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Towards an evolutionary perspective on regional resilience

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This paper proposes an evolutionary perspective on regional resilience. We conceptualize resilience not just as the ability of a region to accommodate shocks, but we extend it to the long-term ability of regions to develop new growth paths. We propose a comprehensive view on regional resilience, in which history is key to understand how regions develop new growth paths, and in which industrial, network and institutional dimensions of resilience come together. Resilient regions are capable of overcoming a trade-off between adaptation and adaptability, as embodied in their industrial (related and unrelated variety), network (loosely coupled) and institutional (loosely coherent) structures.

1. Introduction

The concept of regional resilience has drawn a lot of attention in the context of the current economic crisis. This has brought about more clarity on the definition and meaning of resilience but no consensus. In economic geography, there is a tendency to refute the engineering, equilibrium concept of resilience, in which resilience is regarded as a response to external disturbances and a move back to a steady state. Scholars have advocated an evolutionary approach to regional resilience instead, in which the focus is on the long-term capacity of regions to reconfigure their socio-economic structure (e.g. Christopherson et al., 2010; Simmie and Martin 2010; Cooke et al., 2011). However, Martin (2012) argues that the long-term adaptive capacity of regions is still 'largely unresearched' (p. 11). As such, an evolutionary perspective on regional resilience is still work very much in progress.

The objective of the paper is to show that an evolutionary perspective can bring additional insights to the expanding literature on regional resilience. First, we conceptualize regional resilience not just as the ability of a region to accommodate shocks, as is common in the literature, but we extend it to the ability of regions to reconfigure their socio-economic and institutional structures to develop new growth paths. Second, we propose a comprehensive view on regional resilience, in which industrial, network and institutional dimensions of resilience come together and are combined. Doing so, we take up the question of how related variety may be linked to regional resilience, how networks can be made part of it (Vicente et

al. 2011), an issue that has received little attention in the regional resilience literature despite some focus on complex adaptive systems, and we make an effort to tackle the critique that the resilience literature has drawn too little attention to institutions (e.g. Swanstrom, 2008; Pike et al., 2010; Davies, 2011). Third, we make history a key input to our understanding of regional resilience. There is a tendency in the literature that resilience means to avoid path dependence, or a move away from it, as if new growth paths are detached from their past, and as if regions need to escape from their historical legacy to achieve that. We propose a conceptualization of regional resilience in which history is key to understand how regions develop new growth paths, as pre-existing industrial, network and institutional structures in regions provide opportunities but also sets limits to the process of diversification. Fourth, the evolutionary literature on regional resilience has drawn attention to a trade-off between adaptation and adaptability (e.g. Hassink, 2010; Pike et al. 2010). We explore how this trade-off may be overcome, as we see this as a key challenge for regions to become resilient, that is, how to secure adaptability and adaptation simultaneously.

The paper is organised as follows. Section 2 briefly discusses the treatment of resilience in the economic geography literature. We propose an evolutionary approach to regional resilience in which structural change is the guiding principle, and which explores how the trade-off between regional adaptation and adaptability may be overcome. Section 3 discusses how regional resilience can be associated with configurations of the industrial structure in a region, Section 4 discusses how networks can be made part of regional resilience, and Section 5 will incorporate the institutional dimension. Section 6 draws conclusions and sets out some unresolved issues that an evolutionary approach to regional resilience needs to take up.

2. Towards an evolutionary conceptualization of regional resilience

When social scientists speak about resilience, they refer to the responsiveness of individuals, organizations or systems to shocks. There is an almost endless list of shocks the resilience literature has dealt with, and the nature of these disturbances varies widely¹. Shocks can occur as sudden and discrete events, or evolve more gradually, as ‘slow-burn challenges’ (Pendall et al., 2010). Examples are individual trauma’s, terrorist attacks, natural disasters, natural developments like global warming, global economic crises, major plant closures, technologies becoming obsolete, fall of complete industries, political transformations, and so forth.

Triggered by the current economic crisis, economic geographers have shown a strong interest in the topic of regional resilience. This has led to many empirical papers, ranging from case studies on particular regions (e.g. Treado 2010), comparative analyses of two or more regions (e.g. Swanstrom et al., 2009; Simmie and Martin 2010; Wolfe 2010; Hill et al. 2012) to more systematic approaches analyzing the resilience of many regions (e.g. Diodato and Weterings 2012; Fingleton et al., 2012; Martin 2012). However, this interest has also led to fierce debate.

Christopherson et al. (2010) have stated that the “question of regional resilience is, at base, a very old and enduring question” (p. 3). Indeed, many economic geographers have investigated in the past how regions responded differently to, for instance, de-industrialization, the shift from Fordist to neo-Fordist types of production (Piore and Sable, 1984; Scott, 1988; Chapple and Lester 2010), and economic recessions in general (Domazlicky 1980). Some scholars

¹ Because there are so many different shocks, it is impossible to generalize about how a shock may affect the resilience of a region, as a region may well adapt to one type of shock, but not to another.

have come to the conclusion that the resilience concept has little to add to existing concepts like path dependence and lock-in (Hassink 2010; Pike et al. 2010; Davies 2011). Other scholars have stated that the resilience concept is at risk of being a fuzzy concept (Pendall et al. 2010) that is in need of more precision and clarity (Martin, 2012). One of the crucial issues is how to relate resilience to regions, as regions (at whatever spatial scale) are collections of individuals, organizations, industries, networks and institutions, each of which may have their own distinctive features of resilience². Another issue is that it is not always clear in the regional resilience literature what is cause, and what is effect. For instance, is institutional resilience a sign of regional resilience, or is it a determinant?

The regional resilience literature differentiates between three types of approaches. The engineering-based concept of resilience (Rose 2004; Fingleton et al. 2012) refers to the ability of a system to return to a pre-existing stable equilibrium state after a shock. In this framework, regional economies (at whatever spatial scale) show different levels of resilience in terms of "... whether or not, and to what degree, and in what time frame an economy can return to its pre-existing shock position and level of output" (Pike et al. 2010, p. 61). Economic geographers tend to refute this equilibrium approach, as it makes no reference to changes in the structure and function of regions, among other reasons (Martin 2012).

There is more ambiguity about the second approach, which is the ecological concept of resilience that is based on multiple equilibria (e.g. Reggiani et al. 2002; Swanstrom et al. 2009; Zolli and Healy 2012). Here a region can change its structure and function in the face of an external shock, and move into a new equilibrium state. Still, this approach adopts an equilibrium perspective in which a resilient region shifts from one possible steady growth path or equilibrium to another. Crucial issues like the role of human agency, institutions and structural change are not well captured by such an equilibrium perspective, but are key to understand the long-term economic evolution of regions (MacKinnon and Driscoll Derickson 2012). Moreover, this approach fails to see resilience as much broader than just assessing the sensitivity of a regional economy to shocks, and it often misleadingly portrays the region as an autonomous spatial unit (Christopherson et al. 2010).

