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Green growth – A synthesis of scientific findings

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ABSTRACT

Governments in countries across the world increasingly adopt the "green growth" discourse to underline their ambition for the greening of their economies. The central tenet of this narrative is the economic opportunities rather than challenges arising from the pursuit of environmental sustainability. Our paper synthesises insights from 113 recent scientific articles, dealing with both environmental issues and economic growth, as well as innovation. Our ambition is exploratory in attempting to take stock of heterogeneous contributions across the spectrum of social science. The articles have been reviewed with a focus on six themes, derived from current discussions in economic geography and transition studies: skills, technology, physical resources, markets, institutions and policies. Four major implications emerge from the review. First, green growth requires competences that allow for handling complex, non-routine situations – in both the private and the public sector. Second, technological progress should be directed towards greener technologies, to avoid investments funds being channelled to brown technologies for short-term returns. Third, our knowledge of the opportunities for achieving green growth must base upon a joint assessment of market failures, structural system failures and transformational system failures. Finally, greater attention should be devoted to the geography of green growth processes at different scales.

1. Introduction

The purpose of this paper is to synthesise insights on green growth with an explicit account of drivers and barriers of innovation and the geographic context of green growth.

Governments in countries across the world increasingly adopt the "green growth" discourse to underline and promote their ambition for the greening of their economies. The central tenet of this narrative is the economic opportunities rather than challenges arising from the pursuit of environmental sustainability. While definitions of green growth abound, we here follow the often cited OECD (2011, p. 9) definition of green growth as *"fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies"*.

Consequently, green growth is suggested to be a key element in achieving sustainable development: on the one hand, protecting the environment, while on the other hand allowing economic growth. This arguably makes the concept more attractive to politicians and other decision makers than traditional environmental protection approaches, which were often assumed to lead to economic slowdown. Especially in the last ten years, that is since the onset of the Financial Crisis, the need of a policy-driven stimulation of demand has become stringent. However, the increase in unemployment has left little room for unleashing private demand, leading authorities to look for unexpressed demand in areas of the economy where the market would not automatically function. The well-being deriving from a preserved environment cannot be easily attained through market transactions, also due to "tragedy of the commons" features of environmental goods, i.e. the discrepancy between individual and common interests. Consequently, environmental sustainability constitutes an area where unsatisfied demand can be looked for. In particular, a bounce of the economy could be made possible if the scattered demand for a sustainable environment is gathered through policy and reconducted into a market. Indeed, green technologies are suggested to be the foundation of a new technological revolution (Perez, 2015), and industrial leadership in emerging green industries may therefore secure long-term growth (Stern,

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2010) and high-paying jobs (Jacobs, 2013; The Pew Charitable Trusts, 2009).

Previous reviews on green growth have focused on describing the central elements of the concept, as well as its intellectual heritage and occurrence as a concept in policymaking and academia (Bowen and Fankhauser, 2011; Jacobs, 2013; Jänicke, 2012). These aspects are hence well understood and synthesised in previous contributions. However, conversely, the central drivers and barriers of green growth are less well understood. One aspect of particular importance here is that of innovation. As the transition towards green growth necessitates radical transformations of technologies and associated markets and institutions, any account of green growth should explicitly consider the role of innovation. The need for an explicit account of innovation comes also from the potential rebound effects between the economy and the environment. If "green industries" contribute to economic growth, the corresponding increase and diffusion of income and production in the economy, multiplied also throughout traditional sectors, could have detrimental environmental effects. Innovation would then be key for allowing contemporaneously an increase in well-being due to an improved environment and an increase in well-being due to traditional forms of consumption (Holdren and Ehrlich, 1974).

Our paper synthesises insights from the current scientific literature on drivers and barriers of green growth with an explicit account of innovation. Importantly, our aim is not to review what has been written under the heading of 'green growth', but rather to review contributions that are concerned with drivers and barriers of green growth, even if the green growth term is not applied explicitly. The reviewed literature was selected (see Section 2) on the basis of social science studies focusing on the interaction between environmental issues, economic growth and innovation. To narrow down the scope of the review we excluded studies from developing and emerging economies, not least because the conditions for green growth vary between and across categories of countries. Otherwise we refrain from discrimination based on research subject or discipline. Green growth is a complex phenomenon, interdisciplinary by nature, whose social and political relevance has recently come to permeate the scientific discourse. Our ambition is thus exploratory in attempting to take stock of existing insights from heterogeneous contributions originating across the spectrum of social sciences on the drivers and barriers to green growth. In order to structure our review, however, we draw on existing insights from evolutionary economic geography (EEG) and the sustainability transition (ST) literatures to derive six interrelated themes that are considered crucial for understanding drivers and barriers to the emergence of green growth paths in specific spatio-temporal contexts. EEG and ST research share roots in evolutionary economics – a field fundamentally concerned with innovation and *growth* (Dosi, 1982; Nelson and Winter, 1982). EEG has until recently primarily been concerned with innovation, growth and industrial development (in particular countries, regions or places) without any particular interest in greening or sustainability. The opposite can be said for ST; this literature has focused on innovation for transitions towards sustainability (often in a national context), but had little to say about the implications for (the geography of) industrial change. Recently, however, considerable dialogue and interaction has emerged at the intersections of EEG and ST related e.g. to processes of national, regional or local industrial development and transformation in the context of desired or necessary sustainability transitions (see e.g. Binz et al., 2016; Boschma et al., 2017; Hansen and Coenen, 2015; Truffer and Coenen, 2012). Thus, we argue that these literatures provide a good starting point to depart from for our review of drivers and barriers to green growth.

EEG (and economic geography more broadly) has a long-standing tradition in explaining where and how specific industrial growth paths emerge in the economic landscape, with key emphasis placed on the presence of pre-existing regional capabilities (e.g. knowledge and skills) that may support the development of a new industry (e.g. Frenken and Boschma, 2007; Neffke et al., 2011; Tanner, 2014). More recently, this debate has been broadened to include not only new growth paths but also the renewal or upgrading of existing paths (see e.g. Isaksen, 2014; Trippl et al., 2019). Whereas EEG has tended to focus on knowledge and firms, the current debate has placed particular attention on political and institutional contexts (MacKinnon et al., 2019), hinting towards processes such as market formation and the role of institutional agency and policy-making (Binz et al., 2016; Dawley, 2014; Sotarauta and Pulkkinen, 2011). In the search for new growth models after the financial crisis, research on the geography of transitions has further stressed the importance of institutional drivers and barriers especially for path development around the emergence of new green industries and technologies contributing to sustainability transitions (Truffer et al., 2015; Truffer and Coenen, 2012; van den Bergh, 2013). In line with the abovementioned, a review of contributions to the geography of transitions by Hansen and Coenen (2015) identified five core themes that research had highlighted as crucial for the emergence of place specific transition paths: technological and industrial specialisation (including knowledge), natural resource endowments, market formation, institutions and policies.

Based on EEG and ST, our review focuses on six themes that we consider generic and key to understanding green growth processes: skills, technology, physical resources, markets, institutions and policies. We suggest that not only the mere presence or absence of these, but more importantly their quality and appropriateness, translate into drivers and barriers for green growth. Our review discusses those identified barriers to green growth, by drawing on the literature on sustainability transitions and rationales for policy intervention and failure types.

