Cambridge Journal of Regions, Economy and Society 2019, **12,** 195–212
doi:10.1093/cjres/rsz001
Advance Access publication 21 May 2019

Cross-specialisation policy: rationales and options for linking unrelated industries

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Received on August 14, 2018; editorial decision on March 18, 2019; accepted on March 21, 2019

In this article, we discuss how economies' established stronghold industries can form a basis for sustaining competitiveness. As changing market circumstances demand economic strongholds to stay adaptive, their knowledge bases need to be enriched continuously. Previous research has shown that experimentation based on bridging rich knowledge bases provides important opportunities for diversification. Inspired by insights from evolutionary economic geography, we argue why, rather than (only) focusing on related variety, economies should 'cross-specialise' by creating linkages between strong but unrelated industries. We discuss how policy makers can facilitate uncommon interactions by targeting cross-over industries or creating platform-like interfaces.

Keywords: industrial policy, innovation policy, additionality, related variety, platforms, intermediaries
JEL Classifications: O25, O33, O38

Introduction

Policy makers and economists have since long debated the merits of pursuing an economic development strategy in which policy support is targeted at specific industries (Bailey et al., 2015; Hausmann and Rodrik, 2006). One main argument in favour of industrial policy builds on the opportunities offered by local presence of unique assets (Lazzarini, 2015), like specialised knowledge bases, capabilities and institutions. Assets with such properties particularly occur in scientific and technological domains that have developed into strengths during a long period of knowledge and capability accumulation (Asheim et al., 2011). Government support for the exploitation of this specialised knowledge can be understood as a backing-winners approach (Dohse, 2007), which is justified by the expectation of additional growth within industries that continue to be economic 'strongholds'. Through externalities in the form of local knowledge spill-overs and spin-off companies, backing such stronghold industries may also spur growth in other related industries (Boschma and Frenken, 2011; Hidalgo et al., 2007). The belief that these benefits can exceed the relatively high governance costs of industrial policy when compared with the costs of a generic policy has motivated a new generation of policy makers to design and implement more targeted support measures.

Frequently used policy options for supporting specific industries include the development of industry-based innovation programmes and cluster policy (Warwick and Nolan, 2014). Implementations of such types of specific policy, however, suffer from various potential weaknesses, especially when a clear rationale for intervention is missing (Rodrik, 2008). The main question concerns 'additionality': stronghold industries generate a great deal of economic growth and industrial diversification on their own. One may thus wonder whether innovations within stronghold industries would also occur without any industry policy support. A further problem of backing-winner policies is that the target industry is so broadly formulated that support measures become available to a part of the economy that is arguably much larger than the notion of 'specialisation' would suggest (Jacobs, 2000). Relatedly, it also has been noted that there is considerable overlap in the domains that regions select (Asheim et al., 2011). Given that the uniqueness of a knowledge base is supposed to be the basis for competitive advantage, choosing common domains is unlikely to be a successful strategy (Foray, 2016). Finally, there remains the risk of failure to select genuine strongholds and being manipulated by lobbying activities of the established order (Rodrik, 2008).

Especially in the context of regional economies, some authors have reconsidered the respective advantages of backing winners by fostering established stronghold industries (Lambooy and Boschma, 2001). While such industries might be competitive in existing business conditions, the question to ask is how success can be sustained over time. The pace with which markets are currently changing demands economies to be adaptive. Therefore, in order to continue capitalising on the competitiveness of historically developed assets, even industries with a stronghold position might have to transform to some extent (Asheim et al., 2011).

The mechanisms behind economic transformation and industrial evolution can be interpreted as processes of knowledge recombination: whether a competitive industry can develop further is largely determined by the availability of knowledge that can enrich the industry's current knowledge base. Since knowledge is most likely to spill over between related industries, opportunities to exploit and expand idiosyncratic strongholds typically arise from industries with a high degree of technological relatedness. This would imply that policy makers should shift their support from the stronghold itself, which is already performing rather well, to 'related variety' (Frenken et al., 2007), that is, to adjacent domains that might either strengthen the stronghold or become a stronghold itself.

Even when policy support is aimed at related variety, a pitfall remains. While such a strategy may well have a greater additionality than backing-winner policies, it remains essentially conservative in its focus on established technological linkages rather than being truly progressive in fostering radically new crossovers between previously unrelated industries. Related-variety policies focus on industries that are known to be related in the *past*, but are blind to unrelated industries to may become more related in the *future*. In particular, one can argue that a conservative focus on spillovers between related industries is justified for regions with limited budgets catching up with the technology frontier, while a more progressive policy is needed for developed regions that aim to move the technology frontier itself by true *Neue Kombinationen*. Indeed, there is increasing evidence that major innovations tend to stem from recombining unrelated types of knowledge (Alstott et al., 2017; Castaldi et al., 2015; Fleming, 2001). Such innovations render technologies related that were previously unrelated, thus altering the relatedness structure of an economy itself. By recombining previously unrelated knowledge, an economy can generate competitive advantage as innovation stemming from unrelated knowledge will be harder to imitate than innovation stemming from related knowledge.

This article addresses the question how an industrial policy can be conceived that takes up the challenge of linking unrelated industries. We draw on recent innovation (policy) literature to develop a theoretical argument, stating that policy makers should concentrate on the links between strongholds that are generally unrelated, rather than on the strongholds themselves. Although firms from unrelated industries are unlikely to collaborate and to learn from one another, recent evidence, nevertheless, suggests that policy makers have both reasons and means to facilitate such unlikely crossovers (Corradini and De Propris, 2017; Montresor and Quatraro, 2017). These findings, suggesting that cognitive distance (and thus technological relatedness) is a malleable rather than a static condition, provide possibilities for a new type of industrial policy, which we will refer to as 'cross-specialisation policy'.