There is increasing interest in an evolutionary approach to regional resilience (see e.g. Christopherson et al. 2010; Clark et al. 2010; Pike et al. 2010; Simmie and Martin 2010; Cooke et al. 2011). In an evolutionary framework, resilience in the meaning of the capacity of a region to sustain long-term development is regarded as important as the capacity of a region to respond positively to short-term shocks. This approach focuses more on the long-term evolution of regions and their ability to adapt and reconfigure their industrial, technological and institutional structures in an economic system that is restless and evolving. Here, "resilience is considered as an ongoing process rather than a recovery to a (pre-existing or new) stable equilibrium state ..." (Simmie and Martin 2010, p. 31). This basic need for fundamental economic renewal is ever present, though in times of crises, this is felt more pressing. Resilience then depends on the ability of regions to cope with structural change, that is, to create new growth paths, in order to offset inevitable processes of stagnation and decline

² The question of how to relate a region to resilience is a crucial one, but not peculiar to the topic of regional resilience (for a similar discussion on the usefulness of the regional competitiveness concept, see e.g. Lawson 1999; Camagni, 2002). Studies on regional resilience often tend to take a rather pragmatic approach: a region is viewed as a collection of heterogeneous units (individuals, organizations and institutions) that interact or not within predefined boundaries, but that is also part of a wider system outside the region that affects its resilience.

in their regional economy (Saviotti 1996), as “no region can rely on its legacy of past successes to succeed in the future” (Swanstrom, 2008, p. 1)³.

When conceptualizing resilience in terms of a region’s capacity to develop new growth paths, the evolutionary approach tends to fall back on the distinction made by Grabher (1993) between adaptation and adaptability (Christopherson et al., 2010; Pike et al 2010; Bristow et al. 2012). Adaptation concerns changes within preconceived paths, while adaptability is about developing new pathways, i.e. departures from existing paths. In this framework, scholars argue there is a trade-off between the two. As Grabher (1993) put it, “adaptation leads to an increasing specialization of resources and a pronounced preference for innovations that reproduce existing structures. And while the system optimizes the ‘fit’ into its environment, it loses its adaptability Adaptability crucially depends on the availability of unspecific and uncommitted capacities that can be put to a variety of unforeseeable uses: redundancy” (p. 265). Here, regional resilience has been associated primarily with long-term adaptability, how history can stand in the way of true economic renewal, and how to overcome negative lock-in (Boschma and Lambooy, 1999). This has led to a tendency in the literature to depict history as something negative that one has to get rid of, or to escape from, to secure regional resilience.

We argue in this paper that the evolutionary approach of regional resilience is still underdeveloped for at least five reasons. First, there is a need to integrate the two meanings of resilience, that is, the short-term capacity of a region to absorb shocks and the long-term capacity of a region to develop new growth paths (Martin and Sunley, 2013). We will redefine the ability of regions to respond to shocks in terms of how shocks affect the capacity of regions to develop new growth paths like new industries or technological breakthroughs. New growth paths can be understood as new path creation but also path renewal, as long as these are distinct from existing regional paths (Martin and Sunley 2006; Garud et al. 2010). Second, this requires better understanding of how regions develop new growth paths. However, there is still little understanding of what determines the long-term adaptive capacity of regions (Martin, 2012). Accordingly, a key task is to identify the main determinants of a region’s ability to develop new growth paths. Third, there is a misleading tendency in the literature to associate regional adaptability with new growth paths that are detached from their past, as if path dependency will cause only problems of adjustment (Magnusson and Ottosson 2009; Henning et al. 2013)⁴. There is a need to redefine the role of history here. We argue that the legacy of the past has a strong imprint on regional resilience not only in terms of constraints but also in terms of opportunities, as it sets the scope for re-orientating skills, resources, technologies and institutions in regions⁵. Drawing on recent empirical work (e.g. Neffke et al.

³ Every year, more than 10 percent of all companies in the US disappear (Ormerod 2005), and only very few firms grow old (Brouwer, 2005). There is also no industry in a region that will thrive forever. Even when it survives for a longer period, the nature of that industry (as embodied in its products, technologies, firms, surrounding institutions) will change dramatically over time.

⁴ There is a tendency to perceive resilience as freeing itself from path dependence, as if it stands in the way of true economic renewal. Magnusson and Ottosson (2009) argue instead that one should leave behind the view that ‘path dependence and (radical) change cannot go together’, as if radical change can be explained only by an exogenous event. Ebbinghaus (2009) advocates ‘a not-too-narrowly defined, nondeterministic concept of path dependence, in which different forms of change can come about, and the emergence of new structures is not restricted to chance events’. Ebbinghaus proposes that the nature of change should therefore be object of study, and that we should go ‘beyond the heuristics of the path dependence metaphor’ (p. 203).

⁵ Bristow et al. (2012) argue that the path dependency concept is not well equipped to help us understand the process of adaptability. Instead, they propose the notion of path interdependence, which refers to unforeseen innovations due to crossovers and recombinations of knowledge between firms and industries.

2011; Kogler et al. 2014), we claim that pre-existing resources and capabilities in regions often tend to shape new growth paths in regions, as these are rejuvenated and redeployed in new combinations. Fourth, this requires a rethinking of regional resilience as the capacity of regions to overcome the trade-off between adaptability and adaptation. While a lot has been said on how adaptation may preclude adaptability, the evolutionary approach has drawn little attention to the other side of the trade-off, though there are good reasons to believe that adaptability may also hurt adaptation, as, for instance, explorative search for new things may go at the expense of focus and local cohesiveness, and therefore positive externalities in a region may fail to materialize. This requires a better understanding of how regions can achieve adaptation without a loss of adaptability, and adaptability without compromising on adaptation. And fifth, an evolutionary approach to regional resilience needs to account for the complex and multi-dimensional nature of resilience (Pendall et al., 2010). Regions (at whatever spatial scale) are collections of individuals⁶, organizations⁷, industries, networks and institutions, each of which, and in combination, can display their own processes of path dependence, and each of which can be associated with this tension between adaptation and adaptability. In this paper, we limit our attention to the industrial, network and institutional dimensions of regional resilience, and we explain for each of these dimensions how this trade-off may be overcome.

The aim of this paper is to incorporate regional resilience in a long-term evolutionary perspective that is theoretically, but above all, empirically informed. This requires understanding of how regions develop new growth paths, and whether, and how history plays a role here. Instead of arguing that resilience means to avoid path dependence, or a move away from it, we argue that the long-term adaptability of regions is conditioned by its industrial, network and institutional legacy which provides opportunities but also sets limits for local actors to be resilient. Doing so, we aim to develop a regional resilience concept that goes beyond this trade-off thinking. This requires a clarification of how this tension can be overcome at the level of industries, networks and institutions and, thus, how particular industrial, network and institutional structures in regions, alone or in combination, impact on the resilience of regions. This will be taken up one by one in the subsequent sections.

3. Techno-industrial variety and regional resilience

⁶ In psychology, individuals are characterized as resilient or not. In economic geography, there is increasing attention on key individuals that can make a difference in regions, like influential entrepreneurs, top managers, star scientists, political leaders, et cetera (see e.g. Feldman et al. 2005; Sotarauta et al. 2012; Trippel 2013; Blomkvist et al. 2014).