Based on our readings, the review highlights two aspects of green growth that any future research on the topic should not neglect: the different geographies involved in the triggering and diffusing green growth, and the intertwining of economic, social and political challenges which green transformative innovation entails. The "transformative" features of green growth processes, in terms of political alignment, social and economic interactions, consumer vs. producer power balance, should always be thoroughly scrutinised, and their analysis should constitute a constant "checkpoint" for any new study of green growth. Notably, the alignment of goals and investment actions in society must often occur through coordination among nations and among regions, across different geographic scales. Moreover, different contexts entail different possible pathways towards green growth. Depending on the current state of a region, green growth could be driven by a single sector, e.g. associated to a novel "green" product, or by a diffused process where traditional sectors become less polluting and more resource-efficient, e.g. through the development and adoption of new technologies. Local capabilities, in terms not only of technologies and natural resources, but also of institutions and skills, must then be considered before defining the appropriate policy action.

The remainder of this paper proceeds as follows. The next section outlines the review methodology. Section 3 presents insights on drivers and barriers of green growth, specifically pertaining to the role of skills, technologies, physical resources, markets, institutions and policies, for green growth processes. Section 4 discusses how insights from research on rationales for policy intervention and geographical perspectives on economic and industrial transformation can further our understanding of green growth, thus, outlining future avenues for green growth research. Finally, Section 5 concludes.

2. Method

The analysis aims to achieve a synthesis of the recent literature on green growth. In order to provide a critical assessment, we followed the approach of evidence-informed review methodologies (Tranfield et al., 2003). In particular, we clarified the criteria for inclusion and exclusion of articles in the review, including a quality assessment of the potential candidate articles. Three preliminary decisions defining the breadth and scope of the review have been taken before proceeding to the article selection. First, our review considers both theoretical models and empirical findings. Second, the review considers previous reviews and original analyses. Third, the review considers also studies where green growth is not driven by a specific intervention or policy.

The selection of articles to be considered in the review is effected through the following three steps:

Step 1: search automatically through the scientific articles published in the period 2010–2016 in journals indexed in the Social Sciences Citation Index of Web of Science (Core Collection), writing in the "topic" field the following string:

(innovation) AND (("green growth") OR (("economic growth" OR "employment growth" OR "income growth" OR "wealth growth" OR "output growth" OR "product growth" OR "economic development") AND ("green*" OR "environment*" OR "sustainability" OR "climate change" OR "low carbon" OR "zero carbon" OR "decarbon*" OR "pollution" OR "bio*"))) NOT ("developing countr*" OR "emerging countr*" OR "developing econom*" OR "emerging econom*" OR chin* OR brazil* OR Argentin* OR vietnam* OR ghan* OR mexic* OR india* OR "Sri lanka*" OR thai* OR pakist* OR turk* OR malay* OR tunisi* OR Chile* OR iran* OR Nigeria OR Africa* OR Bangladesh* OR Colombia* OR Philippin* OR "costa rica*" OR Bhutan* OR Uzbekistan* OR lesot* OR Nepal* OR Kazakhstan* OR Beijing OR burund* OR Ethiopia* OR Venezuela*)

Following our previously introduced definition of green growth, we are interested in studies that explicitly focus on both environmental issues and economic growth, not just one of the two. Furthermore, we exclude empirical studies in developing and emerging economies, since contextual differences imply that the transferability of results is highly uncertain. The relevance of the search terms was tested by scrutinising abstracts of papers identified through them. This led to the exclusion of the search term "green economy", which does not necessarily relate to growth, since some papers on the green economy analyse greening in relation to a no-growth or shrinking economy. In the environmental component of the string, the word "sustainable" was also excluded, since the combination with "growth" led to the inclusion of many papers focusing on conditions for continuing growth rather than green growth. Finally, we have assumed that innovation is an essential factor, although not a sufficient condition, for green growth; the search string above also reflects this view.

Step 2: evaluate, by reading the abstracts of the articles, whether both environmental issues and economic growth (and the relation between them) are considered, as well as innovation. In addition, we also ensure that: the articles are not of limited importance for current time, i.e. purely historical studies are excluded; the articles are not empirical studies in developing and emerging economies; the articles consider the interaction between "green" elements, innovation elements and growth elements, and do not simply analyse separately the elements above (e.g. to construct indicators).

Step 3: evaluate, by full reading of the articles, whether the method adopted is sufficiently sound and fits the proposed research questions, and if there is sufficient support for the conclusions drawn. The aim of this step is to avoid including contributions that would introduce unjustified conclusions in the survey. This follows Tranfield et al. (2003) in not simply relying on quality ratings of journals, but assessing the quality of each individual paper. Consequently, included papers have passed two quality checks: the review phase prior to publication and the review for the current paper. While disciplinary differences in ontological and epistemological starting points may influence the understanding of quality, Davies et al. (1999) still suggest that there is a need for more critical examination of the evidence base of studies within the social sciences. In order to minimize the risk of false negatives, we took several precautionary measures. Firstly, we took a conservative approach in the quality assessment, leading to a low number of excluded papers (see below). Secondly, readers were assigned papers according to their expertise. Thirdly, in cases of doubt, multiple readers were assigned to the papers and the final decision of including or excluding a paper was reached in discussion.

For Step 2, the evaluation is done by two of our study's authors. In particular, of all the articles previously selected according to Step 1, one author evaluates the ones published in years 2010, 2012, 2014 and 2016, while the other author evaluates the ones published in years 2011, 2013 and 2015.

For Step 3, eleven readers were involved in the reviewing process. The readers are social scientists from different disciplines, all conducting research on sustainability-related themes and collaborating on a large project on green growth. The readers include also, but not only, all of our study's authors. For each article that passed selection steps 1–3, the reader 1) records whether particular drivers or barriers of green growth can be identified in the article, 2) labels them as belonging to one or more of the following categories: skills, technologies, physical resources, markets, institutions, and policies, and 3) writes a short description of the mechanism by which the driver/barrier exerts its influence. The reader does not have to report all the mechanisms described in a reviewed paper: she summarizes only the ones that are emphasised in the reviewed paper and/or judged by the reader herself as neglected in the previous literature. If a reviewed article points at a mechanism which involves different categories of drivers/barriers (e.g. a policy which influences institutions which influences green growth), then only one category is selected as more relevant, but also the other categories required for the mechanism to work are mentioned in the description. Additionally, the reader must provide information about the geographic and sectoral focus of the article (all reviewing readers are bounded by the same review protocol). A random sample of papers was read by more than one author to ensure consistency in assessments and syntheses. This confirmed high degree of accordance between the reviewers with only some differences in interpretations, which were compatible rather than contradictory. The readers' reports were sent to the authors of this review, who are also responsible for the final synthesis.

The first step of the selection process, consisting in the automatic search based on keywords, led to an initial set of 383 articles. After the second step of the selection, 125 articles remained under consideration for the review.

As shown in Fig. 1, only 75 of 125 articles (60%) were classified "sufficient or better" during Step 3 of the selection process, while 12 articles (9.6%) were deemed "insufficient". The following subsections refer to those 113 articles (90.4%) that were at least judged "questionable" (and accordingly not "insufficient"), while articles judged "sufficient or better" were clearly prioritised.

As mentioned above, drivers and barriers were grouped in the six categories: skills, technologies, physical resources, markets, institutions, and policies. Fig. 2 shows the frequency of articles referring to these categories (for a detailed description of the correspondence

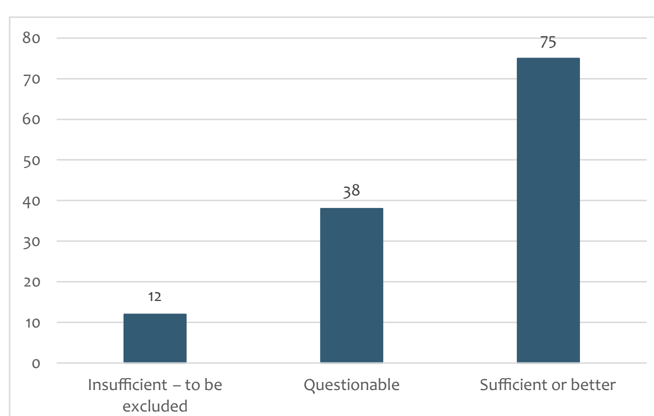

Fig. 1. Counts of articles' critical appraisal.

