruments constituting national implementation of EU legislation). Even though local or regional initiatives also influence transition processes (e.g. Hodson and Marvin, 2010, 2012), they are beyond the scope of this paper.[2] Our analysis is limited to three regimes - mobility, electricity and heating of buildings – which cut across policy domains such as innovation, energy, fiscal and transport policy in two different countries (Finland and the UK). We look for mixes of policies supporting transition processes and, thus, define policy mixes, extending from Borras and Edquist (2013) as the specific combinations of policy instruments which interact explicitly or implicitly in fostering (in our

[2] The existing databases used for the analysis only cover national level instruments.

illustration, low-energy) innovations and disrupting dominant (high-energy) regimes.[3] We examine instruments influencing innovation related to energy demand reduction and improved energy efficiency; thus, for example renewable energy policies focussing merely on the supply side (e.g. wind power, biofuels) are outside the scope of our analysis.

The research method used is a policy mapping exercise. By using four international data sources of policy measures, to enable the collection of comparable data for both countries, lists of relevant policies potentially influencing low energy transitions were identified in September and October 2013. The following sources were used: The International Energy Agency's reviews of energy policies in the UK (IEA, 2012) and Finland (IEA, 2013) and the IEA policies and measures databases on energy efficiency (http://www.iea.org/policiesandmeasures/), the European Environmental Agency's database on climate change mitigation policies and measures in Europe (www.eea.europa.eu/data-and-maps/pam/), the European Commission's Erawatch research and innovation policy database (http://erawatch.jrc.ec.europa.eu/erawatch/opencms/) and the IEA Sustainable Buildings Centre's Building Energy Efficiency Policies (BEEP) database (www.sustainablebuildingscentre.org/pages/beep)[4]. Information on the identified policy instruments was complemented by searches made on both countries' governmental websites to find out the objectives, justifications and main content of the policy instruments. The draft lists of policy instruments were sent to four experts from policy and academia in each country, of which two replied per country, to validate the list and to check possible major omissions. We initially identified 70 instruments in the UK and 58 in Finland and added six Finnish instruments and two UK instruments through the expert review process. One shortcoming of the use of databases as a data source was that local or regional policies are not included in the study. This was also pointed out in the expert review.

The identified policy instruments were divided into groups based on their target regime: mobility, heating in buildings and electricity. Many policy instruments contributed across these sectors so these were categorised as generic innovation policy or energy and climate change instruments. The instruments that linked across sectors were also often instruments that did not only deal with energy efficiency but also energy production – making drawing explicit boundaries between energy efficiency and other energy policy instruments difficult. Subsequently the policy instruments where

[3] While in terms of empirical illustration, we focus on instrument mixes, we see the usability of our proposed framework also in examining in more detail mixes of policy goals, instruments, outputs (of implementation) and processes and how they in combination influence transitions. However, such a wider analysis is beyond the scope of this paper.
[4] No equivalent database exists for transport policies but the other sources cover many transport-related policies.

coded in Excel based on the analytical framework categories (Table 1). Investigator triangulation was used in that both authors coded independently, after which the results were compared. In case of differing opinions, the final coding was negotiated between the authors to ensure consistency. The aim of the mapping exercise was to analyse how current policy mixes engage or do not engage with processes argued to be crucial for low energy transitions. Particular attention was paid to the relative importance these policy mixes placed on creation vs. destruction, the relative coverage of the different regimes and any important gaps.

3.3 Empirical cases: Low-energy transitions policy in Finland and the UK

Empirically, the analysis focuses on low-energy innovations which we define as innovations reducing the demand for energy and/or increasing energy efficiency. Such innovations include more energy efficient technologies, such as LED lighting or new building designs, but they might also include social (e.g car clubs, tele-working) or organisational (e.g. new business models providing energy services) innovations. Our focus complements the existing literature on energy innovation which mostly deals with energy supply (e.g. Foxon et al., 2005; Klaassen et al., 2005; Bergek et al., 2008). Practices for energy saving and demand have gained some interest recently (Breukers et al., 2013; Heiskanen et al., 2013), while this is a new topic for innovation policy analysis.

