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Multi-scalar knowledge bases for new regional industrial path development: Toward a typology

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Abstract: The topic of new regional industrial path development has recently received increasing attention in economic geography. The core idea is that actors in a specific region mobilize both intra-regional and extra-regional resources, especially knowledge, to develop a new regional industrial path. However, the extant literature has not yet fully explored how actors in different types of regions mobilize different forms of knowledge at various spatial scales to develop different types of paths. To fill this gap, we establish an analytical framework combining four key theoretical concepts, that is, new regional industrial path development, regional innovation systems, differentiated knowledge bases and multi-scalar knowledge sourcing. Drawing on this framework, we propose a typology distinguishing six scenarios.

Key words: new regional industry path development, regional innovation system, differentiated knowledge base, knowledge sourcing, multi-scalar

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1 Introduction

Nurturing new industries and upgrading established ones to promote regional structural change has attracted interest from both academia and politics. In economic geography, this topic has received much attention in the paradigm of evolutionary economic geography (EEG), which deals with the question of 'how the process of path creation and path dependence interact to

shape geographies of economic development and transformation' (Boschma & Martin, 2007, p. 540). Most of the scholarly work in EEG initially focused on endogenous-led regional industrial development. For instance, Martin (2010) argued that a new path is conditioned by preexistent regional economic and institutional endowments. Similarly, Boschma & Frenken (2011) suggested that new regional industries tend to emerge in regions hosting technologically related industries. Recently, more and more scholars have called for a move beyond this regional focus by elaborating on the role of extra-regional sources in regional industrial path development (Dawley, 2014; Binz, Truffer & Coenen, 2016; Boschma, 2017; Trippl, Grillitsch & Isaksen, 2018; Hassink, Isaksen & Trippl, forthcoming). The principal claim of this recent work is that actors in a specific region mobilize both intra-regional and extra-regional resources, especially knowledge, to develop a new regional industrial path.

However, three research gaps remain. First, while acknowledging the importance of both intra- and extra-regional sources, research has been largely mute on how these multi-scalar sources influence the probability of developing a specific type of path in different kinds of regions. For instance, Isaksen & Trippl (2016) developed a typology that elaborates the relations between different forms of path development and various types of regions, but they did not explicitly discuss the role of multi-scalar sources in this typology. Second, knowledge is the crucial resource for new path development. However, the extant research considers knowledge as a whole and does not differentiate between the forms of knowledge that strongly influence the possible strategies of knowledge mobilization. For example, Trippl et al. (2018) presented two forms of knowledge mobilization on the extra-regional scale (i.e., the arrival of actors from outside the region and extra-regional knowledge linkages) but they did not further discuss how different kinds of knowledge impact the availability of these two forms of knowledge sourcing. Third, due to the above-mentioned two gaps, the extant literatures have not yet explored how actors in different types of regions mobilize different forms of knowledge from various spatial scales to develop different types of paths. This, to some extent, echoes several key avenues in the field of regional industrial path development identified by Hassink et al. (forthcoming, p. 7):

> 'We see great potential in paying more attention to the multi-scalarity of sources, relations and influences on new path development in future research. How does the significance of non-local sources and relations vary between different industries? What are the differences of non-regional sources and relations in new path development in different kinds of regions […]?'

In order to bridge the above three gaps, this paper establishes an analytical framework, which builds on four theoretical concepts, to answer the following three questions:

- How do the actors in various types of regions mobilize *knowledge from different spatial scales* to develop *different types of paths*?
- How do the actors in various types of regions mobilize *different types of knowledge from different spatial scales*?
- Combining the above two questions, how do actors in *various types of regions* mobilize *different types of knowledge* from *various spatial scales* to develop *different types of paths*?

The remainder of this paper is structured as follows. Section 2 introduces and discusses the four key concepts underlying the analytical framework. Section 3 establishes an analytical framework and proposes a typology. Section 4 summarizes the main findings of the paper and draws some lessons.

2 Review of the literature

Before introducing the analytical framework, this section analyzes the four primary theoretical concepts on which the theoretical framework is built, namely new regional industrial path development, regional innovation systems, differentiated knowledge bases and multi-scalar knowledge sourcing.

2.1 New regional industrial path development

New regional industrial path development refers to the emergence and development of new economic activities in a region (Hassink et al., forthcoming; MacKinnon, Dawley, Pike & Cumbers, 2019a). In principle, regional industrial path development is understood as the process of mobilizing and anchoring resources, especially knowledge resources (Binz et al., 2016; Trippl et al., 2018; MacKinnon et al., 2019a). Based on this understanding, four types of new regional industrial path development have been distinguished, i.e., path upgrading, path diversification, path importation and new path creation (Isaksen & Trippl, 2016; Grillitsch, 2018; Grillitsch, Asheim & Trippl, 2018). Path upgrading means developing a new path within an established industry. It results from adding new knowledge to the existing sector. Path diversification refers to the development of a new industry that is the outcome of combining preexisting knowledge and newly mobilized knowledge. Although both path upgrading and path diversification rely on preexisting and new knowledge, path upgrading remains in the existing industry, while path diversification creates a new sector. Unlike path upgrading and path diversification where preexisting knowledge plays a crucial role, path importation and new path creation are mainly based on new, rather than on existing knowledge. More specifically, path importation refers to the emergence of a new industry that almost entirely consists of new knowledge imported from outside the region. New path creation concerns the development of an entirely new industry based on the commercialization of scientific discoveries, new business models or social innovation. The main difference between path importation and new path creation is that the former is new to the region but not new to the world, while the latter is new to the world.