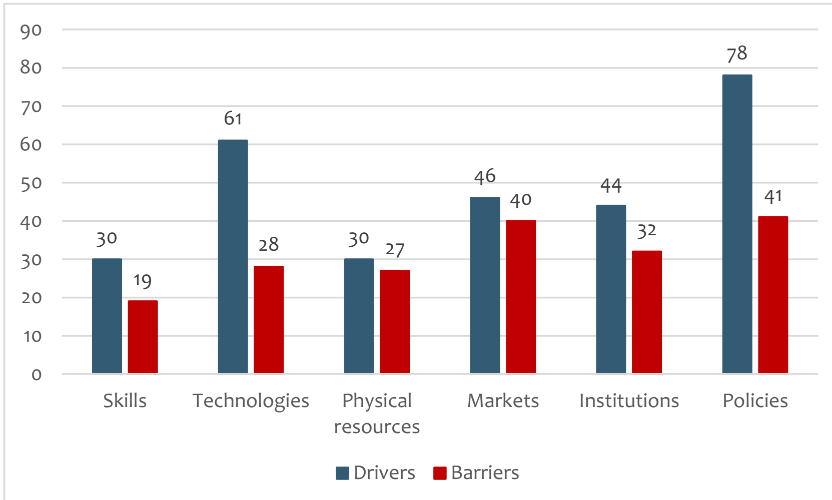

Fig. 2. Frequency of articles referring to each category of potential drivers or barriers.
(113 articles judged not insufficient; each article may include information on more than one category).

between articles and driver/barrier categories, see our Online Appendix, provided on the publisher's website as supplementary material of our study).

3. Drivers and barriers of green growth

3.1. Skills

Articles concerning skills as a driver or barrier to green growth highlight the importance of ***universities*** to provide for the knowledge and skills needed to drive green growth in a region or country. While Calzonetti et al. (2012) and Gibbs and O'Neill (2014) showcase how local US universities in Boston and Toledo have an important role in supplying local green energy cluster and clean-tech niche industries with skilled workforce, Elliot (2011) shows how science can drive IT-enabled business transformations towards more sustainable business models, further relating to the importance of educational expenditures for green growth (Navarro et al., 2014).

Advanced IT-skills may further enable existent IT ***firms*** to branch into new fields of green technologies important for green growth (Cecere et al., 2014). Different skills and types of learning are being highlighted in different fields, such as technical skills and on-the-job training (Calzonetti et al., 2012; Consoli et al., 2016), but also creativity in the educational sector itself (Sahlberg and Oldroyd, 2010) and knowledge of place specific institutions, laws, and markets (de Medeiros et al., 2014).

Whereas the presence of certain skills may be a driver for green growth, their absence may be a barrier. For instance, the lack of a relevant skill base in renewable energy in a region's industrial structure and among policy-makers may hamper deployment (Drake, 2013). In other cases, it may be less the lack of specific skills, but rather the inability to combine existing skills that constitutes a barrier. In this sense, Sepe (2013) indicates that innovation for sustainable urban water front renewal requires skill inputs from different disciplines.

While many studies contribute to an understanding of how the absence or presence of skills affect growth in green industries, Consoli et al. (2016) look at the inverse relationship, indirectly asking what kind of skills matter in the presence of green industries in the US. They find that routine analytical skills are much less important in green occupations, whereas non-routine analytical skills are highly required for existing industries to become more sustainable, as well as technical and manual skills in emerging green industries. For these, they advocate a stronger focus on on-the job training opportunities rather than classical higher education that may provide the "wrong" skills for these industries (ibid.). Thus, the set of skills required for a region to develop greener industries will highly depend on the existing industrial structure.

In the domain of ***policy***, better planning and policy-making requires skilfulness in identifying and addressing relevant system failures at the right spatial scales (Taylor et al., 2012). The lack of monitoring skills constitutes a barrier to green growth and sustainable development pathways in urban areas. ICT-skills may offer interesting opportunities for the monitoring and transition of complex systems, as for example by offering new ways to scientifically evaluate regulatory policy mixes, that is often not available to policy-makers today (Taylor et al., 2012).

However, not only education and skills for companies and policy-makers are needed when addressing green growth issues. In addition, the ***general public***, entailing potential consumers and stakeholders, needs to be equipped with certain knowledge and skills. For example, Boschetti et al. (2015) find that people's visions for Australia in 2050 reflect a need for education for political awareness and democratic participation skills that may be become necessary to "(…) limit the influence of vested interests" (p.223) impeding green growth. In a similar vein, Šlaus and Jacobs (2011) call for the education of human choice and human consciousness with regards to issues of sustainability. They show that the lack of skills for making sustainable and responsible choices is a barrier to societal green growth pathways.

3.2. Technologies

Some studies make a general point in using green or environmental ***technological innovation*** as an indicator for green growth, thus implicitly assuming technology to be a driver of green growth (e.g. Kijek and Kasztelan, 2013; Samad and Manzoor, 2015; Sueyoshi and Goto, 2014). As this assumption may be disputable and contingent on different contexts, studies provide explanatory empirical and theoretical evidence that investments in technological change and innovation in specific fields are key drivers of green growth (e.g. Böhringer et al., 2012; de Medeiros et al., 2014 among others; Musolesi and Mazzanti, 2014; Woo et al., 2014). Articles studying the role of specific technological fields in more depth deal with ICT as a pervasive general purpose technology (GPT) for the greening of industries, firms and ecological systems (Cecere et al., 2014; Elliot, 2011; Faucheux and Nicolaï, 2011; Fouquet and Pearson, 2011; Lopes, 2015). Adapting a more geographical perspective on this issue, the recombination of old and emergent technologies and skills may offer interesting new green growth opportunities for regions (Cooke, 2012; Gagliardi et al., 2016).

Policy-makers may easily fall into the trap of technological optimism regarding solving environmental problems by generating green growth (Shum, 2015). Whether technology is the key to green growth further depends on the underlying definitions of concepts, as Kleinschmit et al. (2014) argue reviewing contributions dealing with a forestry-based bioeconomy. Technology should in this sense rather be seen as one among several other coevolving "systems", like ecosystems, institutions, business strategies and user practices, fostering the creation of a greener growth trajectory (Foxon, 2011) not only by means of new products, but also processes (Jänicke, 2012). Similarly, Patchell and Hayter (2013) argue for both technological and institutional innovation to be integrated in a multi-scalar sensitive green paradigm.

A slightly contrasting set of contributions relates to the ***Environmental Kuznets Curve (EKC)*** debate, and the question at what stage of economic development economic growth can be green, understood as decoupled from negative environmental impacts. Smulders et al. (2011) show that technological innovation can indeed both drive polluting growth at low levels of income and only turns to green growth, decoupling from pollution, at high levels of income. Baiardi (2014) adds to this discussion that nations or regions with a high degree of technological innovation reach the turning point of the EKC, and thus a greener state of growth, earlier than less innovative regions. To achieve a state of green growth in the EKC, regulation supporting abatement technologies may be crucial (Lorente and Álvarez-Herranz, 2016).