Finland and the UK were chosen as case countries as their recent progress in energy efficiency shows differing trends based on an EU wide survey. While the UK was found to have a clear strategy for improving energy efficiency, policy progress in the last three years was ranked from low to moderate; in turn, Finland was ranked among the top three countries in terms of progress in energy efficiency policy (Energy Efficiency Watch, 2013). The countries also differ in terms of their energy consumption profiles, the UK having one of the lowest energy consumptions per GDP among the IEA countries (IEA, 2012) while Finland has one of the highest (IEA, 2013). In Finland, industry is the largest energy consumer with nearly half of the total consumption, while in the UK buildings take up the majority of energy consumption. Furthermore, the countries differ radically in terms of population size and density. Thus, the two countries provide contrasting settings for testing the conceptual framework. In Section 4, the empirical mapping is briefly presented first giving an overview and then covering destabilising functions in more detail as this is where we claim the added value of our framework.

4. Low energy policy mixes in Finland and the UK

4.1 The low-energy policy mix in Finland

With one third of the country being located above the Arctic circle and given its energy intensive industry (incl. pulp and paper, chemicals, metals, electronics) Finland has the highest energy consumption per capita of all IEA countries (IEA, 2013). The industrial sector is the largest energy consumer (47.5% of total final consumption), followed by the residential sector (20%), while the commercial and other service sectors accounted for 15.3% in 2011. Transport accounted only for 17.2%; the lowest percentage among IEA member countries. The Finnish building stock is very efficient and makes extensive use of district heating, 75% of which is provided by combined heat and power plants.

Our analysis of the Finnish policy mix shows a wide range of instruments targeted at different energy regimes that in combination influence all niche creating functions and three of the regime destabilising functions: control policies (D1), significant changes in regime rules (D2), and removal of support for dominant regime technologies (D3). Very few instruments address price-performance improvements (C3) and the destabilising functions (Figure 1). A multitude of policy instruments influencing mobility and the heating of buildings are in force, while electricity use is somewhat less targeted.