The remainder of the article is structured as follows. First, we argue that specialisation in multiple unrelated industries provides a potential for knowledge recombination (and ultimately economic diversification) that is, however, unlikely to occur through spontaneous 'entrepreneurial discovery' (Rodrik, 2008). Policies may thus have large additional effects by providing support to bridge cognitive distances that otherwise remain unexplored. Second, we describe how cross-specialisation policy can be operationalised. One approach is to target firms in cross-over industries. Looking at the case of the Dutch Topsector policy, the online Supplementary Appendix illustrates in detail how such cross-over industries can be identified and exploited. Another policy approach, fitting with rising views on facilitating and mobilising bottom-up entrepreneurial experimentation (Foray, 2019; Rodrik, 2004), is to create cross-over interfaces. This alternative is less demanding in terms of policy capabilities, as it consists of shaping conditions that allow firms themselves to discover potential complementarities between stronghold domains. Proposed interventions consist of platform-like instruments and innovation intermediaries, organised around a certain lateral technology and/or societal theme. We conclude by discussing further research and policy implications.

Exploiting cross-specialisation

Recombinant innovation

Here we are interested in the question whether and how the presence of unrelated but specialised knowledge bases can be used as a starting point for strengthening an economy's competitiveness. Valuable insights on this matter originate in particular from studies on recombinant search. Most of the available studies have been developed in the context of individual firms (Tödtling and Grillitsch, 2014), technologies (Arts and Veugelers, 2015) or even inventors (Kaplan and Vakili, 2015). To a lesser extent, the underlying theories have also been applied for studying an entire industry's 'search' for new product lines or even trajectories (Broekel and Brachert, 2015; Frenken et al., 2007). Given that the key principles of knowledge recombination hold at both the firm level and at the industry level, we consider findings on both accounts when developing our arguments.

The pursuit of creating new solutions, like products that could open up new markets, is often interpreted as a search journey. An inherent element of search, as many have noted, is uncertainty. This uncertainty pertains to technological factors ('does it work?') as well as to economic factors ('is there market demand?'). When searching for new opportunities, firms can face various degrees of uncertainty. If the knowledge they are dealing with has already been applied extensively, the familiarity with these 'components' might make it easier to assess how they can be made part of new products: 'Recombination usually occurs […] between components that are salient, proximal and available for the inventor' (Fleming, 2001, 119). For individual firms, such knowledge is likely to be encountered within the knowledge base of the particular industry it is active in. Both restricted cognitive capabilities and the tendency to leverage already accumulated knowledge lead firms to engage in local search (Fleming and Sorenson, 2004; Laursen, 2012).[1] When actors are not familiar with certain knowledge or components, the risk of recombinant experiments—if such boundary-spanning search occurs at all—to result in failure is substantially higher (Fleming, 2001). Experiments with knowledge that has rarely been applied in a particular context thus generally reduces the chance that a firm will introduce a successful new product.

On the one hand, scholars have argued that opportunities for developing breakthrough innovation reside in particular in new combinations of well-used components (Fleming, 2001; Nelson and Winter, 1982). Organisations having a very comprehensive understanding of the state-of-the-art knowledge in a certain domain are believed to be in the best position to encounter and solve weaknesses (Weisberg, 1999). Rather than searching for combinations based on unrelated knowledge, they are advised to capitalise on the 'deep' knowledge base of an industry by exploiting the fact that they are so familiar with this knowledge. The view that organisations at the knowledge frontier have the highest chance of identifying anomalies, in addition to the claim that building on used components is a relatively secure option, makes a case for investing in an economy's strongest industries.

On the other hand, there are also indications that especially the combination of unrelated knowledge holds a breakthrough potential (Fleming, 2001; Weisberg, 1999). The downside of being immerged in one specific knowledge domain is that it goes at the cost of creativity, ultimately resulting in myopia. A firm's local environment is limited in the amount of opportunities for knowledge (re)combination it offers (Fleming and Sorenson, 2004; Rosenkopf and Nerkar, 2001). For these reasons, one could expect the most original and radical innovation to stem from combinations of highly diverse knowledge. Next to firm-level studies on bridging unrelated knowledge bases and creating commercially successful ideas, evidence is now available for the working of this mechanism at the industry level. Castaldi et al. (2015) show for US states that the presence of unrelated variety in a region increases the probability that innovative breakthroughs will be produced. The same pattern was found for regions in the European Union in a study by Miguelez and Moreno (2018). These results imply a trade-off of advantages: more common ground for exchanging knowledge, based on the presence of related variety, seems to be directly at odds with chances of finding truly original knowledge combinations.

The proposed views might seem inconsistent with each other, since they consider relying on either related or unrelated knowledge recombination to be the most promising way for identifying radically novel propositions. How to balance exploitative and explorative (or local and non-local) search is often regarded as a crucial trade-off in innovation management (Laursen, 2012; March, 1991). Kaplan and Vakili (2015), however, use patent data to provide evidence for the claim that the presumed tension may in fact be a matter of a 'double-edged sword' (Sternberg and O'Hara, 1999). They find that combining knowledge elements from a single deep knowledge base leads to a higher level of novelty, while combining unrelated knowledge can be associated with more economic value. Recently, Arts and Veugelers (2015) have shown that combining formerly non-combined but familiar technology components offers a solid basis for realising breakthrough innovations. The finding that recombining deep knowledge and recombining unrelated knowledge each have their own respective benefits holds important implications for industrial policy, as it calls into question whether there are perhaps any synergies to exploit also at the level of industries (rather than technologies). Why not enjoy both advantages by supporting firms from unrelated strongholds to combine their deep knowledge?