While in general the articles agree on technology as a driver for green growth, as mentioned above, technological innovation is not seen as a panacea and may not necessarily lead to greening of the economy. As Fei et al. (2014) note, a low level of technological innovation may not suffice to reach green growth goals. Further, in an unregulated market, investments in R&D and innovation will always be sub-optimal as incentives often remain higher to invest in brown rather than green technologies (Smulders et al., 2014). This needs to be addressed by policy, e.g. by subsidising green technologies (ibid.). Regional or national efforts in support of green technologies however, need to be globally coordinated to reach sufficient levels of deployment (Mercure et al., 2014), again highlighting the strong interrelation of multi-scalar technology and policy domains. The course of technological progress is additionally very insecure, leaving doubts as to if a new GPT such as IT will actually be able to drive green growth or if rebound effects such as increased consumption will outplay the technologies' emission saving capabilities (Lorek and Spangenberg, 2014; Smulders et al., 2011). Moreover, contrary to other contributions, Fagnart and Germain (2011) argue, technology will hardly ever deliver a state in which man-made production is completely dematerialised and thus independent of physical resources.

3.3. Physical resources

Following Foxon (2011), physical resources are part of ***ecological systems***, in the sense of "(…) systems of natural flows and interactions that maintain and enhance living systems" (p. 2262). Certain set-ups of availability and scarcity, transformation and deployment of resources within ecological systems will either hamper or drive a greener mode of growth. Resource based green growth is then about a trade-off between long-term investments in sustaining natural resources (and long-term income growth) with short-term income growth (Smulders et al., 2014).

A main finding of the articles advocating the role of resources as a driver of greening is that decreasing ***resource availability***, e.g. reflected in rising fossil fuel prices, is likely to foster investments in green energy production and drive a transition towards innovative green sectors (Bretschger and Smulders, 2012; De Cian et al., 2016). However, also the availability and efficient use of unexplored renewable resources may offer new opportunities for green growth. Lopes (2015) provides an example, showing how a certain type of algae is able to capture CO_2 emissions from industrial wastewater. Arbuthnott et al. (2011) showcase how traditional industries consuming regional forestry and chemical resources in a Northern Swedish region were transformed to provide new inputs for a more sustainable bioeconomy. Their case in peripheral Northern Sweden in turn also illustrates that new "green" competitors targeting scarce resources, like timber in forestry, may face resistance to cooperation from old industries using these resources (ibid.). In urban contexts, examples like the new waste management system in the city of Manchester show how residual resources can be transformed into energy sources if infrastructures are adjusted accordingly (Uyarra and Gee, 2013). It is also this kind of substitution and recycling towards a more efficient way of energy and resource use that significantly drives greener growth in Italian regions, according to Baiardi (2014). The path a country or region may choose in this further often crucially depends on the regional resource endowments (Duan et al., 2014). In addition to resource availability, also the method of renewable resource extraction determines whether generated growth is actually green. The harvesting of a renewable resource like timber in forestry may be done sustainably as for example in short-rotation forests, but also in ways where biodiversity protection is repressed in favour of productivity, as in the case of massive mono-cultures of fast growing species (Kleinschmit et al., 2014). The current overexploitation of increasingly scarce resources brings the world closer to what Hepburn et al. (2014) call 'planetary boundaries', understood as dangerous thresholds that should not be surpassed to avoid environmental collapse. While the availability of renewable energy resources may be a driver for green growth, large initial costs may be needed in the case of renewables, limiting the allocation of outputs to other parts of the economy (Dale et al., 2012). Additionally, rising biofuel demand may have negative impacts on nutrition, reduced food supplies and increased food prices (Fan and Brzeska, 2016). At the same time, some renewables like biomass need to be consumed regionally as long-distance transport is not economically feasible (Lopes, 2015). Thus, the literature on physical resources clusters around availability and path dependencies from existing resource-consuming sectors at regional or national scale.

3.4. Markets

Articles dealing with markets as drivers or barriers of green growth can be divided in three topics: the quality of market elements, the interplay of markets and policy, and the quantity of market elements for greening. This review subsection will start commenting on the last block.

Several articles indicate that certain levels of income, growth, development and competition – labelled here as ***quantity of market elements*** – under certain conditions may be a driver of green growth. In general, higher-income countries seem to provide more favourable environments for the diffusion of green technologies than low-income countries, since, e.g., consumers are more willing to purchase more expensive green products (de Medeiros et al., 2014). In contrast, Elliott and Clement (2015), while confirming the general tendency of advanced market economies to reduce their carbon emissions with rising income, show that a relocation of carbon-intensive industrial activities to low-income municipalities may have taken place within the US or offshored from the US to low-income countries. This calls for the importance of geographical interdependencies at different scales in explaining localized market drivers and barriers to green growth. The phenomenon is confirmed by a study of Marin and Mazzanti (2010) on the Italian economy and its global interrelations. They show that trade, while being a driver locally, may be a barrier to green growth on a global scale.

A second block of articles focuses on the ***interplay of policies and market characteristics*** in driving or impeding green growth. The eco-industrial parks studied by Lopes (2015) involve the application of carbon taxes and energy R&D incentives, which can achieve their policy goals only conditional to the local private companies and market forces. The idea is related to that of test or proto markets, as protected spaces for the development of green technology prototypes (Gibbs and O'Neill, 2014). In contrast, from a more global perspective, Grubb et al. (2015) show how consumer behaviour is responding to government-backed market dynamics, corresponding to a call of several authors for market-pull instruments to trigger greener growth and employment (e.g. Kleinschmit et al., 2014; Kunapatarawong and Martínez-Ros, 2016). In harsh opposition to these contributions, Juknys et al. (2014) see the only way to reach an actual state of green growth as policy accepting a decelerated growth path while keeping up efforts to support green technologies.

The quality of market elements driving or impeding green growth comprises the last group of articles in this section. They may to some extent also refer to institutional drivers such as in the case of Woo et al. (2014), who highlight the role of formal and informal business affiliations in driving environmental innovation among Korean manufacturing SMEs. Another interesting finding of this study is that the listing status of SMEs on the stock market may be positively related to environmental innovation, which is explained by the rising interest of stakeholders in corporate social responsibility (ibid.). The case of the pulp and paper industry in a peripheral region of Sweden described by Arbuthnott et al. (2011) outlines the potential a declining market served by a traditional brown industry may have for the emergence of related green industries creating a new market. Their findings also to some extent relates to positive externalities arising from agglomerated industries, that also show to be important for innovation and employment growth in environmental sectors (Horbach and Janser, 2016). Other, more partial contributions name business transformations, joint ventures, and more generally venture capital and investment as possible drivers of green growth (Baiardi, 2014; Elliot, 2011; Lombardi and Laybourn, 2012; Samad and Manzoor, 2015; Sueyoshi and Goto, 2014).

However, market drivers may under certain conditions have negative effects on greening due to rebound effects. While generally of weak importance in high-income countries, rebound effects may even here in the long run erode initial efficiency gains of new technologies (Fouquet and Pearson, 2011). As with economic growth in general, a barrier to green growth may be negative externalities associated with investments in a public good like knowledge, uncertainty of investments, or simply market failure (Fagnart and Germain, 2011; Kijek and Kasztelan, 2013; Leete et al., 2013). With respect to the latter, Hepburn et al. (2014) suggest that the pricing of natural assets is critically distorted in an unregulated global economy, where global subsidies for resource use are vastly available while indirect subsidies through the failure to properly price natural capital are an even bigger barrier to green growth. Juknys et al. (2014) agree that accelerated economic growth with unregulated markets is an environmentally unsustainable mode, while at the same time they highlight that also a radical “de-growth is unstable” (p.60) in a political, social and technological sense.

3.5. Institutions

The literature generally refers to institutions as the rules of the game (North, 1990). The sections here will follow the differentiation between informal and formal institutions and their role as contextual drivers and barriers to variations of green growth.