⁷ At the organizational level, this is known as the ‘competency trap’ (Levin and March 1996), or what March (1991) called a tension between ‘exploration of new possibilities’ and ‘exploitation of old certainties’ in organizational learning, as ‘becoming quite good at doing any one thing reduces the organization’s capacity to absorb new ideas and to do other things’ (Lawson and Lorenz, 1999, p. 311). Beunza and Stark (2003) proposed ‘generative redundancy’ to overcome this tension in organizations, like more ways of doing things. However, when incorporating organizations into our concept of regional resilience, there is a need to leave behind such an atomistic view and embed organizations in their wider socio-economic context. For instance, there is evidence that diversification strategies of firms are influenced by their local environment, as firms tend to diversify into new products that are technologically related to existing products in their own region (Neffke et al., 2014).

The resilience literature has drawn a lot of attention to the industrial composition in a region. Focus is often exclusively on the sensitivity of regions to negative⁸ sector-specific shocks, like a fall in demand⁹. In this context, specialized regions are perceived to be less vulnerable to sector-specific shocks, as their regional economies are dominated by one principal industry. Nevertheless, when hit, such a shock is more likely to damage large parts of the regional economy. In contrast, diversified regions have a higher chance to be hit by a sector-specific shock, as they house a range of industries that may become victim. Nevertheless, despite this higher risk, a diversified region has a lower probability that a sector-specific shock has a negative impact on the local economy as a whole. In other words, industrial variety in a region spreads risks and can better accommodate idiosyncratic sector-specific shocks (Dissart, 2003; Essletzbichler 2007; Davies and Tonts, 2010; Desrochers and Leppala 2011).

However, this effect of industrial variety as shock-absorber will only become manifest when other conditions are met. First, local industries have to be disconnected in terms of input-output relationships, otherwise, the decline in one industry will still trigger decline in other local industries (Diodato and Weterings, 2012). One could also argue that local industries have to be disconnected in cognitive terms, which has been referred to as unrelated variety (Frenken et al. 2007), so the fall of one industry will not affect the learning opportunities available to other industries in a diversified region. However, there is increasing awareness that industrial variety will work better as a shock-absorber when the local industries are skill-related, that is, when industries require similar skills, as this enhances regional labor matching¹⁰ (Neffke and Henning 2013). Regional variety in skill-related industries is expected to speed up the recovery from sector-specific shocks, as the redundant employees can find more easily new jobs in a region with a local supply of skill-related industries in which their skills are still found relevant (Diodato and Weterings 2012). This also prevents the destruction of human capital in a region as well as the outflow of high-skilled people to other regions.

This variety effect covers only one aspect of regional resilience, that is, the capacity of a region to resist a shock, and the speed with which it can recover from that (e.g. Davies, 2011; Martin 2012). It ignores another crucial aspect of regional resilience, as it says little on how shocks affect regional competitiveness more in general, and the ability of regions to create new growth paths and to make crossovers across technologies and industries in regions, out of which new economic activities may develop. This brings us to the other important meaning of resilience, which is the capacity of a region to develop new growth paths. Here, we will argue that this depends on the existing industrial structure in a region, which provides opportunities, or not, to make new combinations that evolve into new growth paths.

⁸ When the resilience literature refers to shocks, in almost all cases, it concerns a negative shock to the region. The analysis concentrates then on the duration and the extent to which a full recovery process unfolds. However, one could also think of positive shocks, such as lower corporate taxes, or the rise of the Chinese economy, and the extent to which regions are capable of fully benefiting from that.

⁹ Studies have identified particular industries that are expected to be most sensitive to general shocks. Scholars have, for instance, determined the shares of recession-sensitive industries like manufacturing in the total output of regions, to estimate the effect of global recessions (e.g. Groot et al. 2011). Davies (2011) found that resilience to the 2009 downturn was lower in regions with overvalued housing markets, a high dependence on construction, strong export dependency, assets bubbles on public debts, and openness to risky assets on financial markets.

¹⁰ The unemployed might also move to other regions. This brings to light the question what is actually meant by resilience, and what indicators are most appropriate to grasp that. If resilience is defined as a return to previous regional output levels (as it often is), then the rapid absorption of the unemployed in the local labour market favors that. However, if all the unemployed move to other regions, this will negatively affect regional output (bad sign of resilience) but will also lower regional unemployment (which might be a good sign of resilience).

To start with, a specialized region has less options at its disposal to develop new growth paths, as it has basically one principal sector (possibly with a few sectors that developed around it), out of which a new industry can branch. It has few recombinatory options available at the regional scale, as there is little (related) variety between knowledge domains in the region that might be recombined. In other words, specialized regions have few potential sources for renewal and diversification. What is more, their ability to diversify into new growth paths might be negatively affected by their specialized industrial structure (Boschma and Lambooy, 1999; Hassink 2005; Martin and Sunley, 2006). Once a region specializes in a knowledge base, this offers opportunities to local firms for further improvements, but regions may also become myopic for opportunities that lay beyond their own development paths, and sunk costs may prevent them from switching to new growth tracks (Malmberg and Maskell, 1997; Maskell and Malmberg, 1999). Here, perfect adaptation to the local environment leads to reproduction and locks a region into a specific trajectory that goes at the expense of a region's adaptability. Here, we find the classic trade-off between adaptation and adaptability in specialized regions in which the former undermines the latter, and which has been described by Grabher (1993) as the 'trap of rigid specialization'.

In diversified regions, this type of conflict, in which adaptation harms adaptability, has less chance to become manifest, at least at the regional scale (at the industry and technology scale, the same lock-in processes might still occur). Diversified regions are considered to have more potential to make new recombinations across local industries, and to develop new growth paths, also known as 'Jacobs' externalities', after the seminal work of Jacobs (1969). So, diversified regions may score high on adaptability, but adaptability may go at the expense of adaptation, as diversified regions may suffer from a lack of industrial focus, a lack of critical mass for each of its industries (no localization externalities), and a lack of cognitive proximity between local industries. Doing many things may not lead to excellence in any of those parts in the region, especially when these parts do not provide complementary resources either, that is, they suffer from unrelated variety. Under these conditions, local industries are more likely to decline and disappear, as these are loosely embedded in the regional context. This is in line with empirical evidence that shows that sectors that are unrelated to other local industries are more likely to fail and exit a region (Neffke et al. 2011a; Essletzbichler 2013; Neffke et al. 2014). In other words, in these circumstances, diversified regions suffer from a trade-off between adaptability and adaptation that has received little attention in the literature so far.

In the evolutionary literature, there is a tendency to equate regional resilience with adaptability (e.g. Pike et al. 2010). We claim instead that adaptability is a necessary but not a sufficient condition for regional resilience, as being resilient depends on the capacity of a region to overcome the tension between adaptability and adaptation. We claim that related variety in a region has the potential to secure both adaptation and adaptability, and thus, may make a region more resilient. Related variety means that a region has a wide range of related industries that provide potentials for inter-industry learning and new recombinations (Frenken et al. 2007): the higher related variety is, the more opportunities for local industries to learn from each other, and the more potential combinations across local industries can be made. In this context, related variety guarantees adaptation because of the local presence of a high number of related industries which provides a supportive local environment. This makes related industries can benefit from each other's co-presence, as each of them can draw from a local pool of relevant capabilities and skills, and so benefit from what might be referred to as 'local related externalities'. Recent studies have indeed demonstrated that industries are less likely to exit a region when these are technologically related to other local industries (Neffke

et al. 2011a), and that especially young firms have higher survival rates in a region that is well endowed with related industries (Neffke et al. 2012).