2.2 Regional innovation systems

Following Grillitsch & Trippl (2016), and Isaksen & Trippl (2016), we adopt the regional innovation system (RIS) concept to present different types of regions. Distinguishing between organizationally thin and thick versus specialized and diversified, three types of RISs are identified (Tödtling & Trippl, 2005; Isaksen & Trippl, 2016). The first type of RIS, described as an organizationally thin RIS, often has a few weak organizations, either firms or non-firm actors. It thus exhibits a lack of critical mass in any specific industry, let alone a diverse regional industrial structure. Typical regions are rural or peripheral areas. The second type is the organizationally thick and specialized RIS, such as old industrial areas and specialized clusters. It is characterized by the presence of strong organizations that concentrate on one sector, leading to a specialized regional industrial structure. The last type is the organizationally thick and diversified RIS. It is usually well endowed with a set of strong organizations as well as diversified industries rather than featuring specialization. Such RISs are often found in metropolitan areas and innovation hubs.

2.3 Differentiated knowledge bases

In economic geography, kinds of knowledge are often analyzed using the concept of differentiated knowledge bases (DKB) (Martin & Moodysson, 2013; Grillitsch et al., 2018; Plum & Hassink, 2011). In line with this, our study draws on the literature of DKB which distinguishes between analytical, synthetic and symbolic knowledge bases (Asheim & Coenen, 2005; Asheim, Coenen & Vang, 2007). Analytical knowledge bases mainly depend on explicit and codified knowledge (Asheim & Coenen, 2005) and may thus be created and transferred at the global scale through scientific communities and industry-university collaborations (Martin, 2013; Martin & Moodysson, 2013). This type of knowledge is usually observed in science-

based industries, e.g., biotechnology, pharmaceutical industry, electronics and solar PV. Synthetic knowledge bases rely more on tacit knowledge from producer-user interactions, on-the-job training and experience (Asheim & Coenen, 2005). As a result, geographical proximity, facilitating the interactions between suppliers and customers, is crucial (Martin, 2013; Martin & Moodysson, 2013). This knowledge plays an essential role in engineering-based industries, such as the food industry, automobiles and wind power. Symbolic knowledge bases concern cultural and aesthetic values that are highly context-specific and rely on temporary teams of skilled people to fulfill one-off projects (Martin & Moodysson, 2013; Plum & Hassink, 2014). Geographical proximity is thus considered crucial as it facilitates understanding of both the culture and know-who (Martin, 2013; Martin & Moodysson, 2013). Symbolic knowledge bases tend to be observed in creative industries, such as design, advertising, new media, film, music and publishing. In brief, whereas synthetic and symbolic knowledge bases prefer the regional scale, the creation of analytical knowledge bases can move beyond the region at hand.

2.4 Multi-scalar knowledge sourcing

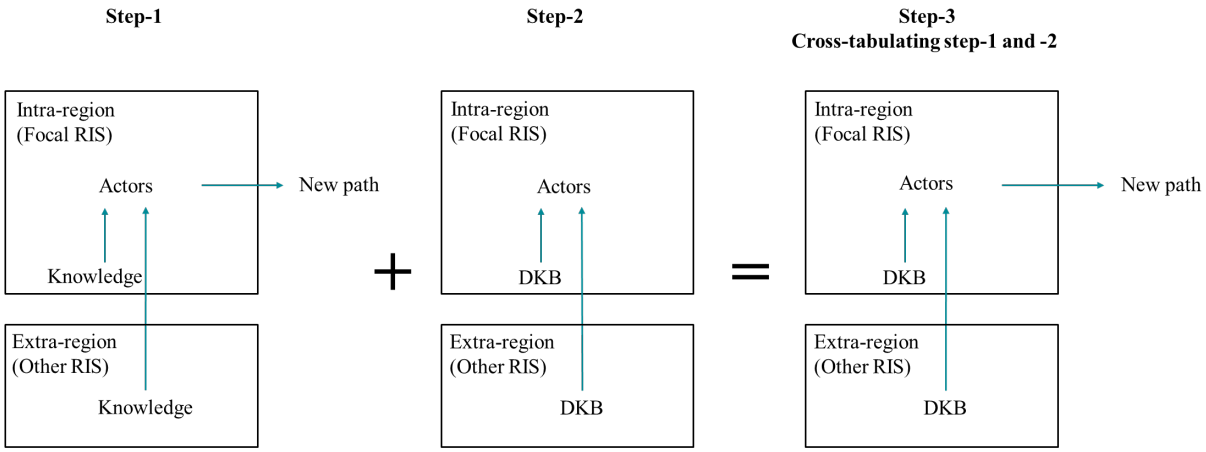
Knowledge can be mobilized and sourced at different spatial scales. Trippl et al. (2018) distinguished between two spatial dimensions of knowledge sourcing, i.e., the arrival of new actors from outside the region and extra-regional knowledge linkages. In this paper, we add one more form: intra-regional knowledge linkages. First, the arrival of new actors from outside the region refers to importing new knowledge from the extra-regional area into the region. It tends to be associated with the relocation of firms or R&D organizations and the mobility of highly skilled people (Saxenian, 2006; Trippl et al., 2018). Second, extra-regional knowledge linkages involve accessing knowledge through trans-regional interactions that often involve market linkages (e.g., buying intermediate goods and machinery, licenses, contract research and consulting), formal networks (e.g., research consortia and epistemic communities) and informal networks (e.g., informal contact based on social proximity and/or temporary

geographical proximity by, for instance, participating in fairs and conferences) (Trippl, Tödtling & Lengauer, 2009; Trippl et al., 2018). Third, as market linkages, formal networks, informal networks and the mobility of highly skilled people can all be available within the region, we consider intra-regional knowledge linkages as an additional spatial dimension.

3 Linking four concepts to build the analytical framework

In order to connect the regional innovation system (RIS), differentiated knowledge bases (DKB), multi-scalar knowledge mobilization and new regional industrial path development, we establish a three-step analytical framework (Figure 1). In this analytical framework, our starting point is the actors in a specific region who are aiming to create a new path. Based on this perspective, the three analytical steps are as follows. First, we analyze how the actors in different types of regions (RISs) mobilize knowledge from different spatial scales (intra-region and extra-region) to develop different types of new paths. Second, as knowledge consists of DKB, we discuss how the actors in different types of regions (RISs) mobilize different types of knowledge (DKB) from different spatial scales (intra-region and extra-region). Finally, combining the above two steps, we discuss how actors in various types of regions (RISs) mobilize different types of knowledge (DKB) from various spatial scales (intra-region and extra-region) to develop different types of paths. The following three subsections will discuss these three steps. Furthermore, the whole picture will be illustrated by reference to some detailed cases in the final subsection.

