Clusters and firm-level innovation: A configurational analysis of agglomeration, network and institutional advantages in European aerospace

Daniel Speldekamp*, MSc
Institute for Management Research, Radboud University
PO Box 9108, 6500 HK, Nijmegen, The Netherlands
d.speldekamp@fm.ru.nl

Prof. dr. Joris Knoben
Institute for Management Research, Radboud University
PO Box 9108, 6500 HK, Nijmegen, The Netherlands
j.knoben@fm.ru.nl

Prof. dr. Ayse Saka-Helmhout
Institute for Management Research, Radboud University
PO Box 9108, 6500 HK, Nijmegen, The Netherlands
a.saka-helmhout@fm.ru.nl

Final preprint

* Corresponding author

Clusters and firm-level innovation: A configurational analysis of agglomeration, network and institutional advantages in European aerospace

ABSTRACT

Clusters have the potential to strengthen firm innovation. However, our knowledge of how firms are affected by the external resources found in clusters, and how this relates to their level of internal resources, is limited. There are seemingly conflicting theoretical assumptions and empirical findings on both the individual and combined impact of these resources. Our paper seeks to reconcile these by adopting a configurational lens, allowing for multiple pathways to innovation. Applying fuzzy-set Qualitative Comparative Analysis (fsQCA) to a sample of firms in European aerospace clusters, we uncover that innovation outcomes can only be explained through combinations of internal assets, and external resources provided by geography, networks, and institutions. No single resource, in isolation, is sufficient. We distinguish between a total of seven pathways. These vary from weak firms benefitting from localized knowledge spillovers, to strong firms with extensive non-local networks. We find that the relationship between internal and external resources is causally complex, with even the potential for negative innovation impacts. Hence, we provide a first step towards harmonizing the literature's different approaches to understanding clusters' impact on firms.

Keywords: clusters, qualitative comparative analysis (QCA), internal resources, innovation.

Classification codes: O320 (Management of Technological Innovation and R&D), R110 (Regional Economic Activity: Growth, Development, Environmental Issues, and Changes).

1. Introduction

Researchers have long been interested in agglomerations of economic activity and their potential to strengthen firms' innovation output (Galliano et al. 2015). In this discourse, Porter's (1990a, 1990b) cluster concept has become the standard (Martin and Sunley 2003; Wolman and Hincapie 2014). He describes clusters as "*geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (…) in particular fields that compete but also cooperate*" (Porter 1998, pp. 197-198). This definition signals that firms in clusters are subject to combinations of geographic, network and institutional forces. For instance, both diverse and specialized geographic concentrations of activity can lower input costs, and foster innovation through knowledge spillovers (Van Der Panne 2004). However, firms may suffer concomitant congestion and competition effects (Sorenson and Audia 2000; Knoben 2008). Interconnectedness enables partners to purposely transmit knowledge, but makes them vulnerable to negative effects from free-riding (Gordon and McCann, 2000; McCann and Folta, 2008). Moreover, certain institutional regimes and structures are conducive to innovation efforts, while others are unfavorable (Allen 2013; Hotho 2014).

Despite considerable academic attention (McCann and Folta 2008; Lazzeretti et al. 2014; Hervas-Oliver et al. 2015), there are disagreements on fundamental matters such as whether geographic specialization or diversity spurs firm innovation (Glaeser et al. 1992; Van Der Panne 2004; Beaudry and Schiffauerova 2009; Van Oort 2015). A recent line of research stresses that these contentions are likely a consequence of earlier studies not considering the moderating impact of firm-internal resources on the effects of external forces, although various assumptions exist on this relation (Frenken et al. 2015; Hervas-Oliver et al. 2018). At one extreme, the resource-based view (RBV) (Barney 1991; Peteraf 1993) and its extension (Lavie 2006; Arya and Lin 2007) suggest that weak firms benefit from clusters. In this view,

not all resources need to be embedded in the firm (Lavie and Drori 2011). External resources can substitute internal endowments (Lavie 2006; Cuervo-Cazurra and Un 2010), and weak firms are unlikely to suffer from knowledge leakage (Frenken et al. 2015). This substitution can be the driving force for innovation in such firms (Grillitsch and Nilsson 2017). In contrast, it has also been proposed that stronger firms benefit from cluster advantages through complementarity between internal and external resources (Hervas-Oliver and Albors-Garrigos 2009). This proposition rests in the absorptive capacity argument that without sufficient internal resources, firms cannot use external knowledge (Cohen and Levinthal 1990; Voudouris et al. 2012). Complicating matters further, it has also been proposed that moderately strong firms benefit the most, experiencing complementarity while being less negatively impacted by knowledge leakage (Hervas-Oliver et al. 2018).