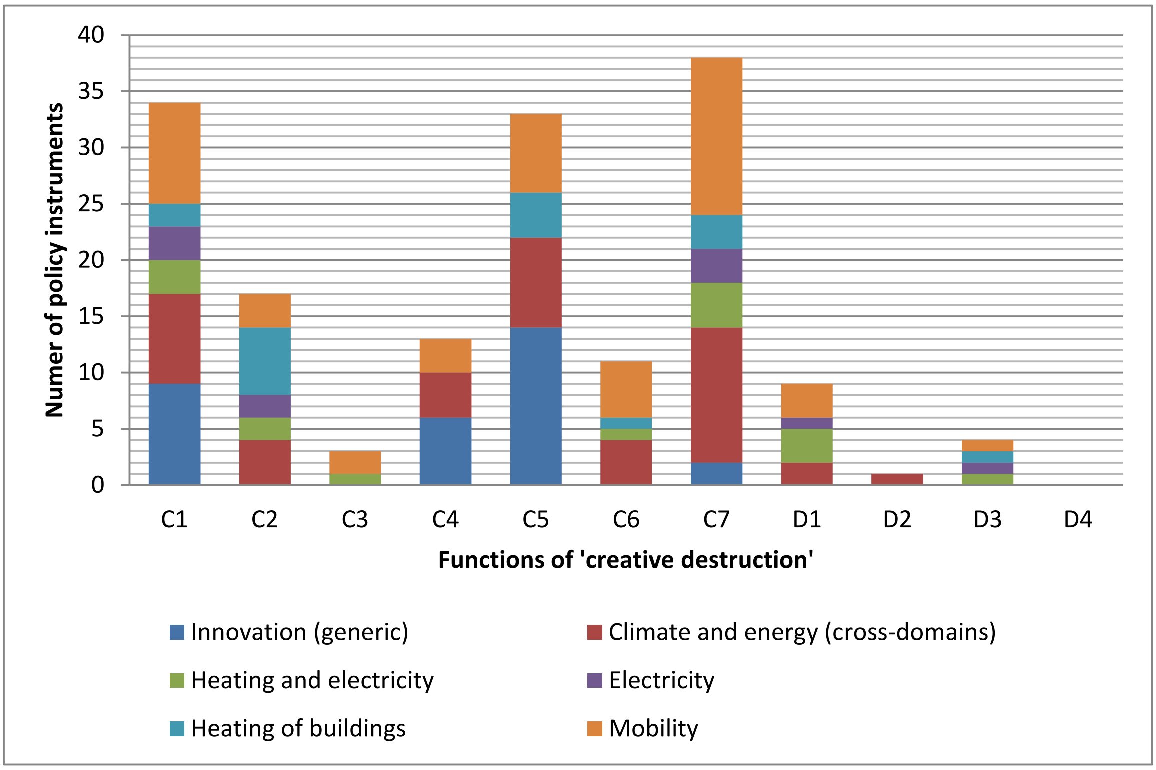

Figure 1: Finland's 'low energy' policy mix

A previous study on mobility-related policies noted a lack of significant national-level instruments related to 'entrepreneurial experimentation' (C4) and 'market formation' (C2) (Kivimaa and Virkamäki, 2014). However, our analysis (see appendix), covering a wider range of instruments shows that generic innovation policy instruments (such as Finnvera's financial services for start-ups and micro-enterprises) and climate and energy policy instruments (for example, the energy-efficiency guidelines for public procurement) may fill these gaps. Yet, there is no guarantee that resources will be actually allocated for this purpose.

A gap in the policy mix also exists for the heating of buildings and electricity regimes regarding 'entrepreneurial experimentation' (C4), which is left to be addressed by generic innovation and climate and energy policies. For example, the energy aid scheme provides subsidies on a discretionary basis on investment projects that "promote energy conservation or improve the efficiency of energy production or use". This policy coupled with electricity tax increases (linked to market formation C2, influence on the direction of search C7, control policies D1) and energy performance requirements for new buildings (contributing to market formation C2, price-performance improvements C3, direction of search D7, and control policies C1) could at the same time destabilise the existing regime, contribute to a transition towards zero energy buildings and create niche-innovations for energy saving solutions in construction.

In total we found nine control policies (D1), one significant change in regime rules (D2) and four policies representing the removal of support for dominant technologies (D3). The regime-specific control policies ranged from environmental amendments in tax regimes (for vehicles, transport fuels, electricity, natural gas and heating) to performance standards and regulations for new cars and buildings. Three of the D1 policies concerned mobility, four concerned electricity and heating, and two were more generic climate policies, such as the EU Emissions Trading Scheme. For example, the National Building Code sets requirements for the energy consumption of Finland's building stock in accordance with the EU Directive on the Energy Performance of Buildings regarding average insulation level, heat losses of the building (building envelope, ventilation and air-tightness) and the calculation of the energy demand per square meter. The 2012 revision pushes Finland's already stringent energy performance requirements up by a further 30%, and now also takes into account the energy source of the building.

We determined a recent revision in the Land Use and Building Act, influencing energy use across regimes, as a significant change in regime rules (D2). The revised Act aims to ensure energy efficiency and resource efficiency in the renovation of buildings and to avoid disruptive land use development and increased transportation needs specifically by limiting the construction of retail centres based on private car transportation. Its significance is based on the expansion of support for energy efficiency through the Act and the strengthening of the instruments of the law (for example, by providing a mandate to municipalities to oblige new buildings in the proximity of district heating to connect to the network except when renewable energy is used).

Amendment of the fuel tax to be based on the energy content of the fuel and an increased tax level for fossil fuel based heating were considered as removal of support for dominant technologies (D3) as was the EU wide ban on incandescent light bulbs. Fuel tax in general reduces support for high-energy consuming vehicles and practices and, when taking into account the energy content of the fuel, this effect is intensified to support the most efficient fuels.

No significant changes in policy networks or key actors (D4) were identified.

4.2 The low-energy policy mix in the UK

The largest end-use of energy in the UK occurs in the residential sector, amounting to 32% of total final consumption, followed by transport with 30%, industry with 25% and commercial and other sectors with 13% in 2010. According to the IEA (2012, p.13), "[e]nergy use per unit of GDP in the United Kingdom is one of the lowest among the IEA member countries, reflecting both the large share of services and the small share of energy-intensive industry in the economy, but also improvements in energy efficiency".