The potential of cross-industry linkages

So far, the debate on related and unrelated knowledge has focused mainly on identifying optimal levels of (un)relatedness, thereby neglecting any other properties of the knowledge and capabilities that are involved. A particularly relevant issue in our view is the question what kind of unrelated knowledge is being combined when engaging in entrepreneurial discovery and searching for new areas of opportunity. For an individual firm, having its own unique experiences and thus facing an idiosyncratic search space, all knowledge that is unfamiliar might be considered as unused. This does not hold at the level of the entire economic system. Here, the question whether a component is used depends on how much it has been applied in general, by any of the actors that are part of the system. It is very well possible that economic systems contain multiple strongholds, each of them relying on a couple of highly related and extensively used knowledge bases that are not necessarily also linked to the strong knowledge bases of other strongholds.

One would expect that particularly promising opportunities arise when deep knowledge from one stronghold is combined with deep knowledge from another stronghold (Fleming, 2001). This may yield different types of benefits. Using the industry space concept (Neffke and Henning, 2008), Figure 1 provides an illustration of possible diversification outcomes. First, as argued before, new combinations may lead to a breakthrough that forms a basis of a whole new industry *i*. In case, this industry *i* was already in its infancy, combining knowledge might also allow diversification to take off in new directions. Finally, new combinations between knowledge from unrelated industries may strengthen the existing strongholds *a* or *b*, by incorporating distant knowledge into existing products and processes. Note that, in all scenarios, unrelated strongholds are bound to

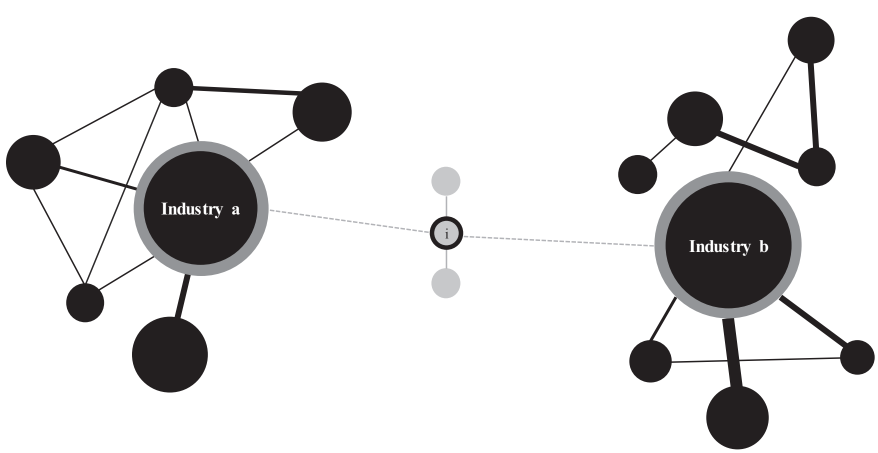

Figure 1. *Conceptual representation of an industry space: node size represents economic importance of an industry for a given region, and tie thickness stands for degree of relatedness between industries. The grey shading marks new economic activity resulting from knowledge flows between the two strongholds.*

become more related as recombinant innovation takes place over time.

The rich potential of recombinant search we envisage requires knowledge to flow between very dissimilar industries. Previous studies have shown that this is relatively uncommon, as economies develop according to a branching process in which economic activity evolves towards (and builds on) industries that are related to the existing ones (Hidalgo et al., 2007; Neffke et al., 2011). Due to a large degree of cognitive distance, spontaneous knowledge flows between unrelated industries remain absent even if actors are close with respect to other forms of proximity (Nooteboom, 2000). And if actors would have some sense of the potential benefits of using knowledge from another stronghold, it is uncertain whether they will actually set out to exploit the possible complementarities. Making use of deep but unfamiliar knowledge requires actors to make substantial investments in absorptive capacity (Cohen and Levinthal, 1990). As long as knowledge from another stronghold is perceived as very different, the risks associated with making such investments are hard to estimate and probably regarded as too high.

One possible and probably overly deterministic conclusion would be that efforts to combine disparate knowledge bases are likely to be in vain. An alternative view holds that policy intervention is particularly relevant in situations in which knowledge flows can be fruitful but will not spontaneously emerge through entrepreneurial discovery. When actors from distinct strongholds possess knowledge bases with little overlap, finding the complementarities that lead to new value creation will be difficult and thus rare. This means that any cross-specialisation policy that successfully links unrelated strongholds will have high additional effects, as such linkages would rarely occur in the absence of government support. In contrast, support to further strengthen existing strongholds will likely have low additionality as such strongholds are populated by successful firms with the capabilities to innovate on their own along the trajectories they already pursue, including diversifying into related industries (Boschma and Frenken, 2011). Furthermore, successful firms are known to yield high rates of spinoffs on their own, who inherit capabilities form the parent firm rendering them competitive as well (Klepper, 2002).

What is more, cross-specialisation policy can foster genuine and long-lasting competitive advantage as the recombination innovations stemming from two or more unrelated industries will be much harder to imitate than innovations stemming from recombining related knowledge. Probably there will be many more economies that share the same set of related industries than economies that share the same set of unrelated industries. Precisely because some industries are related, related industries often co-occur in many economies. Hence, one may expect that a successful recombinant innovation stemming from unrelated industries will be imitated much more slowly than a recombinant innovation stemming from related industries. Therefore, we argue that, rather than advising policy makers to concentrate their resources on individual stronghold industries, and industries most related to those, they should search for ways to enable knowledge transfer and recombinant innovation crossing previously unrelated stronghold industries. This is the core idea underlying the notion of cross-specialisation policy.