We assert that these enduring inconsistencies can be reconciled by not only considering substitution and complementarity between internal and external resources, but also among external resources (see Whittington et al. 2009; Speldekamp et al. 2019). Furthermore, there are likely multiple pathways for cluster firms to innovate, between which internal and external resources have asymmetrical effects and varying degrees of necessity and sufficiency (Fiss 2007, 2011; Denk and Lehtinen 2013). To illustrate, in one path, geographic diversity could be detrimental for weak firms and, in another, it may be positive as it coincides with geographic specialization and a strong network, enabling the use of knowledge spillovers from dissimilar firms, and offsetting congestion effects (Huggins and Thompson 2013; Breschi and Lenzi 2016; Fritsch and Kublina 2018). We thus apply a configurational approach, breaking from the assumption that individual factors either always contribute to, detract from, or are insignificant for innovation (Ragin 1987, 2008; Misangyi et al. 2017). Our accompanying research question is: '*What configurations of geographic, network, and institutional factors combined with different levels of firms' internal resources are associated*

with high firm-level innovation?'

In what follows, we first detail the external and internal drivers of innovation, as well as the literature's different views on how these combine to drive innovation. Subsequently, we present our research setting and methods. Data gathered in the European aerospace industry are analyzed using fuzzy-set Qualitative Comparative Analysis (fsQCA). Our analyses suggest that the different theoretical assumptions and empirical findings characterizing the literature are not contradictory or paradoxical, as often claimed (Hervas-Oliver et al. 2018; Grillitsch and Nilsson 2019). We uncover a total of seven paths to innovation which demonstrate that either external or internal resources, in isolation, are insufficient. The modes of innovation vary between these paths, from agglomerated innovators with weak internal resources, to strong linchpin innovators. In our discussion, we present our study's theoretical and practical implications. We highlight the need for future research to further unpack the complex relationships between contingencies driving firm-level innovation in clusters to advance our understanding.

2. Theoretical background

Our study principally draws on Porter's (1990a, 1990b, 1998) foundational work on clusters (see Lazzeretti et al. 2014) by studying the complementarity and substitution among his three cluster dimensions in their interaction with firms' internal resources. Our theoretical framework also reflects on the (extended) RBV and the theory of absorptive capacity. These have been used to arrive at different expectations of how internal and external resources combine to result in firm innovation. We provide a first step to reconciling these seemingly divergent views, which we also empirically test.

2.1. The cluster concept: the external forces impacting firms

Much of the cluster literature focuses on the innovation consequences of geographically bounded economies of scale (Gordon and McCann 2000). Diverse, urbanized environments offer well-developed infrastructures and proximate services, decreasing transaction costs (Jacobs 1969; Glaeser et al. 1992). In contrast, localization economies arise through the co-location of firms in the same industry, or with a shared technological or product focus (Marshall 1920; Krugman 1991). This concentration results in input advantages such as access to a pool of specialized labor, and specialized services. Moreover, because knowledge is only partially rival and appropriable, it spills over between firms (Breschi and Lissoni 2001). These spillovers are geographically bounded and occur, for example, through labor mobility and chance meetings (Feldman 1999; Bathelt et al. 2004). In clusters with strong urbanization economies, these are more diverse, whereas localization economies provide access to industry-specific spillovers (Glaeser et al. 1992; Van Der Panne 2004).

Firms in clusters also purposefully engage with other organizations to improve their innovation capability (Porter 2000; Pittaway et al. 2004; Boschma and Ter Wal 2007). Geographic proximity to potential partners in clusters lowers communication costs, and facilitates the exchange of tacit knowledge, an important driver of innovation, through face-to-face contact (Von Hippel 1998; Howells 2002; Biggiero and Sammarra 2010; Belussi and Sedita 2012). However, geographical concentrations of firms do not necessarily result in interconnectedness (Boschma and Ter Wal 2007; Ter Wal and Boschma 2009). A growing body of research suggests that despite most networks being local, extra-local connections can be especially useful to innovation (Boschma 2005; Fitjar and Rodriguez-Pose 2011; Huggins and Thompson 2013; Fitjar and Huber 2015; Breschi and Lenzi 2016). They can provide access to more relevant knowledge, especially for specialized firms, and grant learning opportunities otherwise lacking in clusters with few potential partners and knowledge spillovers (ibid.).