Figure 1. An analytical framework for new regional industrial path development.



Notes: RIS = Regional innovation system; DKB = Differentiated knowledge bases

Source: authors (2019).

3.1 Multi-scalar knowledge for new path development in different RISs

The regional knowledge pool in a particular region conditions the options for new path development when this mainly relies on intra-regional sources. In other words, due to heterogeneity in the availability of intra-regional knowledge, different RISs favor different types of endogenous-led new paths (see step-2 in Figure 1 and the 2nd column in Table 1). More specifically, the organizationally thick and diversified RISs offer favorable conditions for path upgrading, path diversification and new path creation, because this type of RIS hosts a variety of new knowledge. The latter may be used to modernize the existing industry for path upgrading, recombined with existing knowledge for path diversification, and facilitated radical innovation for new path creation (Isaksen & Trippl, 2016; Grillitsch, Asheim, & Trippl, 2018). In contrast, in thick and specialized RISs and thin RISs it tends to be more difficult to develop a new path, as the local preconditions offer few new resources (Tödtling & Trippl, 2005; Isaksen & Trippl, 2016; Boschma, 2015). Instead of nurturing a new path, this type of RIS often experiences path extension resulting from incremental innovation, which is based on the

use of existing technology and limited new knowledge (Isaksen & Trippl, 2016; Grillitsch, Asheim, & Trippl, 2018).

As new path development relies on both intra-regional and extra-regional sources, the scarcity of regional knowledge pools may be compensated by accessing extra-regional sources (see step-2 in Figure 1 and the 3rd column in Table 1). First, as the knowledge in new path creation is not yet codified and thus face-to-face communication is necessary, exogenous-led new path creation can hardly succeed (Grillitsch et al., 2018). As a result, the feasible options might be path upgrading, path diversification and path importation. Second, the probability of exogenous-led path upgrading, path diversification and path importation varies in different types of regions. In thin RISs, path upgrading is available as thin RISs have potential to upgrade their small and under-developed industry into a well-developed one (Humphrey & Schmitz, 2002; Montresor & Quatraro, 2017). Path importation is also possible, as the new industry in thin RISs tend to rely on the arrival of extra-regional actors (Yang, 2009; Nam, 2015). Path diversification is more difficult for thin RISs, as it requires substantial firms and R&D organizations in at least one industry, which the thin RISs cannot offer (Grillitsch & Trippl, 2016). In contrast, in thick and diversified RISs and thick and specialized RISs we find at least one well-developed sector that offers favorable conditions for path diversification. With regard to path upgrading and path importation, they are feasible in thin RISs, let alone thick and diversified RISs and thick and specialized RISs, which possess better endowments.

Table 1. Multi-scalar knowledge for new path development in different RISs

Type of region	Intra-region	Extra-region
Thick and diversified RIS	**Feasible new paths** • Path upgrading • Path diversification • New path creation	**Feasible new paths** • Path upgrading • Path diversification • Path importation
Thick and specialized RIS	**Feasible new paths** • Hardly exist (favoring path extension rather than new path development)	
Thin RIS		**Feasible new paths** • Path upgrading • Path importation

Source: authors (2019).

3.2 Mobilizing differentiated knowledge bases from different geographical scales

Differentiated knowledge bases, varying with their geographical attributes, influence knowledge mobilization on different spatial scales (see the columns in Table 2). First, synthetic and symbolic knowledge bases tend to be transferred at the local scale (Martin, 2013; Martin & Moodysson, 2013), geographical proximity is thus the precondition for these two types of knowledge bases. Therefore, when sourcing synthetic and symbolic knowledge bases on the regional scale, intra-regional knowledge linkages are available thanks to spatial proximity. When accessing these knowledge bases on the extra-regional scale, a possible strategy is the arrival of actors from outside the region, as this can guarantee geographical proximity within

the region. In contrast, extra-regional knowledge linkages occur between the region and extra-region, and cannot meet the need for spatial proximity of the synthetic and symbolic knowledge bases. Second, knowledge produced in analytical knowledge bases can be transferred either at the regional or extra-regional scale (Martin, 2013; Martin & Moodysson, 2013). Due to this flexibility, we propose that three types of knowledge mobilization are all available for analytical knowledge bases. In other words, when mobilizing analytical knowledge bases on the regional scale, intra-regional knowledge linkages are feasible. In the case of the extra-regional scale, the available options are the arrival of actors from outside the region and the extra-regional knowledge linkages.

Concerning the type of region (see the rows in Table 2), Trippl et al. (2018) have argued that both the extra-regional knowledge linkages and the arrival of actors from outside the region are available for each type of RIS, although both are more difficult for thick and specialized RISs and thin RISs. In the latter types of regions the capabilities to attract and access external knowledge are namely lower than in the thick and diversified RISs. Since extra-regional knowledge linkages are possible in each type pf RIS, we further argue that intra-regional knowledge linkages are available for all three types of RISs, as intra-regional knowledge linkages, which benefit from geographical proximity, are more easily to occur than extra-regional knowledge linkages that lacking geographical proximity.

Table 2. Sourcing differentiated knowledge bases from different geographical scales.

Type of region	Intra-region	Extra-region	
	Analytical, synthetic or symbolic knowledge bases	**Analytical knowledge bases**	**Synthetic or symbolic knowledge bases**
Thick and diversified RIS	***Knowledge sourcing*** • Intra-regional knowledge linkages	***Knowledge sourcing*** • The arrival of actors from outside the regions • Extra-regional knowledge linkages	***Knowledge sourcing*** • The arrival of actors from outside the regions
Thick and specialized RIS	***Knowledge sourcing*** • Intra-regional knowledge linkages		
Thin RIS			

Source: authors (2019).