But more importantly, related variety also enhances the adaptability of regions. Frenken et al. (2007) claimed that the recombinatory potential of diversified regions is enhanced by related variety, and not necessarily by variety *per se*. There is indeed evidence that related variety appears to be a key ingredient for regions to diversify and develop new growth paths, as new industries tend to branch out of and recombine resources from existing local industries to which they are technologically related. There is a lot of case-study evidence that the long-term capacity of regions to develop new growth paths is depending on the reconfiguration and reorientation of existing regional assets (see e.g. Bathelt and Boggs 2003; Belussi and Sedita 2009; Moriset, 2009). Glaeser (2005) described how Boston was able to reinvent itself by reconfiguring its skill-related assets over a long period of time. Pittsburgh lost most of its steelmaking capacity but not its steelmaking expertise which laid the foundations of a strong economic recovery (Treado 2010). Entrepreneurial studies have demonstrated that the pre-entry experience of entrepreneurs in related industries and a location with related industries increase the life chances of firms in new industries (Klepper, 2007; Buenstorf and Klepper, 2009)¹¹. Studies on the evolution of a technology show that technological competences in regions shape patterns of technological diversification in fuel cells (Tanner 2011, 2014), nanotechnology (Colombelli et al., 2014) and biotech (Boschma et al., 2014a). Empirical studies on diversification show systematically that new industries emerge from related industries, and thus, that the industrial structure of a regional economy has an impact on diversification opportunities of regions (Klepper and Simon 2000; Neffke et al. 2011a; Rigby, 2012; Van der Wouden 2012; Boschma et al., 2013a; Essletzbichler 2013; Muneeppeerakul et al. 2013; Boschma et al. 2014b). Neffke et al. (2011a) found that sectors that are technologically related to other local sectors are more likely to emerge in a region. So, breakthroughs are often novelties that depend on pre-existing technologies that are recombined at the regional scale (e.g. Arts and Veugelers 2012). In sum, these studies confirm that the resilience of regions depends on their industrial history to a considerable degree.

The question is whether a shock may undo the positive effects of related variety on the capacity of a region to develop new paths. This depends on whether the collapse of one industry in a region will also damage other local industries to which it is technologically related. When a shock concerns a complete shift to another technological paradigm or general purpose technology that concerns the whole underlying knowledge base of all related industries in a region, it will seriously undermine regional resilience. Moreover, if the underlying knowledge base of a region is more specialized (that is, there is related variety within only one group of industries), related variety in a region may be weakened by a sector-specific shock, and it might undermine the recombinatory and labour matching potential of a region. However, if the underlying knowledge base in a region is truly diverse, a sector-specific shock is less likely to lead to the decline of other local related industries, and related variety will remain to function as a key source for regional economic renewal. This is the case when the region consists of groups of related activities in which there is a high degree of

¹¹ Scholars (e.g. Andersson and Koster 2011) have argued that regions also have distinct entrepreneurship cultures that persist over time. Fritsch and Wyrwich (2012) have demonstrated that regional entrepreneurship cultures persisted in Germany in the period 1925-2005, despite drastic shocks, such as WWII, the economic crises of the 1930s, German unification, and socialist regime change. So, history seems to matter for regional resilience, but a crucial question remains whether the local knowledge base impacts on this geographical persistence of new firm formation. Colombelli and Quatraro (2013) found that entrepreneurship in Italian regions is related to the exploitation of technological knowledge in regions. Moreover, there is a need to investigate whether these persistent regional patterns of entrepreneurship also induce structural change in regions.

relatedness within each group (i.e. related variety within each group) but a low degree of relatedness between the groups (i.e. unrelated variety between groups). In this case, the loss of one industry might lower the degree of related variety within the group to which that industry belongs, but it will not affect related variety in the other local groups, as these groups of local industries are unrelated, and thus, it will not undermine related variety of the region as a whole. This also shows that, next to related variety, it might be beneficial to have unrelated variety in a region as well to protect the recombinatory potential of a region against shocks.

So far, we argued that unrelated variety, as well as related variety in a region may enhance the region's adaptability, as both increase the potential to make new recombinations. We expect related variety to act more often as a key source for regional renewal, as new industries can build on and draw resources from local industries to which they are technologically related. In other words, adaptability and adaptation go hand in hand in regions with related variety. This is not the case in regions with unrelated variety only, as recombinations between unrelated knowledge domains also imply more risks and higher switching costs, as there is no local supportive environment. Therefore, unrelated diversification is more likely to fail, and successful unrelated diversification will be a more rare event. Having said that, it makes relevant the question whether regions can keep relying on recombinations between related industries (i.e. related diversification) to develop new growth paths in the long run, or whether regions have to diversify in more unrelated activities now and then, that is, making new combinations between unrelated domains that become related as soon as these domains connect (Saviotti 1996; Saviotti and Frenken 2008; Quattraro 2010). As regions have a tendency to diversify into related activities and shake off unrelated activities (Neffke et al., 2011a; Essletzbichler, 2013; Boschma et al 2013a; Neffke et al., 2014), one could argue that regions need to develop new unrelated activities to increase their variety. Castaldi et al. (2013) have claimed that regions with unrelated variety are more likely to produce technological breakthroughs, as it provides opportunities to recombine previously unrelated knowledge domains, while incremental innovations benefit from related variety in a region, as these arise out of recombinations of more closely related knowledge domains along well-defined paths. This would imply that unrelated variety (unrelated knowledge domains) guarantees adaptability while related variety (within each knowledge domain) secures adaptation. Having both types of variety then would make a region truly resilient, as it would overcome the trade-off between adaptability and adaptation.

To sum up, the resilience of a region is enhanced when a region has: (1) a variety of skill-related industries that have little local input-output relationships with one another, which increases the capacity to respond to sector-specific shocks. (2) related variety which enhances the recombination potential of a region but, above all, provides local (related) resources on which new growth paths can build and develop. Consequently, related variety relaxes the trade-off between adaptability and adaptation that might occur in diversified regions. It is still an open question though whether related variety is sufficient, or whether a mixture of related variety within groups of local industries/technologies and unrelated variety between groups is beneficial, as it might protect the recombination potential of a region from shocks. In contrast to diversified regions, specialized regions combine high adaptation with a low adaptability to develop new growth paths, due to a lower recombination potential and a possible state of negative lock-in. Specialized regions may overcome this trade-off by: (1) activating uncommitted local resources or redundancies like skills; (2) using their specialized knowledge base to diversify into new related activities, like Pittsburgh (Treado, 2010); and (3) connecting to industries and technologies in other regions, from which they can draw (related) resources and recombine those with their own local knowledge base (Boschma and Capone, 2014).

The discussion on regional resilience so far has been partial, as it left out other dimensions that need to be integrated in a comprehensive view on regional resilience. We turn now to network and institutional dimensions of regional resilience in sections 4 and 5 respectively.