The quality of formal and informal institutions in clusters are similarly important when considering innovation, because they determine the opportunity structures and constraints that firms have to navigate (Oliver 1997; Hall and Soskice 2001; Casper and Whitley 2004; Boschma 2005; Whitley 2007; Allen 2013; Hotho 2014). The efficacy of formal institutions is principally determined by political stability, regulations, rule of law, control of corruption, and the extent to which citizens can participate in political processes (Kaufmann et al. 2009; Rodriguez-Pose and Di Cataldo 2015). For instance, if the rule of law is strong, firms have better means to protect their intellectual property and are more likely to invest in innovation (OECD 2010). Similarly, the quality of services such as education, health care, and law enforcement impact firms' capacity to innovate. Due to administrative control held by regions, these factors can vary on a regional basis (Rodriguez-Pose and Di Cataldo 2015). Regionally bounded informal institutions, norms and habits in clusters are just as impactful on firm innovation (Boschma 2005). These develop over time, and create trust between firms, facilitating transactions and deeper collaborations (Moulaert and Sekia 2003). When communities in clusters develop their own norms, they often create mechanisms to penalize undesirable behavior. For instance, unwanted copying of designs or production methods may lead to firms being excluded from future engagement with other clustered firms (Dei Ottati 1994).

Access to external resources can also have adversarial effects (McCann and Folta 2008). The geographic concentration of firms may result in congestion, high land prices, and competition for inputs such as qualified labor (Sorenson and Audia 2000; Knoben 2008). In their metanalysis of geographic effects, Beaudry and Schiffauerova (2009) show that localization economies especially generate disadvantages. This includes labor poaching and knowledge leaking to co-located (and perhaps competing) firms (Frenken et al. 2015). This is expected to be especially damaging in institutional environments with weak formal and

informal institutions, where intellectual property rights are underdeveloped and opportunism is left unsanctioned (Khanna and Palepu 1997, 2000; Verbeke and Kano 2013; Doh et al. 2017). Similar concerns apply to networks that expose firms to the risk of free-riding and learning races (Baum et al. 2000).

The balance of positive and negative implications of clusters for firms' innovation is subject to intense debate, with inconsistent empirical findings (McCann and Folta 2011; Frenken et al. 2015). To illustrate, for the last twenty years it has been contentious whether diverse or specialized agglomerations drive innovation and growth (Glaeser et al. 1992; Van Der Panne 2004; Beaudry and Schiffauerova 2009; Van Oort 2015). There is a similar disagreement on whether formal or informal institutions are key (Rodríguez-Pose and Storper 2006). Even the fundamental question of whether it is enough to be located in a cluster, or if firms need to be embedded in extra-local networks remains unresolved (Bathelt et al. 2004; Fitjar and Rodriguez-Pose 2011).

2.2. Firm-level heterogeneity

In order to address the contradictory theoretical assumptions and inconsistent findings highlighted in the preceding section, researchers are increasingly moving away from the idea that clusters have universally positive or negative effects for the firms contained within them (McCann and Folta 2008; Frenken et al. 2015). Instead, they are addressing the question of "*which type of firms profit from clustering and under what conditions?*" (Frenken et al. 2015 p. 20). This development has coincided with efforts to connect to the strategic management and organizational literatures, drawing on the RBV and absorptive capacity theory (Hervas-Oliver and Albors-Garrigos 2009; Hervas-Oliver et al. 2018).

The RBV emphasizes that firm-internal resources drive innovation (Barney 1991; Peteraf 1993). Although an extensive overview of RBV research is beyond the scope of this paper

(for which we refer to Barney et al. 2001, 2011; Kraaijenbrink et al. 2010), three of its features are important for our purposes: its emphasis on combinations of resources, the importance of intangible resources, and the pliability to accommodate the role of external resources. The first two points indicate that individual resources have a limited capacity to generate innovation, and that, instead, this principally results from combinations of intangible assets (Barney 1995; Kostopoulos et al. 2002; Bakar and Ahmad 2010). This is the most evident in research-driven industries such as aerospace, where technological knowledge in the firm, employees' skills, and quality of business processes determine success to a greater extent than imitable tangible resources such as equipment and property (Michalisin et al. 1997; Lefebvre and Lefebvre 1998; Prencipe 2002; Oltra and Flor 2003; Arman and Foden 2010; Kyläheiko et al. 2011). The third point relates to extensions of the RBV that include external resources (e.g. Lavie 2006; Arya and Lin 2007). This research overlaps with the cluster literature, noting that resources are embedded in firms' immediate geographic environment and institutional context (Brouthers et al. 2008) and can be sourced through networks (Eisenhardt and Schoonhoven 1996; Dyer and Singh 1998; Lavie 2006).