3.3 Multi-scalar DKB for path development in different RISs

By combining Tables 1 and 2, this paper develops six scenarios[1] in Table 3. Below we present some empirical cases in each scenario that illustrate how actors in various types of regional types mobilize different types of knowledge from various spatial scales to develop different types of paths. As industrial paths are continually evolving, all cases are time-based. Our focus is to reveal how each scenario occurred within a specific period. To judge about the long-term success of each case goes beyond the scope of this paper.

Table 3. Multi-scalar knowledge bases for path development in different RISs.

<table>
<tr><th rowspan="2">Type of region</th><th>Intra-region</th><th colspan="2">Extra-region</th></tr>
<tr><th>Analytical, synthetic or symbolic knowledge bases</th><th>Analytical knowledge bases</th><th>Synthetic or symbolic knowledge bases</th></tr>
<tr><td>Thick and diversified RIS</td><td>Scenario-1
Feasible new paths
• Path upgrading
• Path diversification
• New path creation
Knowledge sourcing
• Intra-regional knowledge linkages</td><td rowspan="2">Scenario-2
Feasible new paths
• Path upgrading
• Path diversification
• Path importation
Knowledge sourcing
• The arrival of actors from outside the regions
• Extra-regional knowledge linkages</td><td rowspan="2">Scenario-3
Feasible new paths
• Path upgrading
• Path diversification
• Path importation
Knowledge sourcing
• The arrival of actors from outside the regions</td></tr>
<tr><td>Thick and specialized RIS</td><td rowspan="2">Scenario-4
Feasible new paths
• Hardly existed (favoring path extension rather than new path development)
Knowledge sourcing
• Intra-regional knowledge linkages</td></tr>
<tr><td>Thin RIS</td><td>Scenario-5
Feasible new paths
• Path upgrading
• Path importation
Knowledge sourcing
• The arrival of actors from outside the regions
• Extra-regional knowledge linkages</td><td>Scenario-6
Feasible new paths
• Path upgrading
• Path importation
Knowledge sourcing
• The arrival of actors from outside the regions</td></tr>
</table>

Source: authors (2019).

Scenario-1

Thick and diversified RISs mobilizing intra-regional analytical, synthetic or symbolic knowledge bases

In scenario-1, thick and diversified RISs host diverse endogenous knowledge leading to the potential for path upgrading, path diversification and new path creation (see Table 1). As most of the knowledge is accessed within the region, the intra-regional knowledge linkages play a crucial role (see Table 2). Detailed examples are as follows. Concerning path upgrading, an interesting example is the digital transformation of the banking sector in Beijing. Intra-regional collaboration between big banks and technology companies played an important role in upgrading the banking sector (South China Morning Post, 2017). Path diversification is also possible when relying on intra-regional knowledge linkages. For instance, the emergence of the video game industry in Tokyo resulted from local interaction between the consumer electronics industry and the cartoons sectors (intra-regional knowledge linkages) (Aoyama & Izushi, 2003). As regards new path creation, the rise of the ride-sharing industry in Silicon Valley mainly resulted from lead firms, such as Uber and Lyft, recombining regional IT technologies with the new business model of the sharing economy (intra-regional knowledge linkages) (Dudley, Banister & Schwanen, 2017).

Scenario-2

Besides the regional sources, actors can also mobilize extra-regional analytical knowledge bases for new path development. In this scenario, both the thick and diversified RISs and the thick and specialized RISs host at least well-developed industry that offers conditions for path upgrading, path diversification and path importation (see Table 1). Also, as shown in Table 2, the exogenous analytical knowledge bases can be accessed through the arrival of actors from outside the region, as well as extra-regional knowledge linkages. As this scenario consists of two types of RISs, we present a selection of cases accordingly.

Thick and diversified RISs mobilizing extra-regional analytical knowledge bases

A typical example of path upgrading is the development of the memory industry in Seoul Metropolitan Area. Memory is a segment of the semiconductor industry wherein knowledge is analyzed and codified (Binz & Truffer, 2017; Shin, 2017). To upgrade from assembly to integrated manufacturing, the industry mobilized DRAM-related technology by recruiting engineers returning from the US (arrival of actors from outside the region), importing DRAM equipment from the US and Europe (extra-regional knowledge linkages), and collaborating with high-tech US firms (extra-regional knowledge linkages) (Hobday, 1998; Shin, 2017; Yeung, 2016).

Path diversification is illustrated by the example of the personal computer (PC) industry in Taipei-Hsinchu, which diversified into the mobile phone industry. The mobile phone could be simply understood as a combination of a set of analytical knowledge bases, especially PC-related technology and telecommunication technology. Since the PC industry in Taipei-Hsinchu lacked telecommunications knowledge, this had to be mobilized from outside. On the one hand, as telecommunications are embedded in hardware and software, the lead firms in PC with sufficient resources could purchase these components in order to access the target technology (extra-regional knowledge linkages) (Chu, 2009). On the other hand, as there were initially no telecommunication experts, foreign experts were invited to Taiwan to teach local engineers (arrival of actors from outside the region) (Lee & Saxenian, 2008).

One interesting example of path importation is the development of solar photovoltaics (PV) in Wuxi, one of the most important solar PV industry locations in the metropolitan region of Yangtze River Delta in China. The solar PV industry consists of analytical knowledge bases like materials sciences and nanotechnology (Binz & Truffer, 2017; Binz & Anadon, 2018). The development of industry in Wuxi heavily depended on returnee entrepreneurs who brought solar PV-related knowledge from overseas, especially Australia (arrival of actors from outside the region). The purchase of turnkey-based machinery from overseas, particularly Germany, was also crucial (extra-regional knowledge linkages) (Binz & Anadon, 2018).

Thick and specialized RISs mobilizing extra-regional analytical knowledge bases

Path upgrading may be represented by Värmland, Sweden, which is regarded as a thick and specialized RIS where the dominated pulp and paper industry has developed over almost a century. In the last decade, more and more analytical knowledge bases, such as biotechnology and digital technology, have played an important role in industrial transformation in this region (Bellandi, Chaminade & Plechero, 2018). Most of these analytical knowledge bases were accessed from outside the region by cooperating with the national university to develop digital control technology for production processes (extra-regional knowledge linkages) as well as purchasing non-local digital technologies to serve the demands of the forest bio-economy (extra-regional knowledge linkages) (ibid.).