Cross-specialisation policy

Cross-specialisation is a matter of linking distant knowledge bases. Some knowledge bases contain components that have been used already in a wide variety of applications (Fleming, 2001). Such knowledge bases form unique assets for the current competitiveness of an economy, but not necessarily for the future. Our suggestion to propel promising forms of economic transformation consists of offering policy support for facilitating the recombination of used but (so far) unrelated components. If one were to reason from a targeted industrial-policy approach, the problem of cross-specialisation policy would be to select the most promising linkages between unrelated strongholds as sources of recombinant innovation. For regions with just a few unrelated strongholds (possibly also the economically less performing regions), the situation is relatively comprehensive if we neglect possibilities to engage in interregional cross-specialisation. The more unrelated strongholds one can build on, however, the harder it is to decide which specific combinations to focus on.

First, the information problem is overwhelming given the combinatorial explosion of possible recombinant innovation. For example, for an economy with, say, five strongholds, one can identify 10 industry couples (AB, AC, AD, AE, BC, BD, BE, CD, CE and DE). Recombination may also concern nine industry triples (ABC, ABD, ABE, ACD, ACE, ADE, BCD, BCE and CDE), five industry quadruples (ABCD, ABCE, ABDE, ACDE and BCDE) and one involving all strongholds (ABCDE). Thus, in an economy with only five strongholds, no less than 25 cross-specialisation options would have to be considered and evaluated ex ante.

A second difficulty for policy makers will be, for each possible combination, to foresee the innovative potential of recombination. Given that industries are technologically unrelated, little experience has been built up in the past. Combining unrelated knowledge entails a serious risk of failure. Albeit less risky than persuading strongholds to interact with random unrelated industries, an ill-informed cross-specialisation policy targeting specific combinations of unrelated strongholds would still imply substantial uncertainties for anyone involved.

Cross-specialisation policy would thus benefit from focusing devices to enable policy makers to target particular policy support. There are two ways to focus support in a way that triggers recombination innovation among unrelated strongholds without supporting particular combinations of strongholds as such. First, following a top-down approach, one can target industries that are related to multiple strongholds that are unrelated among each other. Analogous to structural holes in social networks, one can detect such bridging industries from an analysis of the relatedness structure among industries in the economy. Second, one can leave room for bottom-up discovery processes by creating interfaces that invite firms from unrelated industries to participate in collective innovation. Such interfaces can be built *supply-led* around a general purpose technology with potential in many different unrelated industries, or it can be built *demand-led* around persistent societal challenges that require radically new solutions.

Top-down approach: identifying cross-over industries

Following the concept of the industry space shown in Figure 1, economic structures can be thought of as networks of more or less related industries (Neffke and Henning, 2008). Characteristic for any pair of unrelated stronghold industries is the large (cognitive) distance between them, inhibiting direct knowledge exchange. However, an economy typically also contains intermediately situated industries. These cross-over industries do not necessarily need to be economically important as well, but they certainly are of interest from a cross-specialisation perspective.

Firms active in cross-over industries have a brokering position, as they might integrate knowledge from industries that normally do not collaborate. Providing policy support to such firms is one way to encourage recombination of deep yet unrelated knowledge components. Besides instruments directly focusing on R&D and experimentation (e.g. innovation subsidies or vouchers), support can also be oriented towards enhancing the conditions favouring entrepreneurial discovery. This might involve adaptation of the institutional framework, as well as other parts of the innovation systems firms in cross-over industries are part of. Especially in the early stage of a nascent industry, there usually are many regulatory and legitimacy barriers to be overcome (Rodrik, 2004). As the cross-over industry develops, its potential for translating knowledge from one specialisation to another can also be mobilised to get firms from unrelated strongholds to interact directly.

Cross-over industries in knowledge networks can be identified by calculating cross-over centrality; a measure expressing to what extent industries are situated between unrelated but major other industries. We illustrate this by looking at the case of the Dutch Topsector policy, which can be regarded as a leading example of modern industrial policy (Rodrik, 2008). Although this particular policy strategy has a national scope, the considerations and methodologies presented here are applicable just as well at more fine-grained regional levels.

The Dutch national innovation strategy, implemented in 2012, offers triple helix consortia a range of possibilities to boost the competitiveness of nine Topsectors (Janssen, 2019). For each of the Topsectors, so-called Top Consortia for Knowledge and Innovation (TKIs) set out knowledge and innovation agendas expressing the development ambitions of underlying industries. A widely shared goal is to diversify by cooperating with other Topsectors.

The Supplementary Appendix describes in detail how we construct the network constituting the Topsector part of the Dutch industry space. Figure 2 depicts each industry represented as a node labelled with a shortened description of the industry's name, preceded by its four-digit NACE industry code. The node colours indicate to which Topsector a certain industry belongs, while the size of the nodes reflects employment figures. Node position is determined by a multidimensional scaling algorithm which tries to minimise tie lengths while accounting for tie strength, as measured by skill-relatedness metrics (Neffke et al., 2011). The Topsectors turn out to consist of relatively coherent sets of industries, which is reflected by the coloured circles indicating what type of Topsector is most dominant in a certain domain of the industry space. Remarkable is that some Topsectors as such can already be regarded as boundary spanners; logistics is, for instance, an axis at the intersection of most of the agricultural industries on the right side of the industry space and manufacturing industries on the left side, while Chemicals is connecting industries from virtually all Topsectors (except Water).

Using the Topsector industry space as a starting point, we apply network analytics for calculating cross-over centrality at the industry level. This measure is determined by summing the products of the economic importance of the industries a focal industry is related to with the strength of the skill-relatedness with these other industries. Optional adaptations of the measure involve excluding direct ties between two industries a focal industry is connecting (i.e. focusing on closing triangles only) or requiring the connected industries to belong to different Topsectors. The calculations shown in the Supplementary Appendix reveal which cross-over industries connect major industries within Topsectors, between Topsectors and throughout the entire network.

Overall, industries with a high level of unconstrained cross-over centrality are often found at the centre of Topsector domains (connecting strong industries from the same Topsector). Given the scope of this article, perhaps the most interesting observations concern the cross-over industries best positioned to link relative strongholds from different Topsectors.