4. Regional resilience and knowledge networks

So far, we have looked at regions as collections of competences and industries that are technologically related or not, but we left open whether these local resources actually connect. Regions may also be viewed as what Lawson (1999) referred to as ‘ensembles of competences that emerge from social interaction’ (p. 157) in which regional actors have knowledge networks of relationships with other local actors but also with actors outside the region (Antonelli 2000; Huggins and Thompson 2014). In the regional resilience literature, little attention has been drawn to the role of knowledge networks so far, despite some focus on complex adaptive systems¹². Few studies in economic geography (yet) exist that have applied systematically the adaptive system approach, although scholars have used it as a background or as a source of inspiration (see e.g. Simmie and Martin 2010; Cooke et al. 2011; Wink 2012; Bristow and Healey 2013)¹³. We explain below how regional resilience may depend on network structures in regions. In this section, we focus on knowledge networks, not on other types of networks like urban transport networks (e.g. Reggiani 2012) or regional trade networks (Thissen et al. 2013), to which the resilience concept has also been applied.

The internal structure of knowledge networks in a region, as well as their openness to the outside world, matter for regional resilience, because they impact on the sensitivity of regions to shocks (i.e. some network structures are more sensitive to the removal of a tie or a node), but also on the capacity of regions to develop new growth paths (i.e. some network structures have a higher capacity to induce radical change). Moreover, the trade-off between adaptation and adaptability outlined in the previous section has its network analogy in what Simmie and Martin (2010) described as a conflict between connectedness and resilience. Local network structures may become excessive and inward-looking, and network partners may become too proximate on various dimensions. These types of networks make regions score high on adaptation. The predominance of a closely tied core in the local network and a high degree of

¹² When taking a network perspective on regional resilience, it is appealing to look at complex adaptive systems which makes use of evolutionary properties like emergence, self-organization, non-linear dynamics and co-evolution (Martin and Sunley 2007; Bristow et al., 2012). Swanstrom et al. (2009) claim that the study of resilience requires to view regions as composed of complex interlinked processes with powerful feedback effects. Interesting for our discussion is that adaptive systems accommodate the conflict between connectedness and resilience through panarchy which is a system state with high connectedness that is still open to experiments (Gunderson and Holling 2002; Swanstrom 2008). Pendall et al. (2010) adopted the adaptive cycle model to propose a dynamic perspective to resilience in which “...resilience levels vary continually as the systems adapts and changes (p. 77).

¹³ This comprehensive concept of systemic resilience has its analogy in literature on sustainability transitions. There, the emphasis is on the formation and transformation of socio-technical systems to support the emergence of radically new modes of sustainable production and consumption. It is about defining the preconditions of radical path-breaking change or the development of new niches that still suffer from a poor alignment with existing technologies, institutions and user practices (Geels 2002). Emphasis is on the link with established, dominant practices and socio-technological regimes that might enable but also inhibit such large-scale system shifts. Truffer and Coenen (2012) have explained that this transition literature has to incorporate a spatial dimension, as regions differ in their potentials to sustainable transformations, and transition processes are multi-scalar phenomena in which changes co-occur at different spatial scales (see also Binz et al. 2014).

proximity between network partners (like cognitive and social proximity) favor control and efficiency, as they enhance information transmission and coordination, and lower the risk of opportunistic behavior. However, the downside of this type of local network is a low score on adaptability: it suffers from a lack of recombination possibilities, it prevents lock-out, and it is vulnerable to shocks (Crespo et al. 2013). This typical network state in which adaptation undermines adaptability has been especially found in specialized regions where the local connectedness (as embodied in interlocking corporate boards and strong social networks) may become so excessive that fundamental renewal is not on the mindset and is even heavily contested by local network players (Grabher, 1993; Boschma and Frenken 2010). These networks will also result into an excess of cognitive proximity between the local network partners, which contribute further to this regional network lock-in. Herrigel (1990) proposed the concept of ‘autarkic firm-based industrial order’, as opposed to a ‘decentralised region-based industrial order’, to describe the adverse consequences of a regional network comprising of hierarchically-organized corporations with standardized supplier linkages.

Local network structures may also be too fragmented, with many nodes that have few connections, and with a lack of proximity between the various (potential) nodes in the region. These local networks score high on adaptability, as these provide opportunities to accommodate shocks, and these give access to new and non-redundant knowledge. Here, the other side of trade-off (i.e. adaptability harming adaptation) is likely to prevail, as there is a lack of regional cohesiveness that weakens the efficiency and control of collective behavior in the network, and there is hardly any mutual learning taking place, as agents are just too distant to each other (geographical proximity being the exception). This might come close to what Saxenian (1994) referred to as ‘independent firm-based industrial systems’, as opposed to ‘regional network-based industrial systems’ that actually promote learning and adjustment.

In the network literature, there are suggestions of how these trade-offs between adaptation and adaptability might be overcome at the level of structural properties of networks. Fleming et al (2007) argue that the trade-off between adaptation (for the sake of control and efficiency) and adaptability (for the sake of openness) can be overcome by a network structure in which embedded relationships within cliques co-exist with strategic ‘structural hole’ relationships among cliques. Likewise, Balland et al. (2013) have described a core/periphery network structure in which a cohesive structure of knowledge interactions (for the sake of coordination and circulation of knowledge) is mixed with a periphery of loosely connected organizations that are poorly tied with the core of the network (to promote new and fresh ideas). Crespo et al. (2013) have explored how to solve potential conflicts between efficiency and resilience in knowledge networks in terms of the relative importance of closure and bridging network strategies. When closure strategies prevail, the structure of the network will exhibit tightly couplings in a core-component and a loosely connected periphery of nodes. This favors technological lock-in and efficiency but prevents regional lock-out which is bad for resilience. Instead, bridging strategies are more open for more disruptive relations between the core and periphery of nodes, but they undermine cohesiveness that weakens the control of collective behavior in the network. In the core/periphery and resilient network described by Crespo et al (2013), there are high levels of connection between the core and periphery which prevent shocks on core members to weaken the whole network structure. At the same time, explorative behavior can diffuse more easily from periphery to core members, due to the ability of key nodes to mix closure and bridging ties for overlapping explorative and exploitive phases in their relational patterns.

To overcome the trade-off between adaptation and adaptability in regional networks, one can also look at the nature of the network relationships, next to the structural properties of networks. The proximity framework is useful to describe the nature of network ties in terms of various dimensions of proximity, and how that enhances, or not, regional resilience (Boschma and Frenken, 2010; Balland 2012a, 2012b). Proximity between agents favors the formation of knowledge network ties, as proximity decreases costs and risks, but too much proximity may lead to lock-in and be bad for breakthroughs. To overcome this proximity trade-off between efficiency and resilience, one could think of optimal levels of proximity between agents on the various proximity dimensions (Boschma and Frenken 2010). The optimal level of cognitive proximity follows from the need to keep some cognitive distance (for the sake of new ideas) and to secure some cognitive proximity (to enable effective communication) (Cohendet and Llerena 1997; Nootboom 2000; Gilsing et al. 2007; Broekel and Boschma 2012). Such optimal levels of proximity are likely to exist for the other forms of proximity as well. For geographical proximity, one could argue that a combination of local buzz and global pipelines is beneficial for the long-term evolution of regions (Asheim and Isaksen 2002; Bathelt et al. 2004; Moodysson 2008; Dahl Fitjar and Rodríguez-Pose 2011), while an optimal level of organizational proximity could be accomplished by loosely coupled networks that combine flexibility and coordination (Grabher and Stark 1997).