One interesting example of path diversification is Shunde, China, that diversified from home appliances into the robotics industry. Shunde, located in southern China, is a thick and specialized RIS dominated by the home appliance sector. As demand in the Chinese robotics market has increased, Shunde recently diversified into this industry. On the one hand, the local players in Shunde had a track record of success in home appliances and thus had accumulated much knowledge related to consumer electronics. On the other hand, to access complementary knowledge, especially related to automation-related technologies, the biggest player in Shunde, Midea, bought the German global lead firm Kuka (extra-regional knowledge linkages), and jointly invested in the robot industrial park in Shunde with Kuka (the arrival of actors from outside the region) (South China Morning Post, 2018).

The emergence of the electronics sector in South Wales is a telling case of path importation in this scenario. In past decades, South Wales was confronted with the decline of its traditional coal and steel industries. As an initiative to transform the industrial structure of the area, one of the most important new sectors to be nurtured was electronics. As the electronics industry depends more strongly on analytical knowledge bases (Binz & Truffer, 2017), foreign inward investment is one of the available strategies. Actually, the electronics sector in South Wales was mainly fueled by the arrival of global lead firms, such as Sony Hitachi and Panasonic

(arrival of actors from outside the region) (Cooke, 2004; Simmie & Martin, 2010).

Scenario-3:

Similar to scenario-2, actors in the thick and diversified RISs can also mobilize extra-regional synthetic or symbolic knowledge bases for path upgrading, path diversification and path importation (see Table 1). However, as the extra-regional knowledge in scenario-3 involves synthetic and symbolic knowledge bases rather than the analytical knowledge bases of scenario-2, available strategies involve the arrival of actors from outside the region rather than extra-regional knowledge linkages without geographical proximity (see Table 2). As this scenario consists of two types of RISs, we present selected cases accordingly.

Thick and diversified RISs mobilizing extra-regional synthetic and symbolic knowledge bases

One typical case of path upgrading is the Istanbul apparel industry that has upgraded from OEM (Original Equipment Manufacturing) to ODM (Original Design Manufacturing). This upgrading relies heavily on design-related symbolic knowledge bases. Therefore, the Istanbul companies hired internationally recognized designers and consultants (arrival of actors from outside the region) (Tokatli & Kizilgün, 2004). With the help of these talents, the Turkish firms could improve their products' style and guarantee that their products satisfied international consumers.

One interesting example of path diversification in thick and diversified RISs is the establishment of the electric vehicle (EV) industry in Silicon Valley. The EV sector is based on trial and error (synthetic knowledge bases) among a set of technologies, such as IT, system, chassis, powertrain and battery pack (Dicken, 2015; Binz & Truffer, 2017). Although Silicon Valley hosts diversified technologies, especially IT-related technology, it could not offer every type of knowledge necessary for the EV industry, so battery pack technology had to be mobilized from outside. As a result, Tesla, the dominant player in Silicon Valley's EV industry, attracted Panasonic to relocate its battery factory from Thailand to California (arrival of actors from outside the region) (Marcus, 2015).

The emergence of the car industry, consisting of synthetic knowledge bases, in Shanghai is a typical case of path importation. It started with the arrival of Volkswagen (VW) (arrival of actors from outside the region). As synthetic knowledge bases are tacit, the successful development of the automobile industry requires tight co-location and coordination between the carmakers and its suppliers (Sturgeon, Van Biesebroeck & Gereffi, 2008). VW thus asked its suppliers to relocate to Shanghai to facilitate geographical proximity (arrival of actors from outside the region) (Depner & Bathelt, 2005). As a result, the automobile sector boomed in Shanghai.

Thick and specialized RISs mobilizing extra-regional synthetic and symbolic knowledge bases

Path upgrading in this scenario has been observed in Detroit, a typical old industrial area with a focus on the automobile industry. During the 1970s and 1980s, Detroit suffered from disinvestment caused by a shift from the Sunbelt area to low-wage locations, as well as the decline of the mass-production model (Bluestone & Harrison, 1982). However, the region was revitalized during the 1990s in terms of productivity, income and job opportunity. This upgrading was mainly caused by Japanese inward investment (arrival of actors from outside the region) (Florida, 1995). On the one hand, these Japanese firms transferred production technologies and management practices to the region; on the other hand, the existing establishments within the region quickly learned and adopted these synthetic knowledge bases (ibid.).

Path diversification in this scenario may be exhibited by the case of Bremen which diversified from the shipbuilding industry into the offshore wind sector. Bremen is a typical thick and specific RIS with a long tradition of shipbuilding. Offshore wind power is dominated by synthetic knowledge bases, especially experience-based skills and crafts (MacKinnon et al., 2019b). The diversification into the wind sector was developed by recombining some existing shipbuilding knowledge with non-local offshore wind knowledge. On the one hand, the existing shipbuilding sector offered mainly infrastructure, and to some extent technologies such as welding and assembling large components, electronics in autonomous systems and maritime

logistics (Fornahl, Hassink, Klaerding, Mossig & Schröder, 2012). On the other hand and more importantly, complementary knowledge was accessed by the arrival of key firms from other regions of Germany, such as WeserWind (foundation structures and towers), REpower (turbine production) and Powerblades (blades and rotors) (arrival of actors from outside the region) (MacKinnon, Dawley, Steen, Menzel, Karlsen, Sommer, Hansen & Normann, 2019b).

In contrast to Bremen where the offshore wind sector was developed by path diversification, the Humber region depended more strongly on path importation (MacKinnon et al., 2019b; Dawley, MacKinnon and Pollock, forthcoming). The Humber region is considered a thick and specialized RIS focusing on the fishing and maritime sectors (Dawley et al., 2019). In order to create an offshore wind industry, the Humber leveraged its natural assets (North Sea wind zones) and port-related facilities to attract investment from Siemens (arrival of actors from outside the region) (MacKinnon et al., 2019b). Unlike the path diversification in Bremen where the local shipbuilding sector offered technologies relevant to the offshore wind industry, the contribution of the fishing sector in the Humber region remained limited, and thus the mechanism of development is path importation (MacKinnon et al., 2019b).