Our analysis of the UK policy mix shows a wide range of instruments targeted at different energy regimes that in combination influence all niche creating functions and three of the regime destabilising functions: control policies (D1), significant changes in regime rules (D2), and removal of support for dominant regime technologies (D3). As in the Finnish case, very few instruments address price-performance improvements (C3) and the destabilising functions (Figure 2). A multitude of policy instruments influencing mobility and the heating of buildings are in force, while electricity use on its own is somewhat less targeted. However, several instruments address electricity and heating simultaneously.

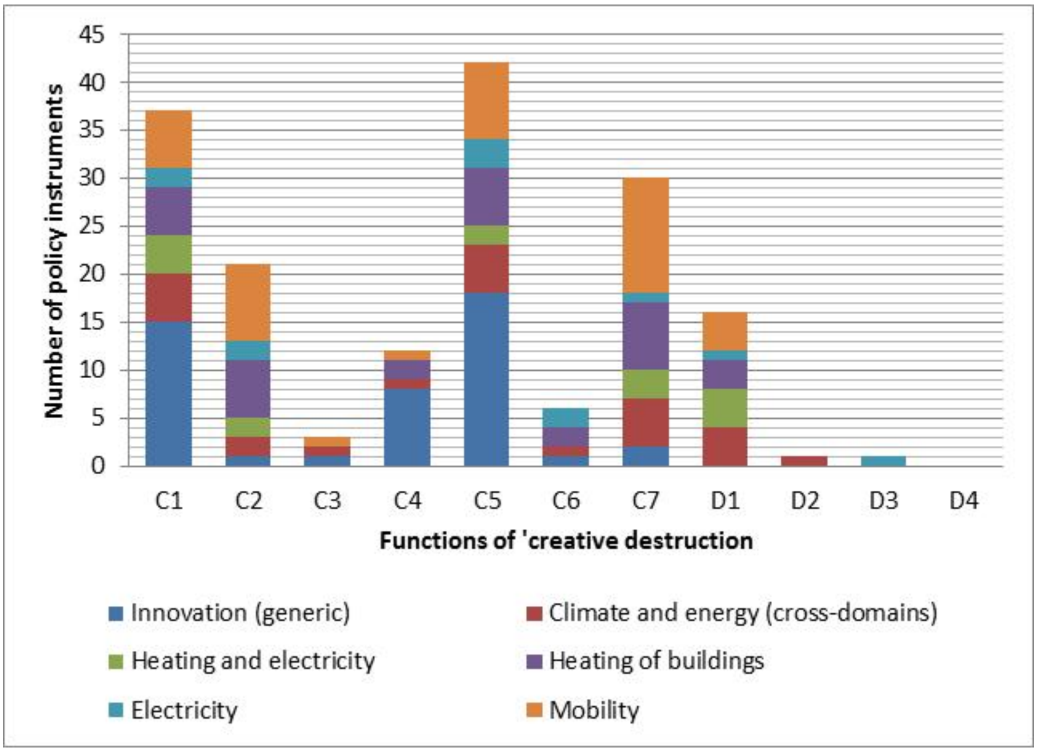

Figure 2: UK 'low energy' policy mix

The UK has recently introduced several policy instruments influencing energy efficiency and energy demand in the heating of buildings and mobility. Both sectors present fairly comprehensive policy mixes from the perspective of niche creation with only legitimising instruments (C6) missing for mobility. However, many of the mobility policies (at least at the national level) focus specifically on automobility (such as car tax reforms, programmes for electric mobility, fuel economy labels, the Low Carbon Vehicle Partnership) rather than alternative mobility systems (cycling, walking, public transport) (see appendix). Many of such initiatives are happening at the city or local level (e.g. congestion charging in London, city bike schemes, car clubs).[5] Less focus has been placed on the electricity sector that is dominated by supply side instruments trying to stimulate the uptake of renewable energy technologies, nuclear and CCS.

As in the Finnish case, a gap in the policy mixes for the heating of buildings and electricity regimes exists regarding 'entrepreneurial experimentation' (C4), which is mainly left to be addressed by generic innovation and climate and energy policies (with the exception of the Carbon Trust which fosters 'entrepreneurial experimentation' (C4) for example through an incubation scheme).