Several articles stress the importance of changes in ***informal institutions***, often understood as consumption habits and behavioural change (Elliot, 2011), to drive long-term green growth. For example, Juknys et al. (2014, p. 61) call for “voluntary self-restriction” in food consumption, or Lorek and Spangenberg (2014, p. 36) more specifically advocate the role of “behavioural routines, of role models and the symbols they use to signal their superiority, of convenience and status, of individual and collective identities shaping consumption clusters, or of the trajectories of business and state in setting the framework conditions for individual consumption decisions”. Going beyond individual consumption habits, Mitchell (2012) highlights the importance of more general personal factors such as convenience, cultural preferences and willingness to take risk among all kinds of actors in driving transition dynamics. These informal institutions may play an important role in driving or hampering organisational change in firms (Faucheux and Nicolaï, 2011; Kijek and Kasztelan, 2013; Lombardi and Laybourn, 2012) or in different regimes like transportation (Drut, 2015), often being the outcome of socially constructed deliberation processes among different types of actors (Shum, 2015). In this sense, institutional innovation may be a key to triggering paradigmatic change towards greener growth (Patchell and Hayter, 2013).

Likewise, informal institutions may hinder greener modes of growth. Vested interest in industries and governments may create inertia regarding the development of capacity, willingness, opportunity, and motivation needed to change paths (Ashford and Hall, 2011; Drake, 2013). In Uyarra and Gee's (2013) case study, a dominant institutional, cultural and professional culture in waste management was initially supporting unsustainable mass disposal operations and needed to change over time. Articles like Péti (2012) or de Medeiros et al. (2014) further provide evidence that cultural heterogeneity, language barriers and communication problems, as types of informal institutions, may constitute barriers by seizing market opportunities related to green innovations in confined geographical areas. On a societal level, informal institutions can have a role in shaping conditions to greening. In a modelling article on the development of economic growth, population growth and pollution, Constant et al. (2014) plan an overarching institution governing the fertility behaviour of adults, who generally accept an improvement of their economic situation to come along with a lower quality of the natural environment for their children at a later point in time. While this assumption is not tested in its validity, it signals a potential major institutional barrier to green growth.

Formal institutions may in most cases be understood as policy drivers or barriers, and therefore some of the insights from this subsection are closely related to the policy instruments described in the following subsection on policy. On the national level, Han (2015) provides an account of how South Korea has successfully established various formal institutions, such as green growth committees and laws, geared towards a greener economy. In line with these findings, also for nation states, like the US, a coherent regulatory framework with strong decision making capabilities, e.g. bundled in ministries, appears to be favourable for green growth (Ashford and Hall, 2011). On a local scale, Gibbs and O'Neill (2014) elaborate on a plethora of formal institutions that have been driving the transformation of cities, such as city climate action programmes, green construction standards, incubator spaces, initiatives for auctioning carbon in the energy sector, regional legislative acts against GHG, lobbying at the federal level, or engagement of the city in a regional energy council. Drake's (2013) case of a British region illustrates that what was true for the national level may also hold for regions. Their actions towards a greener growth path need to be backed by strong formal institutions resulting in strong regional authorities that possess the capabilities to take the initiative.

On a more conceptual level, Vazquez-Brust et al. (2014) inform about the necessity of both narratives and indicators, understood as a kind of informal and formal institutions in science and policy, to change towards new growth measures with indicators favouring environmentally sound sectors and a democratic, critical green growth paradigm for policy. This claim is taken up by Drut (2015), who argues that the measures of classic economic theory may be a barrier for the transformation to a sustainable transportation regime. While the policy-formal institutions interaction is important with respect to the public spheres of governance at different spatial scales, formal institutions do also matter for greening in private organisations driving green growth. As Sen (2015) discusses, firms where ownership and management are separated, might be more prone to develop and adopt environmentally sound practices as a response to environmental regulation, because they may to a higher degree work as disciplinary devices for managers than for owners.

3.6. Policies

The role of policy in driving or impeding green growth is signalled by a number of articles, which is higher than for any other driver/barrier category: 95% of all articles deal with the role of policy or draw specific recommendations for policy adjustments at different levels of governance.

Despite such overwhelming emphasis on policy, and an agreement on the fact that proactive policy in general is a crucial driver of green growth (e.g. Karkatsoulis et al., 2016) the distinct ***effects of certain policies*** may not always be easy to disentangle. For example, while showing empirical evidence for a general importance of policy in reducing CO_2 emissions, Musolesi and Mazzanti (2014) find no significant support for their hypothesis that the Kyoto protocol, one of the most prominent examples of global environmental policy in the last decades, has caused a structural break in the global carbon dioxide emissions-economic development relation.

Accordingly, the choice of the right ***policy instruments*** for driving green growth by overcoming system and market failures is highly disputed. For example, Kijek and Kasztelan (2013) and Lorente and Álvarez-Herranz (2016) call for environmental regulation instruments, fees, and taxes on pollution emissions to incentivize green innovations and reduce GHG emissions. In the same vein, Jones et al. (2016) come to the conclusion that regulations for energy efficiency would lead to a greater adoption of resource efficient techniques in the UK construction sector. In their study of EU countries, Cecere and Corrocher (2016) show that performance-based regulations have had a positive impact on waste management technologies, in line with other authors calling for a regulatory-push towards green growth (Kunapatarawong and Martínez-Ros, 2016). However, regulation at different scales may be interdependent. Regarding the interplay between institutions and policy at different spatial scales, Uyarra and Gee (2013) show in their Manchester case study how national and regional policies for urban waste management were interdependent with the supra-national regulatory environment of the EU.

Typically, however studies suffice to differentiate between demand-pull and technology-push instrument effects on the national level. *Demand-pull* oriented policies go beyond technology and innovation policies. They may address institutions such as consumer habits to encourage efficiency, greening of supply chains, co-design and consumer innovation, producer-responsibility, a sharing-economy, ethical marketing (restrictions for advertisements), fair trade, and consumer awareness (Lorek and Spangenberg, 2014). The creation of experimental spaces for community based initiatives may help detect new societal demands and markets, as Seyfang and Longhurst (2013) illustrate in the case of alternative monetary systems. While ‘demand side policy tools’ (Cohen and Amorós, 2014) are discussed by various authors, other contributions advocate a more important role for *technology-push* instruments in certain industries. The study by Böhringer et al. (2012) on the German manufacturing industries for instance, illustrates how costs arising from environmental regulation can have negative effects on productivity and thereby hinder green growth. Technology-push instruments are further advocated by scholars discussing the EKC. Balsalobre et al. (2015) argue that maintained or increased R&D expenditure incentivised by technology-push policies needs to alleviate the scale effect of the EKC.

Since many articles call for policies targeting systems or fields, which we already have considered in the previous subsections, we will here focus on the empirical evidence related to specific policy characteristics driving green growth. An important characteristic appears to be policies' ***comprehensiveness and credibility***. The quality and duration of implemented policies have a major importance, as Dalton and Ó Gallachóir (2010) show with their case studies of the wind energy industry in Denmark and the wave and tidal energy industry in Ireland. Similarly, Leete et al. (2013) set out how stable and predictable long-term policies reduce investor risks in the case of marine renewables in the UK. If policies are being withdrawn too easily due to budget constraints, as is evident from the case of Spain following the last financial crisis, credibility suffers significantly constituting a barrier to future green growth (Duan et al., 2014). In comparison, ***consistency and coherence*** across scalar boundaries are further important characteristics implicitly highlighted by several authors. In his British case study, Drake (2013) calls for vertically consistent policy mixes spanning from the national to the local scale, where individual regions' interest in economic growth may have to stand back in favour of the overall national greening targets. The importance of vertical coordination of policies for green growth and transitions becomes particularly apparent in devolved or federal nation states like the UK, as Li et al. (2016) illustrate.