Scenario-4

Thick and specialized RISs and thin RISs mobilizing intra-regional analytical, synthetic or symbolic knowledge bases

Due to limited new knowledge within thick and specialized RISs and thin RISs, the endogenous potential for new path development is low (see Table 1). In other words, while rarely relying on the regional knowledge pools, these regions tend to continue the old path (path extension) rather than develop a new path (path upgrading, path diversification and path importation). In order to develop a new path, these regions should move beyond the region into the extra-region to access new knowledge.

Scenario-5

Thin RISs mobilizing extra-regional analytical knowledge bases

In contrast to the thick and diversified RISs and the thick and specialized RISs in scenario-2, path diversification is not an option as it requires at least one substantial industry within the region. The feasible new paths in thin RISs are therefore path upgrading and path importation (see Table 1). The strategies of knowledge sourcing are similar to scenario-2, i.e., the arrival of actors from outside the regions and extra-regional knowledge linkages (see Table 2). Detailed examples are as follows. Regarding path upgrading, a typical case is peripheral regions upgrading their industry based on key enabling technologies (KETs) invented by core regions (Montresor and Quatraro, 2017). These KETs are technologies that can enable process, goods and service innovation throughout the economy, such as ICT, biotechnology, nanotechnology and advanced materials (European Commission, 2009). The exogenous KETs tend to be accessed by technology transfer and research collaboration (extra-regional knowledge linkage) and labor mobility (arrival of actors from outside the regions) (Montresor & Quatraro, 2017). A telling story concerning path importation is the development of the electronics industry in Dongguan, China. As aforementioned, the electronics industry mainly consists of analytical knowledge bases (Binz & Truffer, 2017). Before the 1980s, Dongguan was a rural area without any manufacturing. The emergence of the electronics sector was initiated by the relocation of Taiwanese electronics suppliers (arrival of actors from outside the region) producing, e.g., power supplies, motherboards and plastic parts (Yang, 2009).

Scenario-6

Thin RISs mobilizing extra-regional synthetic or symbolic knowledge bases

The feasible new paths in this scenario are similar to scenario-5, i.e., path upgrading and path importation (see Table 1). However, in comparison with scenario-5, the knowledge in this scenario is synthetic or symbolic rather than analytical. The possible strategy of knowledge sourcing is thus the arrival of actors from outside the region (see Table 2). A typical case of path upgrading is the footwear industry in Sinos Valley, Brazil (Humphrey & Schmitz, 2002).

In the 1960s, this area was dominated by SMEs producing for the domestic market. The upgrading was mainly driven by the arrival of international buyers (arrival of actors from outside the region). With the help of these global buyers, the local producers learned a set of synthetic knowledge bases, such as production technology, quality management on site and logistics. As a result, several large companies emerged in the 1980s. An interesting example of path importation is the establishment of the automobile industry in Shiyan, a small town in central China. The emergence of the car industry in the 1960s started with the relocation of the car industry from northern China (the arrival of actors from outside the region) (Nam, 2015).

4 Conclusions

This paper responds to the need to analyze how actors in different types of regions mobilize different forms of knowledge from various spatial scales to develop different types of paths. The findings can be summarized by six scenarios, as shown in Table 3. In scenario-1, the thick and diversified RISs host varied endogenous knowledge leading to the potential for path upgrading, path diversification and new path creation. The specific strategy of knowledge sourcing is intra-regional knowledge linkages. Conversely, due to the lack of diversified regional knowledge in thin RISs and thick and specialized RISs in scenario-4, they often experience path extension rather than develop new paths. In scenarios 2 and 3, the thick and specialized RISs and the thick and diversified RISs can mobilize extra-regional new resources for path upgrading, path diversification and path importation. Concerning differentiated knowledge bases, the analytical knowledge bases in scenario-2 can transfer globally and can thus be accessed by the arrival of actors from outside the region and by extra-regional knowledge linkages. In contrast, the synthetic and symbolic bases involve local transfer, and therefore require the arrival of actors from outside the region to guarantee geographical proximity. In scenarios 5 and 6, the thin RISs lack strong firms and R&D organizations; this

thus favors path upgrading and path importation rather than path diversification that requires at least one well-developed sector. With regard to knowledge sourcing, the analytical knowledge bases in scenario-5 can be accessed by the arrival of actors from outside the region and extra-regional linkages. Similarly, due to the requirement of geographical proximity, only the arrival of actors from outside the region is suitable for the synthetic and symbolic knowledge bases in scenario-6.

The findings of this paper have important policy implications. First of all, policies for new path development should be both place- and knowledge-sensitive. Second, policymakers, especially those in thick and specialized RISs and thin RISs, should not rely solely on endogenous sources, but should also overcome regional myopia and lock-ins (Hassink, 2010) and pay more attention to extra-regional sources. Third, as differentiated knowledge bases have various spatial attributes, policy should be tailored to the analytical, synthetic or symbolic knowledge bases. Fourth, although there are various types of new regional industrial path development, each RIS has its preferred type of new path. Policymakers should therefore use regional characteristics on which to base decisions concerning the specific type of new path to be pursued.