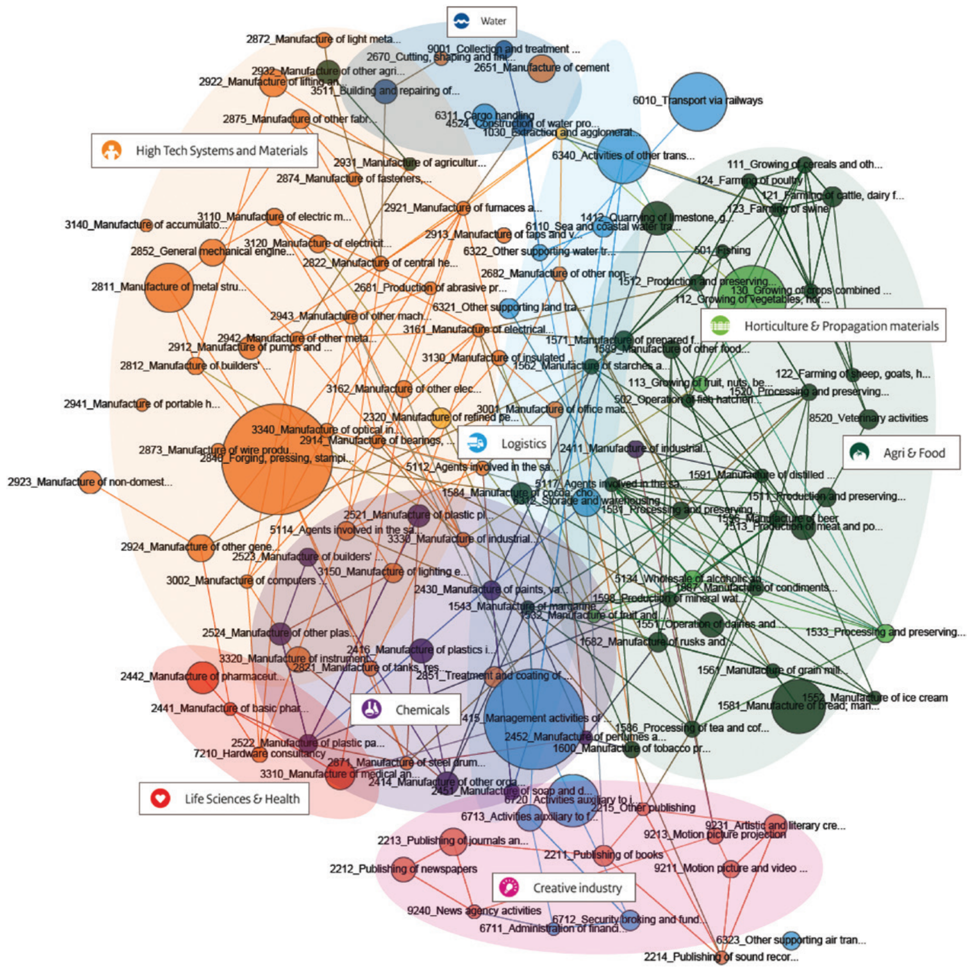

Figure 2. *Topsector industries in the Dutch industry space. Node size represents employment and tie thickness stands for degree of skill-relatedness between industries (SR > 15, p < 0.05). See Supplementary Appendix.*

Generally we find them more towards the fringes of the Topsector domains. For instance, the Chemicals industry ‘manufacturing of perfumes and toilet preparations’ (NACE 2452), at the border with Logistics and Agri & Food, connects economically significant industries from High Tech Systems & Materials (HTSM), Agri & Food, Life Sciences and Health, and the Creative Industry. As this industry is not particularly present in the Netherlands, it is a non-obvious candidate for exploring knowledge recombination possibilities.

Another example surfacing in our calculations is ‘manufacturing of industrial process control equipment’ (NACE 3330). While there are more HTSM industries positioned at the intersection with Chemicals, Logistics and Agri & Food, this one in particular turns out to attain a high level of inter-Topsector centrality. Our calculations also point at industries hardly connected to other industries of the Topsector they belong to. The Agri & Food industries of manufacturing agricultural tractors as well as other agricultural and forestry machinery

(NACE 2931 and 2932), for instance, are in fact mostly related to industries found in the HTSM Topsector, as could be derived already from their position in the upper left corner of Figure 1. Again, this poses a basis to reconsider what industries, firms and topics are most suitable for featuring in policy for cross-over linkages.

Bottom-up approach: developing cross-over interfaces

Even if well informed, a top-down cross-specialisation approach might, nevertheless, be demanding in terms of policy capabilities needed to set knowledge recombination in motion. An alternative is to create the conditions allowing firms themselves to overcome cognitive distance and discover potential complementarities between stronghold domains. Facilitating bottom-up entrepreneurial experimentation is acknowledged to be a promising policy strategy for determining fruitful innovation directions (Foray, 2019).

Especially this second avenue for spurring knowledge flows between unrelated industries starts out from the assumption that relatedness is malleable (Asheim et al., 2011). If firms realise that they are in fact (to a certain extent) similar to firms in other industries, they might be willing to learn from each other or with each other (Nooteboom, 2000). It is these kinds of interactions that then form the basis for more intensive knowledge exchange, possibly resulting in original and even break-through knowledge recombination. Essential in this respect is the identification of a body of knowledge that is potentially relevant for, but not actually shared yet by unrelated industries. Such knowledge forms the basis for creating cross-over *interfaces* through which knowledge flows can stream. Integrating findings from existing research on cross-sectoral linkages, we present interfaces as a constellation of three elements (Figure 3).