Most articles, like Fouquet and Pearson (2011) on efficient lighting technologies, do not advocate a single one-size-fits-all policy to foster green growth, but rather a “flexible and heterogeneous ***policy mix***”, often directed by a strong state, although regional or international arenas also represent relevant levels of governance (Vazquez-Brust et al., 2014, p. 47). Most importantly, a well-designed policy mix may make use of synergies among individual instruments, thus becoming more effective than the sum of its individual parts would be (Mercure et al., 2014). To effectively implement these mixes, policy integration across different domains may be crucial when targeting green growth (Ashford and Hall, 2011). Policy may also be an important contextual factor to support green growth on the regional level (Cooke, 2012). For policy makers at the regional level, it may be important to network and exchange knowledge with other regions that try to achieve similar green growth goals, as Gibbs and O'Neill's (2014) case study of Boston indicates. Contrastingly, Hepburn et al. (2014) argue that not only policy mixes of the demand-pull and technology-push type may be important to drive green growth, but also the cutting or even withdrawal of existing subsidies for unsustainable material and resource use, as well as of other policies fostering activities detrimental to green growth.

The withdrawal of existing measures links to the notion that misdirected policy mixes can constitute major barriers to green growth. Some policies that are primarily directed to short term economic growth targets would be an example (e.g. Drake, 2013), as well as policies that delay current environmental problems, such as R&D support for carbon capture and storage technologies (Juknys et al., 2014). Several studies indicate how geography adds a layer to the complexity of misdirected policy mixes. While policies successfully applied to drive green growth in more developed places have been shown to have negative effects on green growth in less developed areas (Elliott and Clement, 2015), the regional income inequality encountered in developed countries itself may play against the effectiveness of green growth policies (e.g. Vona and Patriarca, 2011). Some authors therefore argue in favour of global policy instruments (like a global pollution tax rate e.g.) to avoid narrow-minded approaches by individual states or regions (Daubanes and Grimaud, 2010).

4. Discussion

In the current section, we draw on the two bodies of literatures that structured the review (see Introduction section), economic geography and sustainability transitions, to reflect on the reviewed green growth contributions and point towards future research directions on green growth. We draw on, firstly, work from economic geography on how green growth needs to be understood as a localized process (or processes) occurring in multi-scalar and networked contexts and, secondly, literatures related to sustainability transitions on rationales for policy intervention and policies for transformative change. In this, we highlight how a multi-scalar perspective is necessary in order to fully comprehend green growth drivers and barriers (4.1). We also highlight the multiple co-existing perspectives on the core green growth challenges, which are implicitly or explicitly found in writings on green

Table 1
Overview of reviewed articles in terms of main geographical and scalar dimensions[a].

	Scalar focus		Scalar relations	
	Count	Perc.	Count	Perc.
Local	10	8%	6	5%
Regional	11	9%	13	10%
National	52	42%	35	28%
Continental	8	6%	6	5%
Global	19	15%	28	22%
N/A	25	20%	37	30%
Total	125	100%	125	100%

[a] Counts are approximate due to e.g. inconsistent usage of terms in/within different strands of research.

growth (4.2). Finally, we summarise the discussion by outlining a framework for future analyses of green growth processes (4.3).

4.1. The geography of green growth

The reviewed green growth literature covers contributions on multiple spatial scales – from studies at the local level taking e.g. municipalities at the main analytical scale to papers on green growth at the global level. However, as evident from Table 1, the national scale is the predominant analytical level for studying green growth. This reflects findings from related literatures such as sustainability transitions, which has also until recently taken the national scale as the natural starting point for studying transition processes (Coenen et al., 2012; cf. Hansen and Coenen, 2015). In a sense, it is not surprising that the national level is an important analytical scale for studying green growth. First, national governments and state policy levels are key in terms of e.g. setting emission reduction targets vis-à-vis supranational agreements such as the Kyoto-protocol and the Paris-agreement. Second, emission reduction targets are, in turn, linked to national level policy goals and instruments that e.g. aim to foster national development and/or deployment of renewable energy or other clean technologies. Third, although political power has been transferred from the state to both supranational and regional levels over the last decades, the state remains a key domain for the formulation and enactment of policies related to achieving economic growth, including trade and finance, industry, natural resources, education and innovation policies (Matti et al., 2017).

Nonetheless, due both to the substantial sub-national variety in terms of where green growth occurs as well as the ‘trickling down’ of green policy targets to the regional and local scale, it is somewhat surprising that only a fraction of the green growth literature focuses on the local or regional scale. Consequently, we see it as an outstanding challenge to understand the opportunities for green growth development at the regional scale. As noted by Essletzbichler (2012, 793) “while national policies are clearly important, there are a number of cases where regional policy intervention resulted in strong regional clusters of renewable development and deployment that may, in some cases, accelerate development and deployment at the national scale.” This reflects how knowledge creation, experimentation, innovation processes and industrial development are strongly linked to particular cities and regions, and also the central role of sub-national policy levels in concretising (and often even surpassing) policy ambitions at the national level (Bulkeley and Broto, 2013; cf. Madsen and Hansen, 2018; McCormick et al., 2013). A regional perspective may also be needed to disentangle different sources of green growth: to detect, for instance, local clusters of firms specialised in “green” products and services, or to highlight locally bounded events of “green” technology diffusion across firms and sectors.

A first implication of researching regional green growth is a need for a broader analytical perspective than traditionally applied in work on regional development (Coenen et al., 2015a): an emphasis on both greening and growing implies the need for considering questions relating to technology diffusion on equal terms to technology development. Specifically, future research should explicate the relations between green technological development and diffusion at the regional scale. In some cases, regions excel in technology development despite low or absent diffusion rates (e.g. solar PV in Berlin, see Monstadt, 2007); in other cases, greening relies fully or predominantly on imported technologies, which contribute little to regional growth. A case in point is the offshore wind industry in the UK, which has largely developed through transplantation and the import of products and services from elsewhere, despite the UK market having constituted the world's largest offshore wind market in recent years (MacKinnon et al., 2018).

Thus, the conditions for linking development and diffusion are key to regional green growth and of central importance for future research. This also necessitates a broader perspective on regional development policies, beyond simply supporting technological development capacities of regional actors, to include complementing demand-side policies. However, as argued by Coenen et al. (2015b, p. 861) “critical bottlenecks remain beyond the reach of regional innovation policy” when it comes to market-shaping policies. Regional green growth furthermore demands policy coordination apt to address structural and transformational failures, which we will discuss in more detail in Section 4.2. As argued by Taylor et al. (2012) “[f]rom a policy perspective, better planning and policy-making requires to be skilled in identifying and addressing the relevant system failures at the right spatial scales.” This requires high levels of institutional or policy capacity that many regions may simply not have. The role of regional actors may in some areas (e.g. renewable energy) be limited to lobbying at the national or supranational scale. Thus, future research ought to examine the impact on regional green growth of combining technology development policies with policies targeting consumption behaviour, public procurement and other types of demand-side policies, including lobbying towards national and supra-national regulators of markets.

A second implication of researching regional green growth is the necessity of giving greater attention to the varying opportunities for achieving green growth in different types of regions. Pre-existing industrial specialisation is a key factor influencing the possibilities for greening of existing industries and development of new green industries (Grillitsch and Hansen, 2018). Especially recent work in economic geography has investigated how adaptation or renewal of old industries or the emergence new industrial development paths occur as a result of dynamic interplay between regional assets, agency, particular growth mechanisms and multi-scalar policy initiatives and institutional environments (see e.g. MacKinnon et al., 2018). The particular opportunities for developing new green industries may also be constrained or enabled by the institutional context shaped by pre-existing economic activities and industry structures in regions (Boschma et al., 2017; Martin and Sunley, 2010).