Besides looking at network structures as a whole, studies have investigated the strategic role of key agents in networks to ensure coordination and induce real change at the same time (Cattani and Ferriani 2008). These studies focus on gatekeepers in regions, and on the extent to which local agents benefit or not from the presence of gatekeepers and their global linkages (Giuliani and Bell 2005; Cantner and Graf 2006; Morrison 2008; Morrison and Rabelotti 2009; Graf, 2011; Munari et al. 2012). Gatekeepers can prevent a region to enter into a situation of lock-in, as they have strong external linkages through which external knowledge diffuses widely to local actors. In doing so, they can overcome the trade-off between what has been called embeddedness and structural holes, as they facilitate "... the formation of a network structure that combines the benefits of local clustering (i.e., high trust and cooperation) with the existence of short pathways to external sources (i.e., rapid and facilitated access to novel information) (Verspagen and Duysters 2004)" (quoted in Morrison et al., 2013, p. 81). Morrison et al. (2013) have claimed that global pipelines enhance knowledge accumulation in clusters when there is high-quality local buzz that makes this external knowledge circulate, or when the cluster is small and has a weak knowledge base. Breschi and Lenzi (2014) found evidence that the transcoding function of gatekeepers is especially important in cities with a specialized knowledge base, while in cities with a diversified knowledge base, direct linkages to external knowledge are more important for innovation, and the role of gatekeepers as translators and circulators of external knowledge is less pronounced. Gilly et al. (2012) have pointed out the importance of local authorities and hub firms to activate new network relationships to make new recombinations of know-how.

In the regional resilience literature, it is remarkable how little attention has been paid to the sensitivity of regional networks to the removal of specific nodes or the dissolution of particular linkages. One can depict a regional economy as a knowledge network in which the nodes stand for industries/technologies and the ties reflect the degree of technological relatedness between these nodes (see e.g. Neffke et al. 2011; Boschma et al. 2014b), as described in Section 3. Then, one can identify how resilient a region is to changes in this network structure. For instance, in a tight local network that connect many technologically related industries, one may expect that the loss of one industry will not have huge consequences, as the technological cohesiveness of the region will be lowered only

marginally, and thus the recombination capacity of a region remains more or less intact. However, when a boundary-spanning industry, that is, an industry that bridges two distinct technology fields, disappears from the region, the recombination potential of the region may be more seriously affected. Following such a network approach, one can directly link the issue of sensitivity of regions to shocks to the ability of regions to develop new growth paths.

In summary, regional resilience is enhanced in network terms when a region has: (1) a core/periphery network structure with a balance between embedded relationships within cliques and strategic ‘structural hole’ relationships among cliques, as proposed by Fleming et al. (2007) among others, as this might provide a solution for trade-off between adaptation (control and efficiency) and adaptability (openness); (2) a network structure with combinations of optimal levels of proximities (e.g. combinations of local and non-local ties, cognitively proximate and distant ties, loosely coupled networks), as proposed by Boschma and Frenken (2010) among others, as this may overcome the trade-off between adaptation (efficiency) and adaptability (novelty) in the network; (3) key agents in the network who ensure access to novel information and enable its wide diffusion to other local actors, as this secures adaptation (local clustering) and adaptability (short links to external knowledge).

5. Regional resilience and institutions

Our conceptualization of regional resilience is not complete without accounting for institutions. There is widespread agreement that the resilience literature has drawn too little attention to the role of institutions and the state (see e.g. Swanstrom et al. 2009; Bristow 2010; Hassink 2010; Wolfe 2010; Pike et al. 2010; Davies 2011; MacKinnon and Driscoll Derickson 2012; Wink 2012)¹⁴. In our evolutionary perspective, institutions are closely intertwined with the two other dimensions of regional resilience, that is, techno-industrial variety and networks, as institutions like laws, norms and cultural attitudes enable, or not, interactions across knowledge bases and local industries (Huggins et al. 2012; Crescenzi and Percoco 2013). Second, institutional structures may be subject to shocks (like the erosion of social capital, the loss of property rights, a sudden change in economic policy, the downsizing of public gatekeepers) that have a direct impact on the capacity of regions to develop new growth paths, and thus, on regional resilience (see e.g. Dawley, 2014). Third, institutions can be linked to the trade-off between adaptation and adaptability, as there is a strong historical and path-dependent dimension to institutions. When new industries develop, new institutions come into being that fulfill a specific need, but once these institutions become firmly established, they may hinder the development of new growth paths, due to institutional hysteresis and inertia (Setterfield 1997; Murmann 2004). This requires a search for institutional structures that can cope with this tension between adaptability and adaptation.

So, new institutions tend to co-evolve with new industries in a region (Freeman and Perez, 1988; Nelson 1994; Coenen et al. 2013). The more regions specialize, the more the institutional structure will be geared towards and customized to the specific needs of the local industries. Gradual adjustments in local institutions in order to meet the changing needs of these industries can be more easily accommodated in specialized regions. Ebbinghaus (2009) refers to this type of gradual institutional change as path stabilization. However, this adaptation tends to undermine the adaptability of the region, as it might impede the

¹⁴ Swanstrom (2008) argues that the concept of ecological resilience is ‘fundamentally anti-statist’ (p. 15), as social affairs are not driven by natural but by human forces, like man-made institutions and policies.

development of new institutions to support the growth of new industries. So, regions may become victim of institutional lock-in, when the institutional structure is entirely focused on the specific needs of the principal industries. This is reinforced when the local political elite is completely interwoven in the tight and rigid network described in Section 4. Olson (1982) referred to this as ‘institutional sclerosis’, when powerful special-interest organizations take over a local economy and slow down the capacity of a region to reallocate resources to new activities. Specialized regions may be subject to what Grabher (1993) called ‘political lock-in’, which refers to a conservative culture of long-standing relations between vested players like large firms and public authorities that show rent-seeking behavior and actively opposes radical change. A prime example is Detroit (Hill et al. 2012).

Thus, the possibilities of institutional adaptability may be higher in regions with a more heterogeneous industrial mix. In those circumstances, it may be harder for industries or powerful players to monopolize and dominate the design of regional institutions (Neffke et al., 2011b). So, diversified regions may be in a better position to make institutional change in order to support new growth paths, as one expects less opposition in these regions from vested players, and there might be more redundant institutional capacity around that can be put to unexpected uses (Grabher 1993). This might come close to what Hollingsworth (2009) called a ‘weak’ institutional environment which allows for greater variation in organizations and the development of more radical innovations, as opposed to strong and rigid institutional environments. However, in diversified regions, the other side of trade-off may prevail (that is, adaptability may go at the expense of adaptation), as there is lack of institutional cohesiveness with too many interests that harms local institutional focus, coordination and control. In other words, regions with such a fragmented institutional structure may well be more responsive to experimentation and newcomers, but the problem is that these creative actions will remain unnoticed and too isolated, as the new institutions have to be built from scratch, and local public support is hard to get due to many competing local claims.