Form

The form of the interface, to begin with, stands for the type of policy instrument that is being deployed in order to unite parties from unrelated strongholds. Almost by definition, creating linkages and facilitating knowledge streams requires a platform approach (Asheim et al., 2011). Examples include research labs, production facilities, training centres, applied knowledge institutes etc. Although all of them

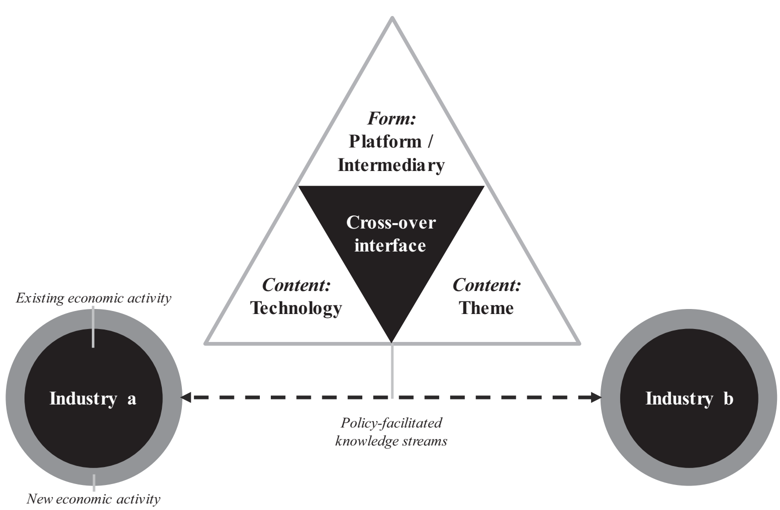

Figure 3. *Cross-specialisation policy as a matter of designing cross-over interfaces.*

are common interventions, the emphasis normally lies on the scale advantages that arise when sharing a facility between multiple users. Here, the main criterion when selecting a policy form is that the instrument should allow parties to get in touch with each other. Whether a knowledge institute is producing state-of-the-art knowledge is not crucial from a cross-specialisation perspective: what matters is if it manages to bring together seemingly unrelated firms. Community management is one way to ensure that the unrelated firms do not use a platform in parallel, but with each other. When investigating platforms as a basis for innovation policy, Cartel et al. (2014) find that platform interactions can be supported by means of three types of activities: catalysing recombinant experimentation, facilitating learning and fostering of compromises (e.g. standard setting). Clearly, the first type is most explicitly focused on bringing about innovation. As long as the activities lead to reduction of cognitive distance, however, also the other two types lend themselves for ultimately establishing productive knowledge flows between unrelated firms. In the case of learning activities, for instance, the focus should be on mutual learning rather than on individual programmes.

An alternative policy form consists of appointing innovation intermediaries like knowledge transfer offices (Dhanaraj and Parkhe, 2006). Such brokers can play an important role in facilitating innovation-based interactions between various parties (Howells, 2006). While some intermediaries focus on small groups of actors, systemic innovation intermediaries typically operate at the level of sectors or countries (Abbate et al., 2013; Kilelu et al., 2011). As they engage in boundary spanning, articulating needs, aligning goals and transforming innovation networks, the intermediaries are pre-eminently equipped to spark collaborations between actors with distinct knowledge bases (Klerkx and Leeuwis, 2009; Van Lente et al., 2003). Particularly relevant in this respect are government-associated intermediary organisations (Kivimaa, 2014). Policy makers can orchestrate knowledge interactions by establishing public bodies tasked with mobilising knowledge and competences for solving innovation problems (Abbate et al., 2013).

Apart from choosing a policy form, an intervention for bridging unrelated strongholds should also have a certain content. By 'content' we refer to the specific subject of the interface, which has to be relevant for multiple unrelated strongholds. We distinguish two varieties of content with a lateral scope: themes, as in societal or system-level challenges (i.e. the *demand* for solutions), and horizontal technologies (i.e. the *supply* of technological opportunities).

Themes

Even when engaged in only economic or innovation affairs, most of the issues policy makers are facing are not directly related to distinct industries. Rather, policy reality consists of challenges that occur at the level of the entire economic system. Examples are issues like education, unemployment, entrepreneurship or environment. Also, grand challenges like the ones central in the EU research and innovation framework Horizon2020 lead to an increasing interest in mission-oriented innovation policy (Edquist and Zabala-Iturriagagoitia, 2012). Complex societal problems in the domains of health, energy or climate demand solutions in which a wide variety of disciplines are involved. The resulting fact that system-level themes stretch over a broad range of industries implies that there are ample opportunities for actors from disparate industries to interact with each other. A topic like health might involve firms from industries as different as pharmaceutics, robotics, chemicals, web-solutions and so forth. Whereas a regular branching process might lead those firms to pursue their idiosyncratic trajectories, being involved in large-scale socio-economic transitions can expose them to knowledge from domains they would otherwise never look at (Boschma et al., 2017). Considering the combinational explosion caused by many linkable unrelated strongholds, selecting challenges and missions is a way to unite diverse actors without imposing who will be included or excluded. Moreover, compared with classical industrial policy, it also provides additional legitimacy.

Technologies

The second type of lateral content is formed by horizontal technologies. Recent research by Corradini and De Propris (2017) and Montresor and Quatraro (2017) has shown that generic purpose technologies (GPTs) and key enabling technologies (KETs) can be regarded as factors that might lead the knowledge bases of unrelated industries to converge. Equally interesting are the kind of research facilities that are of relevance for the development of knowledge that can be applied in very different contexts. This ranges from facilities for very fundamental research, to laboratories for testing new materials and applications for 3D printing. The latter is in fact an example of a research facility for something which might become a general purpose technology, since 3D printing is already being used for fabrication of medical implants, houses and even weapons.