Finally, it is important to underline that an attention to green growth at the regional scale should not lead to a preoccupation with regional effects: there is a need for a thorough understanding of green growth interdependencies across different scales or what we refer to as scalar relations in Table 1. Such interdependencies can be positive, for instance Han (2015) analyses national initiatives for green growth and how those initiatives are also linked to establishing international green growth institutions. However, green growth may also induce negative interdependencies, hidden by the relocation of polluting activities to spatially distant areas (Elliott and Clement, 2015). Whether green growth at the local scale leads or not to higher emissions at the global scale strongly depends on the structure of international value chains, and in particular on how trade affects R&D flows and technology diffusion (Marin and Mazzanti, 2010). Finally, green growth may be constrained by the relation to scarce natural resources that are mined, extracted or otherwise exploited in ways that are not only environmentally, but even socially harmful. Whereas a few of the articles covered in our review discuss how eco-innovation may reduce the use of natural resources (Levidow et al., 2016) or be substituted (Bretschger and Smulders, 2012), the review generally shows that the availability of necessary natural resources can turn out to become a barrier to green growth and requires continuous monitoring and planning.

4.2. What is the green growth challenge?

The preceding synthesis on drivers and barriers for green growth highlights a rather heterogeneous literature, covering insights from various disciplines, including mainstream economics, innovation system studies and socio-technical systems studies. Unsurprisingly, considerable differences can be identified between these various strands of research concerning what are the key challenges in achieving green growth: fundamentally, rationales (Laranja et al., 2008) for (policy) action differ considerably across the contributions. In this section, we discuss identified barriers to green growth, by drawing on the literature on rationales for intervention and failure types (Grillitsch et al., 2019; Laranja et al., 2008; Weber and Rohracher, 2012). Given the significant attention to policies for green growth (see Fig. 2), we follow one of the reviewed papers, Weber and Rohracher (2012), in distinguishing between market failures, structural system failures and transformational system failures. According to Weber and Rohracher (2012), a sustainability transitions perspective requires attention to challenges that hinder system-wide transformation. Thus, policies may be motivated by addressing different types of barriers: *market failures* arise when allocation of different types of resources are sub-optimal from a societal perspective; *structural system failures* point to factors that hinder the functioning of innovation systems; and *transformational system failures* specify barriers to address and steer larger systemic changes (see Table 2).

Market failures are frequently discussed in the literature on green growth. In particular, under-investment from a societal point of view in R&D for technologies and the resulting need for subsidies for their development is emphasised. Such underinvestment is arguably particularly evident for green technologies, due to the double-externality problem: green technologies do not only produce positive externalities in the development phase through knowledge spillovers, but also in the application phase, since green innovations produce benefits for non-payers (Rennings, 2000). Other important market failures considered are the over-exploitation of the commons. Consequently, a number of articles stress the need for policy instruments to penalise pollution emissions and the over-exploitation of scarce natural resources and to internalise negative externalities in order to promote green growth.

Structural system failures are addressed in many of the reviewed articles, which highlight challenges such as the access to the right skills (capability failures), the aversion to cooperation (weak networking), and the need for the development of physical infrastructure (infrastructure failure). Institutional failures are often discussed: the need for trust and different consumption habits and behavioural routines to avoid rebound effects and to drive green growth in the long term (soft institutional failures), but also vested interests and a change-adverse culture in industry and government are stressed as important soft institutional failures. Moreover, as summarised in Section 3.5, challenges relating to formal institutions, in the form of inadequate policies and regulations are an omnipresent topic within the green growth literature. Particular attention should be devoted on re-thinking education and training in terms of localized life-long learning systems, since green growth, as described in Section 3.1, requires evolving non-routine skills as well as knowledge of time- and place-specific institutions.

Transformational system failures are explicitly or implicitly considered in multiple contributions. Questions relating to directionality are evident in discussions around direct and indirect (lack of) subsidies for (green) polluting industries and technologies. Consequently, the necessity of withdrawing subsidies for unsustainable resource use is emphasised (see also Kivimaa and Kern, 2016). Environmental regulation instruments such as fees and taxes on pollution are understood by several authors as drivers of green growth and can be conceptualised as policy instruments, which give a clear direction for economic activities towards more sustainability. Thus, directionality is not limited to providing directions for future technologies, but also to halt the development of old.

The reviewed papers also discuss issues related to demand articulation, including the introduction of test markets to create protected niches for the deployment of green technology, the creation of room for experimenting with community-based initiatives to detect new societal demands, and the importance of considering consumer habits in green growth policymaking. Studied aspects relating to policy coordination include the need to align policies on development and implementation of green technologies with other types of policy fields, including energy consumption of households, food waste, and emissions from transportation. Finally, concerning reflexivity, several papers discuss the need for better skills in policymaking to allow improved monitoring and evaluation of policy implementation processes.

Thus, evidently, the contributions on green growth consider a variety of current challenges, which relate to different rationales for policy intervention. However, one important point of critique towards the reviewed work is that it integrates these perspectives to a very limited extent: individual papers tend to focus exclusively on one type of rationale and the associated challenges, rather than combining the different perspectives.[1] From a theoretical point of view, this is arguably rather unfortunate, since the attention to transformational system failures should not replace previous rationales for intervention. In fact, Weber and Rohracher (2012, p. 1042) explicitly argues for "complementing" conventional market and system failure arguments, not replacing them. Hence, it could also be argued for that some of these rationales are overlapping, such as market failures and transformational failures. Additionally, a central tenet of the recent literature on policy mixes (Binz et al., 2017; Flanagan et al., 2011; Rogge and Reichardt, 2016) is the need for an integrated analysis of policy strategies and instruments in relation to the field of enquiry. This calls for a deeper engagement with the interaction between policy instruments, considering aspects such as consistency and coherence. Some empirical contributions outside of the green growth literature highlight the value of this analytical perspective, including Guerzoni and Raiteri (2015) who find a significant positive interaction effect of tax credits, tax subsidies, and public procurement for innovation, thus, pointing to the complementarity of market-based and transformational policies. Similarly, Jacobsson et al. (2017) demonstrate how combining perspectives on market failures and structural system failures lead to identification of complementary challenges in developing off-shore wind power, and consequently a broader scope for policy intervention. Fully integrating such perspectives in writings on green growth will likely lead to an improved understanding of the possibilities for supporting greening and growing simultaneously.

In turn, such an analytical perspective may also advance the policy mix literature, which according to Kern et al. (2017) has paid insufficient attention to the complexity of "real world policy mixes" (p. 12). Specifically, the implications of the co-existence of the two very high-level abstraction goals of greening and growing may pose new questions to the policy mix literature, which has so far analysed multiple goals at a lower level of abstraction, e.g. climate change mitigation and adaptation (which are arguably both part of "greening"). Effectively, studying green growth policy mixes may allow policy mix scholars to catch up with the reality of many policymakers, where economic growth and greening of the economy are co-occurring

[1] Uyarra and Gee (2013) and Gibbs and O'Neill (2014) implicitly combine different rationales.

Table 2
Overview over theoretical discussions of market failures, structural system failures and transformational system failures.

Core focus	Market failures	Structural system failures	Transformational system failures
Main theoretical foundation	Mainstream economics	Innovation system theories	Transformation of social systems
Types of failures	- Information asymmetries - Knowledge spill-overs - Externalisation of costs - Overexploitation of the commons - Underinvestment in research	- Infrastructural failures - Institutional failures (formal institutions, e.g. regulations & legislation; soft institutions, e.g. norms, values & cultures) - Network failures (too dense or too little interaction) - Limited appropriability of technology - Capability failures	- Directionality failure (steering of innovation to meet societal challenges) - Demand articulation failure (user needs not understood) - Policy coordination failure (lacking coherence between policies at different scales and across sectors) - Reflexivity failure (missing policy learning)
Comments	Under-investment in research has been one of the main market failure arguments and has been used as a rationale for policy intervention, providing generic subsidies for R&D and R&D tax incentives, but also to protect intellectual property rights.	Capability failures point to lack of appropriate competencies, capacity and/or resources at the firm level to access and exploit knowledge. Firms need capabilities such as flexibility, learning potential, and resources to adapt to new generic technologies and changed market demands.	Reflexivity failure highlights missing policy learning feedback loops and lacking ability to monitor, anticipate and adjust transformational change. This requires the development of informal and more formalized discourses to prepare policies, and to keep open a portfolio of solutions to tackle uncertainties.

priorities.