Finally, we identify the following six avenues for further research. First, as actors in various RISs have varied capabilities of knowledge sourcing, future work could discuss barriers to new regional industrial path development (see also Tödtling & Trippl, 2005). For instance, as the thick and diversified RISs have a higher capability to attract and access extra-regional knowledge than thick and specialized RISs, there are lower barriers to exogenous-led path diversification in the thick and diversified RISs than in the thick and specialized RISs. Second, new regional industrial path development tends to rely on the combination of analytical, synthetic and symbolic knowledge bases rather than the rarely occurring single type of knowledge base (Martin & Trippl, 2015; Boschma, 2017). Future research could explore how actors in a specific region mobilize more than one type of knowledge base to develop a different type of new path. Third, in this paper we assume that geographical proximity is a key factor determining the specific strategy of sourcing synthetic and symbolic knowledge bases. However, in reality, a lack of geographical proximity can be compensated by other dimensions

of proximity, such as cognitive, organizational, social and institutional proximity (Boschma, 2005). One promising avenue is to explore how combinations of proximity influence knowledge sourcing. Fourth, we regard extra-regional knowledge as a whole without considering specific geographical sources. In fact, extra-regional knowledge comes from different RISs is another possible topic for future analysis. For instance, what differences can be observed when a thin RIS mobilizes knowledge from thick and diversified RISs as opposed to from thick and specialized RISs? Fifth, future research could use the theoretical framework presented in this paper to analyze whether new path development has been successful, and if so in which constellations this has been the case. Finally, future research could focus on the impact of institutions from a multi-scalar perspective on new path development from a co-evolutionary perspective, as well as the role of critical events in this context (Gong & Hassink, forthcoming).

Notes

1. In Table 1, there are two scenarios on the intra-regional scale and two scenarios on the extra-regional scale. According to the types of knowledge bases on the extra-regional scale in Table 2 (either analytical knowledge bases or synthetic and symbolic knowledge bases), we further divide the two extra-regional scenarios in Table 1 into four scenarios in Table 2. In total, we develop six scenarios in Table 3, that is, two scenarios on the intra-regional scale, and four scenarios on the extra-regional scale.

References

Aoyama, Y., & Izushi, H. (2003). Hardware gimmick or cultural innovation? Technological, cultural, and social foundations of the Japanese video game industry. *Research policy*, 32(3), 423-444.

Asheim, B. & Coenen, L. (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research policy*, 34(8), 1173-1190.

Asheim, B., Coenen, L., & Vangand, J. (2007). Face-to-face, buzz, and knowledge bases: sociospatial implications for learning, innovation, and innovation policy. *Environment and Planning C: Government and Policy*, 25(5), 655-670.

Bellandi, M., Chaminade, C., & Plechero, M. (2018). Transformation paths and the multi-scalarity of knowledge bases under Industry 4.0 challenges. Papers in Innovation Studies, 15, 1-25.

Binz, C., & Anadon, L. D. (2018). Unrelated diversification in latecomer contexts—The emergence of the Chinese solar photovoltaics industry. *Environmental Innovation and Societal Transitions*, 28, 14-34.

Binz, C., Truffer, B., & Coenen, L. (2016). Path creation as a process of resource alignment and anchoring: industry formation for on-site water recycling in Beijing. *Economic Geography*, 92(2), 172-200.

Binz, C., & Truffer, B. (2017). Global Innovation Systems – A conceptual framework for innovation dynamics in transnational contexts. *Research Policy*, 46(7), 1284-1298.

Bluestone, B., & Harrison, B. (1982). *The deindustrialization of America: Plant closings, community abandonment, and the dismantling of basic industry*. New York: Basic Books.

Boschma, R. (2005). Proximity and innovation: a critical assessment. *Regional studies*, 39(1), 61-74.

Boschma, R. (2015). Towards an evolutionary perspective on regional resilience. *Regional Studies*, 49(5), 733-751.

Boschma, R. (2017). Relatedness as driver of regional diversification: a research agenda. *Regional Studies*, 51(3), 351-364.

Boschma, R. (2017). A concise history of the knowledge base literature: challenging questions for further research. Papers in Evolutionary Economic Geography, 17.21, 1-20.

Boschma, R., & Frenken, K. (2011). Technological relatedness and regional branching. In H. Bathelt, M. P. Feldman & D. F. Kogler (Eds.) *Beyond territory. Dynamic geographies of knowledge creation, diffusion and innovation* (pp. 64–81). London: Routledge.

Boschma, R., & Martin, R. (2007). Editorial: Constructing an evolutionary economic

geography. *Journal of Economic Geography*. 7(5), 537-548.

Chu, W. W. (2009). Can Taiwan's second movers upgrade via branding?. *Research Policy,* 38(6), 1054-1065.

Cooke, P. (2004), The regional innovation system in Wales: evolution or eclipse. In P. Cooke, M. Heidenreich and H-J. Braczyk (eds), *Regional innovation systems* (pp. 214-233), 2nd Edition, London and New York: Routledge.

Dawley, S. (2014). Creating new paths? Offshore wind, policy activism, and peripheral region development. *Economic Geography*, 90(1), 91–112.

Dawley, S., MacKinnon, D., & Pollock, R. (forthcoming). Creating strategic couplings in global production networks: regional institutions and lead firm investment in the Humber region, UK. *Journal of Economic Geography*.

Depner, H., & Bathelt, H. (2005). Exporting the German model: the establishment of a new automobile industry cluster in shanghai. *Economic Geography*, 81(1), 53-81.

Dicken, P. (2015). *Global Shift: Mapping the Changing Contours of the World Economy*, 7th edition. The Guilford Press, New York.

Dudley, G., Banister, D., & Schwanen, T. (2017). The rise of Uber and regulating the disruptive innovator. *The political quarterly*, 88(3), 492-499.

European Commission (2009). *Preparing for our future: Developing a common strategy for key enabling technologies in the EU*. Communication from the Commission to the European Parliament COM (2009)-512. Brussels, Belgium: European Commission.

Fornahl D., Hassink R., Klaerding C., Mossig I. & Schröder H. (2012). From the Old Path of Shipbuilding onto the New Path of Offshore Wind Energy? The Case of Northern Germany, *European Planning Studies* 20, 835-55.

Florida, R. (1995). The industrial transformation of the Great Lakes Region. In P. Cooke. (Eds.). *The Rise of the Rustbelt* (pp.162-176), London, UCL Press.

Gong, H., & Hassink, R. (forthcoming). Co-evolution in contemporary economic geography: towards a theoretical framework. *Regional Studies*, 1-12.