[5] Expert review comment.

Similarly to Finland, few policy instruments were found to contribute to the destabilisation of existing regimes (D1-4). In total, we identified 16 instruments as 'control policies' (D1), one significant change in regime rules (D2) and one policy removing support for established technologies (D3). As in Finland, control policies included minimum performance standards for new passenger cars and buildings, changes in taxation (e.g. company car tax reform, fuel duty escalator) and the Emissions Trading Scheme. In addition, the UK had a range of policy instruments and packages – differing from Finland – as further control policies: a requirement of private landlords to make reasonable energy efficiency improvements required by tenants, the Climate Change Levy on energy for lighting, heating and power aimed at encouraging energy efficiency in businesses, the Carbon Floor Price as part of the electricity market reform, and the Government Buying Standards. All these instruments put economic or regulatory pressure on existing regime practices. For example, the Carbon Price Floor, by ensuring a minimum price of carbon in electricity generation, aims to reduce the use of carbon intensive fossil fuels and to address the weakness of the EU Emissions Trading Scheme.

Our UK analysis identified one policy instrument deemed to directly address significant changes in regime rules (D2): the 2008 Climate Change Act. The act aims for a 50% reduction in greenhouse gas emissions from 1990 to 2027 and a reduction of 80% by 2050. It can be interpreted to be a major control policy (D1) as well as a significant change in regime rules (D2) for incumbent energy regimes. According to the Act, a system of "carbon budgets" limits UK emissions over successive five-year periods and sets the trajectory to 2050. Most emphasis has so far been put on change within the electricity regime (e.g. with regard to the roll-out of renewable energy) but the recent electricity market reform introduces a number of instruments putting pressure on fossil fuel plant operators. The reform mainly deals with energy supply rather than energy use or energy-efficiency but, for example, capacity payments have been introduced to ensure sufficient system flexibility to maintain reliable supplies, and will also involve demand-side response issues.

The only instrument we identified as being directly targeted at withdrawing support for a dominant regime technology (D3) was the EU ban of incandescent light bulbs introduced in 2012. The EU ban aimed to increase the energy efficiency of lighting and sent a strong signal manufacturers and consumers by using the most draconian policy measure available: an outright ban. This is the most extreme form of withdrawing support for a technology which has been dominating domestic lighting practices for more than a century. Potentially such an instrument, in combination with other instruments such as the national products policy (legislation to set minimum energy efficiency standards for products on sale and mandating energy efficiency labelling of appliances), also has a signalling effect for manufacturers of other highly-energy inefficient products.

The analysis did not identify any instruments which could be classified as contributing to D4: Changes in social networks or replacement of key actors.

5. Discussion

The empirical analysis showed that the framework developed in this paper – combining seven niche creation (creative) functions with four regime destabilising (destruction) functions – can reveal interesting lessons about current policy mixes for sustainability transitions. As expected we found fewer policy instruments directly tackling regime destabilisation (D-functions) than niche creation (C-functions). Relatively many control policies (D1) were found in both countries that simultaneously typically also influenced market formation (C2) and/or the direction of search (C7), but in the case of some UK instruments also knowledge creation and diffusion (C1) and resource mobilisation (C5). Yet, some control policies did not address any other functions. We found two examples of significant changes in regime rules (D2): the revision of the Land Use and Building Act in Finland and the Climate Change Act in the UK. The rarity of this function can probably be explained by the political hostility towards structural change and the difficulties to politically sustain it (Lockwood, 2013). We identified only a few changes in support for dominant technologies (D3) directly applicable to the reduction of energy demand or improvement of energy-efficiency, such as the EU-wide ban on incandescent light bulbs and the amendment of transport fuel taxation in Finland. However, indirectly, the removal of support for fossil fuels is clearly a measure destabilising the high-energy regime and has clear implications: reduced support for fossil fuel exploration and production may increase energy prices and, thereby, increase incentives for low energy innovations. In the UK, several such measures have been taken, for example, the removal of subsidies for coal mine operating costs, in 2002, and for maintaining access to already exploited coal reserves in 2008 (IEA, 2012, p.93).