Just as in case of the broad societal themes, horizontal technologies mark a possibility to unite actors from different knowledge domains. Rather than contributing knowledge for creating solutions to grand challenges, the focus of parties involved now typically lies on the shared wish to develop and utilise the opportunities of these technologies (Gambardella and McGahan, 2010). For a topic like advanced imagery, one can easily imagine a scenario where firms from very different spheres enjoy the benefits of jointly investing in facilities like microscopes and corresponding software. Relevant learning effects can occur both within the parties directly involved as well as in any other party active in the same innovation system that might benefit from the GPT in question. Experience with using these facilities for various purposes can in the first place lead to improvements in the hardware or software. Second, and more interestingly, the fact that parties from diverse spheres interact with each other increases the chance that they learn from each other's experiences with the technology, or any other knowledge that might flow once linkages are established (Asheim et al., 2011; Corradini and De Propris, 2017).

Perhaps the most pervasive development of modern times is the ongoing adoption of GPTs like ICT, 'Industry 4.0' or robotics. The rise of mobile telephony, computers and internet has led to drastic changes in the production modes and business models of firms in virtually every industry. Although those developments resulted in the rise of many new sorts of business activities, actors within both old and new industries now share a body of ICT-related knowledge and skills. This convergence effect is inherently connected to the nature of any GPT (Bresnahan and Trajtenberg, 1995).

Apart from ICT, the European Commission believes the following key enabling technologies to be crucial for the competitiveness of industries in the knowledge economy: nanotechnology, micro- and nano-electronics including semiconductors, advanced materials, (industrial) biotechnology, photonics and advanced manufacturing technologies. Evidence suggests that such enabling technologies indeed have the potential of spurring new knowledge flows (Montresor and Quatraro, 2017). When coining the notion of 'smart specialisation', Foray et al. (2009) urged policy makers to enrich local strongholds by adopting new multi-purpose technologies. By following the smart specialisation approach, regions that will not lead in the development of new technologies can at least take the lead in specific applications of these technologies. The kind of specialisation we envisaged goes one step further, since the focus is on at using generic technologies not only for boosting individual strong industries, but also for linking them to each other in order to open up even more opportunity areas.[2]

In addition to developments pertaining to 'technology' in the narrow meaning of the word, also the increasing importance of services makes (or could make) the knowledge bases of industries converge. As manufacturing firms started realising, they can only beat the commodity trap by switching to the delivery of customer-specific solutions and experiences, many of them now focus on service-based business models (Chesbrough, 2011). Both the challenges of 'servitisation' as well as the actual business models are factors with relevance for firms from a high variety of industries (Olivia and Kallenberg, 2003). Therefore, supporting mixed sets of firms in developing service capabilities poses possibilities to combine cross-specialisation with enhancing the resilience of manufacturing industries (Janssen and Castaldi, 2018).

Discussion

Conclusions

This article contributes to policy debates on how to capitalise on traditional stronghold industries when guiding structural change (Foray, 2016; Mazzucato et al., 2015; Rodrik, 2008). The status of specialised knowledge bases is easily mistaken: instead of being a basis for future competitiveness, they sometimes are only the result of past excellence in certain domains. In order to sustain the success of path-dependent configurations of knowledge, capabilities, experience and institutions, policy makers need to identify ways for making stronghold industries adaptive to changing market circumstances.

The proposition we advanced holds that special opportunities reside in linking strong but unrelated knowledge bases. Since multiple domains can contain deep knowledge, recombining these used components unites the advantages of being well positioned to identify anomalies and being highly familiar with components on the one hand, with the breakthrough potential of recombining unrelated knowledge on the other hand. Essentially, cross-specialisation is about combining advantages of unique hard-to-imitate knowledge bases with the evolutionary imperative of increasing variation. While this might give rise to the emergence of new industries, it also is likely to bring the unrelated strongholds closer to each other. So far, such a dynamic perspective on industry evolution has hardly been touched upon in the literature (Castaldi et al., 2015; Neffke et al., 2011). This article thereby provides original pathways for research and policy strategies pertaining to the mechanisms underlying regional diversification.

Policy implications

We believe cross-specialisation to have the potential of spurring the kind of knowledge flows that can drive economic diversification forward. As recent studies have confirmed that key enabling technologies may function as bridges between knowledge domains (Corradini and De Propris, 2017; Montresor and Quatraro, 2017), it is likely that such interface elements can also be deployed for linking unrelated strongholds in particular. Doing so will enhance the pool of useful knowledge components and capabilities from which innovators can draw when experimenting with new technologies and value propositions. Eventually, this strengthens the economy, as existing industries can be sustained and new ones might spawn. The empirical analyses elaborated on in Supplementary Appendix serve to demonstrate a methodology for identifying cross-over industries, which is relevant both for policy formulation and execution (e.g. the development of cross-over research agendas) as well as for monitoring resulting transformations in the economic tissue.

The key objective of cross-specialisation policy is to overcome cognitive distance by making knowledge bases converge—either by targeting cross-over industries or by setting up cross-over interfaces. Besides developing dedicated new interventions, there are plenty of opportunities to adapt or redirect the existing ones. This includes ensuring that policies like technology promotion do not just reach unrelated firms, but also make them interact with each other. The fact that competition inhibits collaboration between related firms might even add to the feasibility of supporting learning across unrelated specialisations. As such, cross-specialisation is not as risky as the idea of linking unrelated industries might seem. The policy strategy is based on building bridges between existing stronghold industries, albeit with the purpose of transforming their innovation paths. While policy makers should avoid giving in to lobbying pressures, the starting point of leveraging present capabilities probably demands less of a leap of faith than hoping that backing winners will yield breakthrough innovations, or—on the other extreme—than targeting policies on activities that at present are entirely absent from the industry portfolio. Essentially, cross-specialising is taking the middle road in between a related variety strategy with low additionality and unguided unrelated diversification with high risk.