Notably, if the origins of knowledge and other types of resources are not important, accessing external resources can be a substitute to building firm-internal resources (Cuervo-Cazurra and Un 2010; Lavie and Drori 2011). Cluster scholars have even argued that firms with weak internal resource bases have the "most to gain and least to lose" (Frenken et al. 2015, p. 15). For these firms, external knowledge is likely to be novel (Oliver 1997; McCann and Folta 2011), and the risk of knowledge leakage minimal (Boschma and Frenken 2011).

Although the extended RBV does not preclude the possibility that innovation results from the complementarity between having both significant internal and external resources, most of the scholarship on clusters suggesting this has relied on Cohen and Levinthal's (1990) absorptive capacity construct (Hervas-Oliver et al. 2015). Through this approach, two

different expectations emerge. On the one hand, a group of scholars argues that firms with the strongest internal resources are best able to navigate their environment, and recognize, assimilate and use external knowledge (Cohen and Levinthal 1990; Kogut and Zander 1992; McCann and Folta 2011). Additionally, such firms are more likely to be able to support larger networks due to greater resources, and reputation effects (Ter Wal and Boschma 2011). On the other hand, this view on complementarity has been criticized for ignoring the detriments of clustering (e.g. Frenken et al. 2015). External resources are more likely to be redundant the stronger a firms' internal resources are (ibid.). Moreover, knowledge leakage may occur, leading to firms empowering their competitors (Tallman et al. 2004; Alcácer and Chung 2007; Rigby and Brown 2015). Therefore, firms with a moderately developed resource base may be in the best position to gain from external assets, having sufficient capacity to absorb them, and fewer costs relating to leakage and redundancy (Frenken et al. 2015).

Although there is agreement within this strand of research that internal resources are impactful and shape the role of external resources, the assumptions on this relationship are thus disparate. Similarly, there are divergent empirical findings, providing evidence for each of the preceding arguments, which have been perceived as contradictory (Hervas-Oliver et al. 2018, p. 10), conflicting (Knoben et al. 2016, p. 19), and even paradoxical (Grillitsch and Nilsson 2019, p. 2). First, location choice studies support the existence of a substitution effect (e.g. Kalnins and Chung 2004; Alcácer and Chung 2007, 2014). For instance, Shaver & Flyer (2000) demonstrate that larger, resource-rich and foreign greenfield investments in US manufacturing tend to avoid clusters, as they are likely to lose out, whereas the opposite is true for small greenfield projects. This is strengthened by Grillitsch & Nilsson's (2017) study, which finds that weaker Swedish firms' employment and sales growth are positively impacted by their location in clusters with strong geographical externalities. Stronger firms in their sample do not benefit from such externalities. However, in a more recent study in the same

context, these authors find that knowledge intensive, high-growth firms' labor productivity improves in knowledge-rich regions (Grillitsch and Nilsson 2019). McCann & Folta (2011) present similar findings, detailing that the larger the knowledge stock of US biotech firms, the more their innovativeness is strengthened from being located in bigger and more knowledge-rich clusters. Finally, work by Hervas-Oliver et al. (2018) and Knoben et al. (2016) provide evidence for the benefits accrued by moderately strong firms. Hervas-Oliver et al. (2018) show that for product innovation, Spanish firms with strong resources have less to gain from clusters than moderately strong firms. In addition, when their internal resources are very weak, external resources cannot be accessed and internalized. Knoben et al. (2016) uncover similarly complex interrelationships in their study of Dutch firms. Here, the productivity of very small and large firms, which can be expected to have to the fewest and strongest internal resources, suffers from strong urbanization and localization externalities. In contrast, moderately strong firms benefit.