Destabilisation policies are politically difficult. That we find few examples of such policies is therefore not surprising. Jänicke and Jacob (2005), for example, have argued that necessary structural change from an environmental perspective, such as the phasing out of nuclear energy or the use of lignite coal, requires huge political endeavour and is therefore possible only in exceptional circumstances. Also Meadowcroft (2005) has made a similar point. Moreover, designing policies attempting to undermine existing regimes is challenging, because they present a contradictory ideology to that of traditional innovation policies often aimed to contribute to economic growth (e.g. Alkemade et al., 2011), irrespective of the direction of innovative activity (Stirling, 2009), and are likely to require significant backing of major political parties (e.g. Strunz, 2012). An example for the political difficulty of destabilising policies is the tax break for work-based travel in Finland. A decision for a reduction of the tax break was made in 2012 and later cancelled due to pressure from various stakeholders.[6] Yet, there are a number of arguments policymakers can use to justify destructive policies: one is that destabilising existing regimes is one way of achieving more effective competition (in the sense of 'levelling the playing field'). A second justification might be that such policies are necessary to 'free the 'animal spirit' necessary for radical entrepreneurship and its effects in terms of 'creative destruction'.

Our empirics also point to connections within policy mixes. While the discussion on the synergies and contradictions (cf. Rogge and Reichardt,2013) or cumulative causation (cf. Suurs and Hekkert, 2009) between the elements of this framework cannot be addressed here in detail, some observations on the links between creation and destabilisation policies can be made. Control policies (D1) have a clear dual function in destabilising the current regime, often by controlling the environmental impacts, while at the same time facilitating niches through creating markets for niche innovations (C2), in effect contributing to multiple "motors" (see Section 2.2) at the same time. The EU Directives on Emissions Trading or the Energy Performance Standards for buildings are good examples. Less directly, knowledge creation, development and diffusion (C1) and resource mobilisation (C5) might be linked to the removal of support for established technologies (D3) in that re-directing research funding, education and science to certain areas simultaneously may promote niches and withdraw support from established technologies. This means that a mix of policy instruments could both contribute to the Science and Technology Push (STP) Motor of a new TIS and diminish the STP motor of the dominant regime simultaneously or within a short period of time. In that sense it seems useful to expand the concept of 'motors of innovation' to 'motors of creative destruction': we argue that while the cumulative build-up of various innovation system functions (here covered through the niche creation functions) is necessary, on its own it is insufficient to drive sustainability transitions. Therefore, cumulative effects and dynamics of both niche creation and regime destruction processes should be at the centre of attention. Further analysis of these links - particularly those linking significant changes in regime rules (D2) and changes in networks and replacement of key actors (D4) with impacts on niche creation functions (C1-7) - would need more detailed case studies with a more limited scope of policies than analysed in this paper.

[6] YLE News 30.8.2012: http://yle.fi/uutiset/kilometrikorvauksia_leikataan_kahdessa_vaiheessa/6276673; Prime Minister's Office news release 25.10.2013: http://vnk.fi/ajankohtaista/tiedotteet/tiedote/fi.jsp?oid=363721

Our empirical analysis also points to a need for further conceptual and methodological developments. The placing of instruments into functions was sometimes difficult and more specific indicators for each function are needed – particularly on how to interpret the functions 'legitimisation' and 'price-performance improvements'. Often policy instruments can be interpreted to be contributing to specific functions or not depending on how narrow or wide the interpretation of the function is. For example, in terms of resource mobilisation (C5) a policy instrument can directly provide resources (e.g. by setting up a public fund for R&D on energy efficiency) or indirectly stimulate the mobilisation of resources by other actors (e.g. by setting vehicle emission standards leading to stronger R&D efforts by car manufacturers or by establishing a prestigious energy efficiency award which might stimulate investment by private actors). This is not only a problem of classification but also influences the potential effect of policies. Interpreting functions in a narrow way would enable better identification of potential policy gaps to be analysed in more detail when observed.

We did not detect any instruments aimed at changes in social networks or replacement of key actors (D4) probably because the data sources used are not likely to include such instruments. Further analysis of this is necessary, as many of the organisational changes observed, e.g. the change of the Energy Market Authority to Energy Authority in Finland, while widening the mandate and tasks, cannot be seen as network changes or replacement of key actors. This also indicates that function D4 might benefit from more specific criteria regarding what types of organisational changes can be classified as destabilising measures (e.g. new ministries with new tasks or new kinds of systemic intermediaries).