Cross-specialisation policy can be considered as a generic principle that is not necessarily restricted to a particular geographical scale. Yet, one could still argue that it works best at a fairly low scale of regions or small countries, since geographical proximity between actors provides favourable conditions for thick interactions needed to bridge cognitive distances (Boschma, 2005). A recent study by Li et al. (2019) indeed found that unrelated technology combinations occur more likely in a region if the two technologies recombined are already well developed in the region.

Furthermore, while any region may in principle adopt a cross-specialisation policy, it may turn out less effective in lagging economies compared with advanced economies for two reasons. First, lagging economies are often highly specialised and accordingly have fewer cross-specialisation options. Second, the firms and policy actors residing in such regions may have fewer organisational and absorptive capacities to cross unrelated industries. More specifically, given that lagging regions often have fewer strongholds, a top-down approach may be more feasible as it will be easier to identify cross-over industries. This choice may only be reinforced if most firms in such regions have less developed capabilities of their own, limiting the effect of bottom-up policies, which rely much more relying on firms' initiatives. Regions further differ in the extent to which skills are receptive to a particular GPT or political actors define a particular societal challenge as a shared concern. Hence, cross-specialisation policies based on GPTs or societal challenges may not apply well to every region.

When designing cross-over interfaces, it is recommended to align the form of the intervention with its technological and/or thematic content. In practice it will mostly be platform-like instruments and innovation intermediaries that allow firms from unrelated strongholds to experiment together, to engage in mutual learning and/or to jointly set standards on which future innovations can be built. In the selection of suitable content, particular attention should be paid to whether a certain topic (be it technology or societal theme) is indeed relevant for the strongholds in an economy that can be linked, whether it is currently unexploited or overlooked by firms from the strongholds in question (i.e. is there still latent but unfulfilled demand for the envisaged intervention), and whether the intervention really offers attractive collaboration possibilities, so that knowledge flows are likely to emerge. Lateral topics might best be employed when fitted to the context of the specific unrelated strongholds that are being linked to each other, provided that the number of relevant strongholds is sufficiently comprehensive for non-trivial communalities between them to exist. The actual design of cross-over interfaces is likely to benefit from more focused investigations into the particular needs and trends relevant for the specific strongholds involved. While developments like the rise of 3D printing technologies can affect business practices in virtually any part of the economy, opportunities and needs shared by a select set of industries can perhaps best be triggered by setting up a tuned rather than universal approach. This is to say, when boosting 3D printing activities in, for instance, life sciences and chemicals, this asks for a different approach than policy efforts focused on the adoption of 3D printing in general.

Directions for future research

From a practical perspective, the most urgently needed extension of this study concerns the selection of suitable interfaces. Analysing which industries and topics can connect unrelated strongholds is only one starting point for examining which trends policy makers can use to increase the perceived relatedness between firms who hardly use each other's well-developed bodies of knowledge. More research is needed to determine which interfaces are appropriate, and how the selection and implementation of an actual intervention should be organised.

Amongst others, the interventions suggested here include possibilities to turn industrial policy into holistic innovation policy, addressing economic, technological and societal issues. This invites research on the linkages between industrial policy and mission-oriented innovation policy (Foray, 2019). Ambitions to solve societal challenges and boost socio-technical transitions can be combined with the knowledge orchestration possibilities offered by innovation intermediaries (Van Lente et al., 2003). Surprisingly, the nascent literatures on both mission-oriented innovation policy as well as on innovation intermediaries have devoted only little attention to the strategic question which forms of recombinant search to support specifically. The impact of such policies, at least when it comes to economic transformations, can be enhanced by safeguarding that resulting collaborations go beyond connecting already related knowledge bases. Moreover, apart from possibly strengthening the economy, spurring cross-overs between different sectors might also lead to the improved of the solutions themselves (Mazzucato, 2018).

Cross-specialisation has the potential to lead to new types of economic activity in strongholds as well as in intermediately situated niches. In order to strengthen evidence for the merits of a cross-specialisation approach, further examination of these diversification mechanisms would be a fruitful addition. Relevant in this respect is the question under which conditions cross-over industries show (themselves) or cause (in other industries) upsurges in economic performance. For the case of the Dutch Topsector approach, it would also be relevant to assess to what extent a cross-specialisation strategy has been adopted in actual interventions and innovation roadmaps, and whether this is having any effect on innovative performance and the structure of the industry space itself. Noteworthy generic lines of additional inquiry include examination of the role of services in industry evolution (are service industries situated at cross-over positions?), and options to use cross-specialisation for designing interregional policy (which complementarities do we find between strongholds on two sides of a border?), but many other extensions can be thought of. With this article we hope to provide fruitful directions for investigating as well as guiding structural change, starting from the idea that merely clinging on to strongholds will ultimately leave little to defend.

Supplementary material

Supplementary material is available at *Cambridge Journal of Regions, Economy and Society* online.

Endnotes

[1] 'Local' does not have a geographical notion here; it refers to knowledge that is similar to the existing knowledge base of a firm (Rosenkopf and Nerkar, 2001).

[2] The European Commission's Smart Specialisation Platform for Industrial Modernisation is using the KET themes for uniting firms that are geographically distant (Heghyi and Rakhmatullin, 2017), rather than cognitively.

Acknowledgements

This study benefitted from the Dutch Ministry of Economic Affairs and Climate's financial support for an invited report, published as 'Cross-overs en industriebeleid' (Dialogic/PBL, 2015). We are grateful to Carolina Castaldi and to fellow researchers at Dialogic and PBL for their valuable suggestions throughout the preparation of this paper. An earlier draft received the Best Paper Award at the European Meeting on Applied Evolutionary Economics (Maastricht, 2015) and was presented at the CJRES 'Industrial Policy revisited' workshop (Bath, 2018) and CJRES annual conference (Cambridge, 2018). We would like to thank the participants as well as two anonymous reviewers for their helpful comments.

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