4.3. Towards a framework for analysing green growth

This discussion of the review results has focused on the geography of green growth and on different rationales for policy intervention and policies for transformative change. We have shown that future research should give greater attention to the spatiality of green growth processes. We suggest that future contributions may acknowledge and embrace the complexity of green growth. This requires analysing not only one of the policy rationales, but combinations of them, and not merely focus just on one spatial scale (e.g. national-level green growth), without taking the interactions across spatial scales into consideration. The review also shows that we know little about how policymakers at different spatial scales act on the base of different policy rationales since most research on green growth addresses the national level and not local or regional scales. Therefore, we suggest that future research of green growth should combine different spatial scales and different policy rationales (see Fig. 3) and considering their interactions. Another point of interest for future research is how the different conditions of green growth influence the policy rationales and vice versa.

5. Concluding remarks

This survey of papers focusing on the interaction between environmental issues, economic growth, and innovation has synthesised insights from a large variety of literatures within the social sciences. Drivers and barriers to green growth are analysed from multiple perspectives, leading to a rich and wide-ranging understanding of the topic.

The synthesis highlights that green growth processes are indeed characterised by certain specificities, relative to a traditional understanding of growth, or environmental greening detached from growth considerations. This includes particularly large requirements for competences that allow for handling complex, non-routine situations – in both the private and the public sector (Consoli et al., 2016; Taylor et al.,

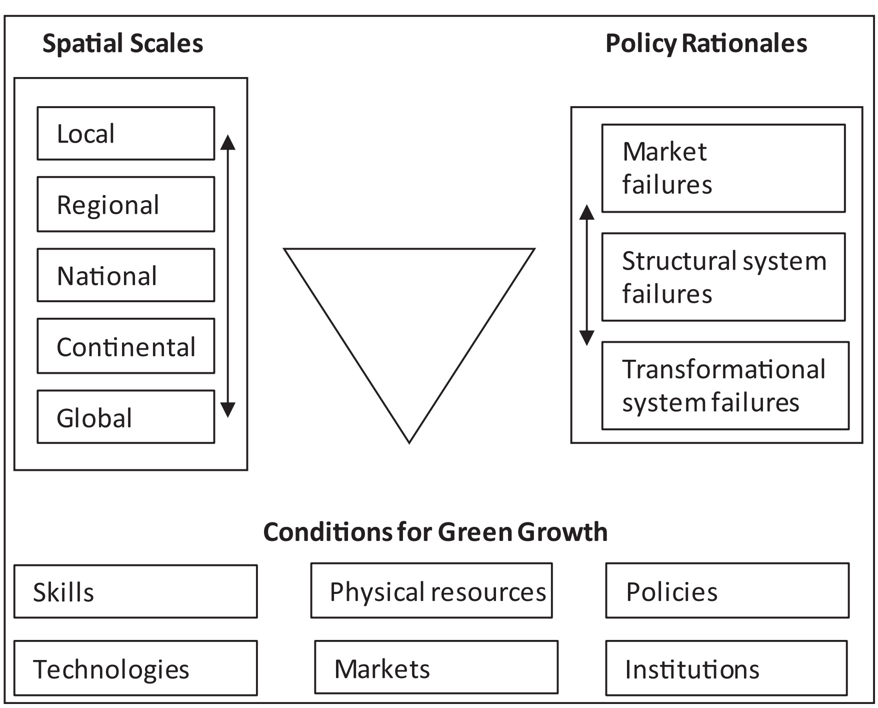

Fig. 3. Theoretical framework for future studies of green growth: A combination of spatial scales, policy rationales and conditions of green growth.

2012). This might be explained by the fact that addressing problems of environmental sustainability (e.g. climate change) constitute so-called wicked problems (Rittel and Webber, 1973), characterised by high complexity and multifaceted feedback loops (Coenen et al., 2015a). Tackling these issues in a manner that allows for economic growth adds further complexity.

A second specificity of green growth processes concerns the role of technological progress. While new technologies are certainly a necessity for achieving green growth, this does not imply that technological progress per se leads to green growth. This highlights the need for directing technological progress towards greener technologies to avoid investments funds being channelled to brown technologies, which often have higher short-term returns (Smulders et al., 2014).

Thirdly, the survey also underlines the need for establishing new formal institutions. Arguably, green growth requires the establishment of different metrics than those systems generally used to measure economic or environmental developments independently (Vazquez-Brust et al., 2014). In a similar vein, green growth also entails a need for reconsidering the governance system around economic development, which continues to be influenced by the Bretton Woods institutions. This requires the establishment of organisations working at multiple scales, which have green rather than traditional growth as their core objective (see Han, 2015).

Finally, in further improving the understanding of preconditions and challenges for green growth, we have called for future research to draw on literatures on rationales for policy intervention and geographical perspectives on economic and industrial transformation. In this, we argue, firstly, for the need to jointly assess the importance of market failures, structural system failures and transformational system failures, in advancing our knowledge of the opportunities for achieving green growth. Secondly, we call for green growth research to give greater attention to the geography of green growth processes at and across different scales. In particular, this involves deeper engagement with analysing differences in opportunities for green growth at the subnational level, but also how regional green growth processes may support or hinder green growth processes at other locations. Given the complexity of green growth processes, it appears evident that place-sensitivity in analysing and supporting green growth is imperative to avoiding partial or even flawed conclusions.

Different routes could have been taken to write this review. A first difference could have lied in adopting a theory-based frame throughout the whole review, starting with the article selection stage. This could have been done by using additional keywords in our “search string”, pointing at specific theoretical concepts. In particular, we could have reviewed only articles which we would expect to embody some preferred theoretical concepts. A similar research path would have consisted in restricting the search on specific journals, which we consider closer to our own theoretical background. In this case, the automatic search would have mimicked a usual sourcing pattern of researchers, who often read the table of contents of specific journals at every issue date, and then select articles to read in their entirety, on the basis of their title and expected topic.

Both these possibilities were considered, but were discarded in favour of a more pluralistic approach which, in our eyes, allowed us to face literature from unfamiliar sources without compromising the consistency of our interpreting schemes. On the other hand, we could have chosen an even more extended search to reach “grey” literature, including technique and policy documents, and mass media, including newspapers. The scope of the review would have then been strongly different, but it would have allowed catching ideas for green growth which do not originate from, and may possibly not reach, the academic community.

In connection to the methodological considerations above, two main limitations may be described for our study. A first one consists in the inherent difficulty of framing insights from a strongly heterogenous range of sources. There may be contradictions and controversies, not only between different schools of thought but even within specific strands of literature, which cannot be ironed out. As a consequence, our review efforts have been constrained towards summarising, more than harmonising, the reviewed literature. Secondly, having chosen a long radius for our article search, in terms of disciplines and journals, forced us to focus on a relatively short time span (years 2010–2016). A share of the previous relevant knowledge on green growth may have been transmitted, for instance through citations, into articles published during this time span; however, we are fully aware that the scientific knowledge of green growth may not evolve by a cumulative process, also due to the complexity of the topic.

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Appendix A. Supplementary data

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