The question is how to tackle these trade-offs between adaptation and adaptability in regions in institutional terms, as to enhance the resilience of regions¹⁵. We propose that some industries and knowledge bases may have complementarities or overlap in institutional terms, that is, they have similar, though not identical institutional requirements, like a new patent regulation may be relevant for a whole set of technologies and industries. We expect that regions with such institutional overlap across industries are better equipped to exploit new recombinations between those industries and to develop new growth paths, without compromising on adaptation, as the overarching institutional framework is not fundamentally challenged, and can even be put to use effectively to accommodate the demands of new industries. In this case, adaptability does not preclude adaptation, because the region can keep its overall institutional focus, as new institutions do not have to be built from scratch but can draw on existing institutions, and little local resistance to institutional change is expected.

This comes close to the notion of institutional complementarity (Amable 2000; Hollingsworth 2000; Hall and Soskice 2001), which is about institutions that reinforce each other and make one another more efficient (see also Grillitsch 2014). The Varieties of Capitalism literature is very relevant here, as it claims that institutional systems at the national level make feasible

¹⁵ Wink (2012) distinguishes between two types of institutions that embody the conflict between adaptation and adaptability. Path-dependent institutions keep their stability for a time, but due to their inability to change, they collapse and lose their functions. In contrast, resilient institutions are capable to adjust to new challenges caused by external disruptions or internal conflicts, and to maintain their functionality which is to stabilize expectations.

only a kind of economic specialization, like Germany's focus on high-quality engineering, and the focus of the US on science-driven industries (Hall and Soskice 2001). Moreover, this is in line with literature that argues that institutional change is often created alongside existing structures. Scholars have proposed taxonomies of institutional change like institutional layering and conversion that fall under this type of institutional change (Thelen 2003; Streeck and Thelen 2005; Martin 2010). So, developing new growth paths in regions does not necessarily mean breaking with the past. On the contrary, Ebbinghaus (2009) defines path departure as a partial renewal of current institutions that does not challenge or redirect its underlying core principles. Strambach (2010) proposed the notion of institutional *plasticity* to emphasize that an institutional system has a range of options for new paths within the dominant institutional framework. Agents can deviate from the established path by creating new institutions but not breaking with the overarching institutional system (Strambach and Klement 2012; special issue in *Zeitschrift für Wirtschaftsgeographie* 2013).

Earlier, we discussed that new industries tend to branch out of existing activities to which new industries are technologically related. The underlying idea was that the local industrial structure makes the emergence of some (but not all) industries more feasible, depending on whether they are technologically related to other local industries. A similar idea can be applied to institutions, as the existing institutional legacy (e.g. at the national and regional level) sets sharp limits to the type and direction of institutional change. This makes the creation of some institutions more feasible, depending on whether they are coherent with the existing set of institutions (again, at various spatial scales), while other combinations of institutions will not work (Amable 2000). Taking these ideas together, we expect that regional branching is facilitated when new industries require institutions similar (though not identical) to those of other related industries in the region, so new institutions do not have to build from scratch, and this new institution-building will not be contested heavily by (local) agents.

There is a recurrent claim in the literature (e.g. Acemoglu et al 2014) that some overarching institutional frameworks are believed to be more responsive to radical change. Hall and Soskice (2001) claimed that the institutional system in liberal market economies is more inclined to generate radical innovations than coordinated market economies, as the latter are characterized by specific assets that cannot be readily put to another use (as opposed to generic assets in the liberal variant)¹⁶. Menzel and Kammer (2012) claimed that the formation of new industries is therefore more tightly connected to established resources and industries in coordinated market economies. Boschma and Capone (2014) have argued that the overarching institutional framework will affect the intensity but, above all, the nature of industrial diversification. Their preliminary findings show that some macro-institutions enable countries

¹⁶ Hall and Soskice (2001) did not mention explicitly which of the two institutional systems is more capable of developing new growth paths. All they claimed is that both institutional systems generate different economic specializations that reflect a different nature of innovation. Liberal market economies, for instance, specialize in science-driven sectors like biotech, where radical types of innovations are especially important. What is missing but crucial for our understanding of regional resilience are the following questions: (1) is there more technological and industrial variety in liberal market economies, as these are considered to have a higher propensity to induce radical change?; (2) are liberal market economies better capable of developing new growth paths, as these are considered to concentrate more on radical change, whereas coordinated market economies tend to focus more on incremental change? (see e.g. Taylor, 2004; Akkermans et al., 2009); (3) if so, would there be more of a tendency in liberal market economies to diversify in unrelated activities, while coordinated market economies would focus on more related diversification?; and (4), are liberal market economies better equipped to support institutional change to enable the development of new industries?

to make a jump in their industrial evolution over time: their overarching institutional framework gives countries more freedom to diversify in more unrelated activities.

As stated before, the role of the state has been neglected in the resilience literature (Bristow 2010; Hassink 2010, Pike et al, 2010). Davies (2011) has made a laudable attempt to assess the effects of the last economic downturn on the resilience of European regions by looking at their dependence on the public sector. Studies have investigated whether some governance structures in regions (like civic capital or quality of government) can better accommodate and facilitate change (see e.g. Christopherson et al. 2010; Pendall et al. 2010; Rodríguez-Pose and Di-Cataldo 2014). Scholars have explored pro-active public strategies to enhance resilience of regions (Bailey and MacNeill 2008; Hill et al., 2012). According to Wolfe (2010), resilient regions engage in collaborative processes to implement change within the constraints dictated by their existing regional assets. In other words, the past conditions the range of possibilities that are available to regions. Other studies have focused more on the role of human agency and institutional leadership (Sotarauta et al. 2012; Bristow and Healey 2013), as key actors (either individually or collectively) can make changes in institutions, rather than being subject to an institutional environment that is favorable or not (MacKinnon et al. 2009; Gertler 2010). Shocks can also trigger new leadership that brings about the necessary changes. Wink (2012) has conceptualized institutions as embedded into complex feedback interactions with other institutions. This makes it necessary to look at institutional change and adaptive capabilities on different levels and with different speed potentials. In this respect, Swanstrom (2008) claimed that “a resilient system is one where ... smaller scale processes are able to deal with the stressor without having to reorganize the larger scale structures” (p. 9).

To sum up, regional resilience is enhanced in institutional terms when a region has: (1) a loosely coherent institutional structure. In this context, there is institutional diversity but still overlap across local industries that favors institutional change to enable the development of new growth paths (adaptability), while the new institutions can build on and expand within an overarching institutional framework (adaptation); (2) an overarching institutional framework that is more open to radical change (adaptability), but that still provides a supportive basis to facilitate institutional change (adaptation); (3) key institutional agents that can take the lead and implement the necessary institutional reforms when confronted by shocks.

6. Synthesis and discussion

It is impossible to give a full and comprehensive account of what makes a region resilient. We limited our attention to the meaning of resilience as the extent to which a shock may affect the ability of regions to develop new growth paths. Focusing on structural change and long-term economic renewal, we left behind an equilibrium concept of resilience, in which resilience is simply regarded as a response to shocks and a move back to a steady state. Instead, we propose an evolutionary concept of resilience that connects shocks to the determinants of regions to develop new growth paths.