Grillitsch, M. (2018) Place-based entrepreneurship and innovation policy for industrial

diversification. Papers in Innovation Studies, 03, 1-21.

Grillitsch, M., Asheim, B. & Trippl, M. (2018). Unrelated knowledge combinations: the unexplored potential for regional industrial path development. *Cambridge Journal of Regions, Economy and Society*, 11(2), 257-274.

Grillitsch, M. & Trippl, M. (2016). Innovation Policies and New Regional Growth Paths: A place-based system failure framework. Papers in Innovation Studies, 26, 1-23.

Hassink, R. (2010) Locked in decline? On the role of regional lock-ins in old industrial areas. In Boschma, R. & Martin, R. (Eds.) *Handbook of Evolutionary Economic Geography* (pp. 450-468). Edward Elgar, Cheltenham.

Hassink, R. Isaksen, A. & Trippl, M. (forthcoming). Towards a comprehensive understanding of new regional industrial path development. *Regional Studies*.

Hobday, M. (1998). Latecomer catch-up strategies in electronics: Samsung of Korea and ACER of Taiwan. *Asia Pacific Business Review*, 4(2-3), 48-83.

Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters?. *Regional studies,* 36(9), 1017-1027.

Isaksen, A., Trippl, M. (2016) Path Development in Different Regional Innovation Systems: A Conceptual Analysis. In M. D. Parrilli, R. D. Fitjar, and A. Rodríguez-Pose (Eds.) *Innovation Drivers and Regional Innovation Strategies* (pp. 66–84). London: Routledge.

Lee, C. K., & Saxenian, A. (2008). Coevolution and coordination: a systemic analysis of the Taiwanese information technology industry. *Journal of Economic Geography*, 8(2), 157-180.

MacKinnon, D., Dawley, S., Pike, A., & Cumbers, A. (2019a). Rethinking Path Creation: A Geographical Political Economy Approach. *Economic Geography*, 95(2), 113-135.

MacKinnon, D., Dawley, S., Steen, M., Menzel, M. P., Karlsen, A., Sommer, P., Hansen, G. H., & Normann, H. E. (2019b). Path creation, global production networks and regional development: A comparative international analysis of the offshore wind sector. *Progress in Planning*, *130*, 1-32.

Marcus, A. (2015). *Innovations in sustainability: fuel and food (organizations and the natural environment)*. Cambridge: Cambridge University Press.

Martin, R, (2010). Roepke lecture in economic geography – Rethinking regional path dependence: beyond lock-in to evolution. *Economic Geography*, 86(1), 1–27.

Martin, R. (2013) Differentiated Knowledge Bases and the Nature of Innovation Networks. *European Planning Studies*, 21(9), 1418-1436.

Martin, R. & Moodysson, J. (2013). Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden. *European Urban and Regional Studies*, 20(2), 170-187.

Martin, R., & M. Trippl (2015) Cluster evolution, regional innovation systems and knowledge bases: The development and transformation of the ICT cluster in Southern Sweden. *Papers in Innovation Studies*, 24, 1-20.

Montresor, S., & Quatraro, F. (2017). Regional branching and key enabling technologies: evidence from European patent data. *Economic Geography*, (1), 1-30.

Nam, K. M. (2015). Compact organizational space and technological catch-up: comparison of China's three leading automotive groups. *Research Policy*, 44(1), 258-272.

Plum, O., & Hassink, R. (2011). Comparing knowledge networking in different knowledge bases in Germany. *Papers in Regional Science*, *90*(2), 355-371.

Plum, O., & Hassink, R. (2014). Knowledge bases, innovativeness and competitiveness in creative industries: the case of Hamburg's video game developers. *Regional Studies, Regional Science*, *1*(1), 248-268.Saxenian, A. (2006). *The new Argonauts. Regional advantage in a global economy*. Cambridge, MA: Harvard University Press.

Shin, J. S. (2017). Dynamic catch-up strategy, capability expansion and changing windows of opportunity in the memory industry. *Research Policy*, 46(2), 404-416.

South China Morning Post. (2017). *Big banks strike partnerships with technology companies as part of fintech wave*. https://www.scmp.com/business/china-business/article/2108468/big-banks-strike-partnerships-technology-companies-part

South China Morning Post. (2018). *'Made in China 2025': a peek at the robot revolution under way in the hub of the 'world factory'*. https://www.scmp.com/economy/china-economy/article/2164103/made-china-2025-peek-robot-revolution-under-way-hub-worlds

Simmie, J., & Martin, R. (2010). The economic resilience of regions: towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 27-43.

Sturgeon, T., Van Biesebroeck, J., & Gereffi, G. (2008). Value chains, networks and clusters: reframing the global automotive industry. *Journal of Economic Geography*, 8(3), 297-321.

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research policy*, 34(8), 1203-1219.

Tokatli, N., & Kizilgün, Ö. (2004). Upgrading in the global clothing industry: mavi jeans and the transformation of a Turkish firm from full-package to brand-name manufacturing and retailing. *Economic Geography*, 80(3), 221-240.

Trippl, M., Grillitsch, M., & Isaksen, A. (2018). Exogenous sources of regional industrial change: Attraction and absorption of non-local knowledge for new path development. *Progress in Human Geography*, 42(5), 687–705.

Trippl, M., Tödtling, F., & Lengauer, L. (2009). Knowledge sourcing beyond buzz and pipelines: evidence from the Vienna software sector. *Economic geography*, 85(4), 443-462.

Yang, C. (2009). Strategic coupling of regional development in global production networks: redistribution of Taiwanese personal computer investment from the Pearl River Delta to the Yangtze River Delta, China. *Regional Studies*, 43(3), 385-407.

Yeung, H. W. C. (2016). *Strategic coupling: East Asian industrial transformation in the new global economy*. Ithaca, London: Cornell University Press.

Zukauskaite, E., & Moodysson, J. (2016). Multiple paths of development: knowledge bases and institutional characteristics of the Swedish food sector. *European Planning Studies*, 24(3), 589-606.

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