6. Conclusions

Our aim was to broaden the discussion within the technology and innovation studies literature about the importance of policy mixes. We argued that policy mixes are particularly important and challenging, if policy is aimed not just at the creation or diffusion of innovations but at transforming entire socio-technical systems towards sustainability. Drawing on the existing policy mix and sustainability transitions literatures, the contribution of this paper is to explicitly conceptualise policy mixes for sustainability transitions. Our key argument is that policy mixes for sustainability transitions should incorporate instruments addressing two dimensions: those aimed at creating niche-innovations and building effective innovation systems around them and those aimed at destabilising currently dominant regimes. We therefore propose to expand to concept of 'motors of innovation' to 'motors of creative destruction' to incorporate attention to the required destabilisation processes.

We specifically built on the Technological Innovation System (TIS) functions and Strategic Niche Management theory for developing niche creation functions, while for the destabilisation functions we utilised Schumpeter's seminal concept of 'creative destruction' , the concept of regime destabilisation by Turnheim and Geels (2012, 2013) and some ideas of transition management (Rotmans et al., 2001). By initiating a discussion on policies destabilising current structures, we wish to facilitate further analyses of policy mixes going beyond stimulating individual technologies as in much of the existing TIS literature.

We argue that the conceptual framework and the analysis presented in this paper are a first step towards examining policy mixes from the perspective of sustainability transitions. Empirically, we have provided an overview of which processes are targeted by existing policy mixes in the UK and Finnish low-energy transitions and have identified some important gaps, particularly the lack of destabilising policies generally as well as sector-specific policies addressing price-performance improvements and entrepreneurial experimentation. Given these gaps, more attention should be placed by policymakers on whether the current policy mixes are enough to achieve the ambitious long-term targets for energy efficiency and energy demand reduction. Conceptually, we have developed an extension of the TIS functions approach, by adding four regime destabilisation functions (D1: control policies, D2: significant changes in regime rules, D3: reduction in support for dominant technologies, and D4: changes in social networks and replacement of key actors), and tested the framework against two case studies which emphasised the need for further conceptual and methodological refinements.

Admittedly, the approach presented in the paper is a very proxy way of analysing policy mixes and necessarily quite crude. One shortcoming of the kind of analysis conducted here is that, while we see a variety of instruments aimed at energy demand reduction, little can be said about their actual effectiveness. A more detailed analysis of a limited set of instruments, their development over time and their impact on the strategies of target groups should be conducted to build on and complement our overview. In more detailed analyses, interviews with target group actors could shed light on how actors interpret the signals they receive from different policy instruments (cf. Huttunen et al., 2014) and how this shapes their strategies. Alternatively, econometric techniques could be used to assess the combined impact of policy mixes. While these kinds of studies have been carried out, so far they have not extended to examining the impacts from the perspective of creative destruction.

We argue that the type of analysis carried out in this paper is also of use for policymakers. Importantly, it shows that the mix of generic innovation policies and targeted sectoral policies is important to create more complete policy mixes from the perspective of transitions – following Weber and Rohracher's (2012) call for a combination of 'structural innovation policies' and 'transformation-oriented innovation policies'. Applying the concept of 'creative destruction' in the context of public policy will hopefully help to expand innovation policy debates to go beyond policy mixes consisting of technology push and demand pull instruments, and to consider a wider range of policy instruments which may contribute to both the creation of niches as well the destabilisation of existing regimes.