Taking an evolutionary perspective, we redefined regional resilience in terms of adaptation and adaptability. We claimed that the resilience of regions is strongly rooted in their past legacy, as embodied in their industrial, network and institutional structures. While adaptation has been closely associated with the notion of path dependency (either in terms of positive or negative lock-in), there is a tendency in the resilience literature to define adaptability as a move away from path dependency, as if new growth paths are detached from their past, as if

regions need to deviate from their past to achieve that, and as if path dependency will cause insurmountable problems of adjustment. Instead, we argued that history is key to understand how regions develop new growth paths, as its past not only sets limits but also provides opportunities for making new combinations and diversifying into new pathways.

We made an attempt to develop a more comprehensive concept of regional resilience that captures industrial, network and institutional dimensions of regions that have been either ignored in the resilience literature, or treated separately. This enabled us to separate more sharply causes of regional resilience from their effects. We have treated structures of industries (e.g. related variety), networks (e.g. a loosely coupled network) and institutions (e.g. a loosely coherent institutional structure) as the main determinants of regional resilience. We moved away from the meaning of resilience as the ability of regions to recover from a shock, and we have redefined regional resilience in terms of the impact of a shock on the capacity of a region to develop new growth paths. What is crucial for our understanding of regional resilience is to investigate how a shock in the industrial structure (e.g. collapse of an industry), network structure (e.g. loss of a node or dissolution of a tie) and institutional structure (e.g. the erosion of a functional or dysfunctional institution) impacts on the capacity of a region to develop new growth paths. In our proposed framework, shocks can have an impact on all three determinants, like lower related variety, the loss of a public node that bridged the core and periphery in a network, or the erosion of trust or property rights. This also requires that the three determinants of regional resilience become more fully integrated, as a change in an institution may lead to a change in the knowledge network which subsequently leads to a change in the industrial structure that all affect regional resilience.

Our attempt to propose an evolutionary concept of regional resilience opens up a whole set of new research challenges (e.g. Balland et al. 2014). In the remainder, we briefly discuss a few.

We argued that the industrial composition matters for regional resilience. First, we have to test empirically our claim that regions with a high variety of skill-related industries with few local input-output relationships have indeed a stronger capacity to respond to sector-specific shocks. And will redundant labour be employed more readily in local skill-related industries, and will labour flows across skill-related industries lead to new and unexpected combinations (Boschma et al. 2013a)? Second, studies have reported that regions with related variety have higher economic growth rates (Frenken et al., 2007; Boschma et al., 2012), but no study, to our knowledge, has yet tested whether diversified regions, as compared to specialized regions, diversify more successfully into new (related) activities¹⁷. Third, there is a need to examine systematically the extent to which specialized regions are resilient in the long-run, and how they prevent or overcome a state of negative lock-in. How successful are specialized regions to develop new growth paths, to what extent do they exploit their specialized knowledge base when diversifying into new activities, and to what extent do they draw on resources from other regions and recombine those with their local knowledge base? Fourth, studies on regional resilience have to test empirically whether regions with related variety or unrelated variety have a stronger capacity to develop new growth paths, or whether a mixture of related and unrelated variety is required. This is closely connected to the question whether regions can keep relying on related diversification to sustain development in the long-run, or whether regions have to diversify in more unrelated activities to remain resilient. There is no *a priori* reason to believe that it is inevitable that related diversification in a region will come to a halt, as (combinations of) existing industries might give birth to new industries in an almost

¹⁷ There are studies though that have demonstrated that young industries are more likely to be found in diversified regions, while more mature industries tend to be located in specialized regions (Neffke et al., 2011b).

endless sequence. However, unrelated diversification (i.e. a jump into a completely new field) rather than related diversification might be needed to secure long-term regional development, as regions have a tendency to diversify into related activities and shake off unrelated activities (Neffke et al., 2011a). This would also shed light on the nature of these two types of new growth paths (i.e. new combinations between predominantly related activities, and new combinations between previously unrelated activities). Finally, it is crucial to investigate which types of agents (e.g. new firms, diversifying firms, relocating firms) are key drivers behind such new growth paths in regions. Findings suggest that new establishments, especially from outside the region, induce structural change in regions (Neffke et al. 2014).

We also argued that the structure of knowledge networks matters for regional resilience, but there are few regional studies that have tested this claim. First, there is a need to determine whether local knowledge networks with optimal levels of proximity on its various dimensions (geographical, organizational, cognitive, social, institutional) are indeed more resilient to shocks, and whether these networks have a higher capacity to develop new growth paths. In theory, one can think of many possible combinations of network structures in such a proximity framework, but we need to explore which combinations are more resilient. Second, we have to test whether core/periphery network structures in regions that consist of embedded relationships within cliques and strategic ‘structural hole’ relationships among cliques are indeed more resilient (Fleming et al. 2007). And are boundary-spanning industries affecting the capacity of a region to develop new growth paths? And third, few studies have investigated whether related industries in regions actually connect and exchange knowledge and skills. Another promising research line is to investigate whether labour mobility between skill-related industries boosts regional resilience (Heurmann 2009; Boschma et al. 2013b).

We have also claimed that institutions matter for regional resilience, but this needs to be worked out more thoroughly, especially with regard to the impact of shocks. First, there is a need to investigate more systematically which institutional structures in regions are more responsive to develop new growth paths. One way to do that is to investigate a direct relationship with the quality of government in regions (Rodríguez-Pose and Di-Cataldo 2014). And is a region with what we have called a loosely coherent institutional structure more likely to develop new growth paths? Second, to what extent is institutional change required for the development of new growth paths in regions, and to what extent are pre-existing institutions in regions shaping that process of institutional change (Streeck and Thelen, 2005)? Are diversified regions more successful in restructuring their institutions, and which types of agents (political leaders, private entrepreneurs, coalitions of private and public players) are driving institutional change (Sotarauta et al. 2012)? Third, to exploit the potential of related variety in a region, institutions are needed to connect related industries and make new combinations. This recombinatory process is facilitated when sector-specific institutions have institutional overlap. Earlier, we discussed that new industries tend to branch out of local activities to which new industries are technologically related. Yet, we have little understanding of which institutional factors facilitate this branching process. It could be that regions branch in new related industries because these require institutions similar to those that sustain related industries. To what extent is there institutional overlap between industries in a region, can we actually define and measure institutional overlap, and if so, is such institutional overlap in a region more likely to generate new recombinations between industries? And to what extent do related industries draw on similar sets of institutions? This would provide an institutional explanation (besides cognitive proximity) for why related industries might benefit from each other’s co-presence at the regional level. And fourth, there is a need to investigate how macro institutional structures affect the intensity and nature of diversification

in countries and regions. Boschma and Capone (2014) have found preliminary evidence that some macro-institutions enable countries to make a jump in their industrial evolution, and thus give countries freedom to diversify in more unrelated activities. This has major consequences for the long-term resilience of regions, as shocks might lead to instability in macro-institutions that could undermine the capacity of regions to develop new growth paths.

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