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Appendix: Examples of policy instruments under functions for mobility (due to the large numbers of policy instruments for some functions, not all identified instruments are included)

Potential innovation/system influence of policy instrument	***Finland***	***UK***
Creative (niche creation)		
Knowledge creation, development and diffusion (C1)	Mobility policies: Fuel Cell R&D Programme, Energy labelling of passenger cars, Voluntary Agreement with Public Transport Climate and energy policies: Green Growth Programme, Consumers Energy Advice Network & Architecture, Government Decision on Energy Efficiency Generic innovation policies: Pioneers of Service Business Programme, Centres of Excellence Programme, Innovative Public Procurement	Mobility policies: Fuel economy labels for cars, ETI Transport Programme, Catapult Centre in Transport Climate and energy policies: National Sustainable Public Procurement Programme, Living with Environmental Change Programme, Energy Programme Generic innovation policies: Knowledge transfer partnerships, R&D tax credits for SMEs, Innovation Voucher
Establishing market niches/ market formation (C2)	Mobility policies: Energy labelling of passenger cars, Amendment of Car Tax and Annual Vehicle Tax Regimes, Amendment of fuel taxation Climate and energy policies: Guidelines for energy-efficiency in public procurement, Energy efficiency agreement with municipalities, Revision of the land use and building act.	Mobility policies: Local sustainable travel fund, Plug-in car grants, Plug-in places programme Climate and energy policies: National Sustainable Public Procurement Programme, Government Buying Standards Generic innovation policies: Small Business Research Initiative
Price performance improvements (C3)	Mobility policies: Fuel Cell R&D Programme, TransEco Programme	Mobility policies: Catapult Centre in Transport Climate and energy policies: The Carbon Trust Generic innovation policies: Collaborative Research and Development
Entrepreneurial experimentation (C4)	Mobility policies: Fuel Cell R&D Programme, TransEco Programme, Electrical Vehicle Systems Programme Climate and energy policies: Built Environment SHOK, Energy Aid Scheme, Green Growth Programme Generic innovation policies: Finnvera's financial services for start-ups and micro-enterprises, product track funding, Seed Fund Vera Ltd.	Mobility policies: Catapult Centre in Transport Climate and energy policies: The Carbon Trust Generic innovation policies: Community Investments Tax Relief, Enterprise investment scheme, the Queen's Awards for Enterprise
Resource mobilisation (C5)	Mobility policies: Fuel Cell R&D Programme, Electrical Vehicle Systems Programme Climate and energy policies: Energy Aid Scheme, Green Growth Programme, Cluster for Science, Technology and Innovation for Energy and Environment Generic innovation policies: Pioneers of Service Business Programme, Centres of Excellence Programme, Investor Extra	Mobility policies: Local sustainable travel fund, Green bus fund, Plug-in places programme Climate and energy policies: The Carbon Trust, Government Buying Standards, Energy Programme Generic innovation policies: Venture Capital Trusts, UK Research Partnership Investment Fund, UK Innovation investment fund
Support from powerful groups / legitimisation	Mobility policies: Letters of Intent for Land Use, Housing and Transport; Voluntary	Climate and energy policies: Government Buying Standards

(C6)	Agreement with Public Transport; Fuel Cell R&D Programme Revision of the Land Use and Building Act; Cluster for Science, Technology and Innovation for Energy and Environment; The energy efficiency agreement of industry and commerce.	Generic innovation policies: The Queen's Awards for Enterprise
Influence on the direction of search (C7)	Mobility policies: Mobility management, Voluntary Agreement with Public Transport, Amendment of fuel taxation Climate and energy policies: Energy Audit Programme for industry and service sectors, Revision of the Land Use and Building Act, Green Growth Programme. Generic innovation policies: The Millenium Technology Prize, Innovative Public Procurement,	Mobility policies: Local sustainable travel fund, fair fuel stabiliser, plug-in places programme Climate and energy policies: Government Buying Standards, Planning and Energy Act, Climate Change Act Generic innovation policies: Foresight Programme, Small Business Research Initiative
Destruction (regime destabilisation)		
Control policies (D1)	Mobility policies: Emission performance standards for new passenger cars, Amendment of Car Tax and Annual Vehicle Tax Regimes, Amendment of fuel taxation Climate and energy policies: Revision of the Land Use and Building Act	Mobility policies: Emission performance standards for new vehicles, Company car tax reform, Fair fuel stabiliser Climate and energy policies: Government buying standards, Climate Change Act, Planning and Energy Act
Significant changes in regime rules (D2)	Climate and energy policies: Revision of the Land Use and Building Act	Climate and energy policies: Climate Change Act
Changes in support for dominant regime technologies (D3)	Mobility policies: Amendment of fuel taxation	None observed
Changes in social networks, replacement of key actors (D4)	None observed	None observed

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