2.3. Complexity and multiple pathways

Given the uncertainties about the effects of clusters on firms (cf. McCann and Folta 2011; Hervas-Oliver et al. 2018), we need to adopt an approach that allows for causal complexity. This is not to say that previous studies do not account for the interaction between factors, or for bell-shaped relationships. Hervas-Oliver et al. (2018), for instance, uncover a curvilinear relationship between internal and external resources resulting in innovation. However, it is likely that there are even more complex constellations of geographical, network, and institutional factors, as well as internal resource strength, which result in innovation over multiple, potentially asymmetrical pathways (Misangyi et al. 2017).

In other words, we propose that a configurational approach that more fully acknowledges conjunction, equifinality, and asymmetry has the potential to advance our understanding of

clusters (Ragin 2000, 2008; Fiss 2007, 2011). Under such an approach, weak firms could substitute building further internal resources by seeking external sources, and strong and moderately strong firms may simultaneously experience complementarity. They do not necessarily rule each other out, as has been assumed thus far (Frenken et al. 2015), but may constitute distinct pathways to innovation. Furthermore, this approach holds the potential to advance debates on whether geographic specialization or diversity, formal or informal institutions, and being in a cluster or having non-local networks spur innovation (Speldekamp et al. 2019). In some contexts and pathways, these conditions each may help firms innovate, and even be necessary factors, yet in others they could prove unimportant or detrimental (Misangyi et al. 2017).

3. Data and methods

Fuzzy-set Qualitative Comparative Analysis (fsQCA) ideally fits our configurational approach, allowing us to uncover the combinatorial conditions under which internal and external resources are associated with high firm-level innovation. fsQCA is a comparative case analysis, where each case is considered as a combination of attributes (Ragin 2008; Fiss 2011; Misangyi et al. 2017). Different combinations of attributes can cohere with the presence of an outcome. To uncover such coherence, both the attributes and outcome are transformed into sets and analyzed through sub- and superset relationships. Therefore, an important step in our study was to create thresholds to ascertain when firms were members of sets—e.g. when they had strong internal resources and were subjected to strong geographical specialization. Below, we first present our data and cases, before we delve into other important characteristics of fsQCA. Finally, we discuss how we constructed and analyzed the different sets.

3.1. Research setting

We opted to study the European aerospace industry for three reasons. First, it is a highly concentrated industry with self-defined clusters (European Cluster Observatory 2015; EACP 2017). Second, its firms (and entire clusters) display significant differences in geographical, network, and institutional conditions, as well as internal resources, and innovation outcomes (Hickie 2006; Rose-Anderssen et al. 2008; ECORYS 2009; Turkina et al. 2016). The third reason is practical in nature. Most European aerospace clusters are member of the European Aerospace Cluster Partnership (EACP). With help from this meta-organization, we were able to enlist the support of six aerospace clusters, spread over four countries.[1]

Our analysis builds on interview and survey data, as well as statistics from secondary sources. We conducted in-depth, semi-structured interviews with managers from the six participating clusters. We also interviewed the managers of four other clusters (which did not participate in the main study) to gain a better understanding of the research context. The interviews lasted between 80 and 180 minutes, averaging two hours. We inquired about the cluster's history, defining characteristics such as geographical reach, institutional conditions, and any regional or sectoral challenges. These interviews were recorded, transcribed verbatim, and coded. They were vital in interpreting our fsQCA results. In addition, we used our interviews to ask each cluster manager to reflect on our survey, using their feedback to develop the instrument.

In our survey, we asked firms about their general characteristics, R&D activities, and their innovation outcomes between 2013 and 2015. Most of these questions were derived from the 2012 edition of the Community Innovation Survey (Eurostat 2019a). We also asked each

[1] The EACP had 34 member clusters in 13 countries at the end of 2013, of which approximately half were active (EACP 2014; personal communication with the EACP). The clusters participating in our study are: Hamburg Aviation, Niedersachsen Aviation, LR BW (all in Germany); NAG (the Netherlands); Madrid Network (Spain); DAC (Italy). We also received assistance from Lazio CONNECT (Italy), FAC (the United Kingdom), FLAG (Belgium), Aerospace Valley (France), and interviewed their cluster managers, but had challenges reaching their members for the administration of the survey. As explained further below, we piloted our survey with help from WEAF (which is in the United Kingdom).

firm to list their ten most important innovative partners both inside and outside the cluster (for a maximum of 20 connections). Listed connections needed to have the primary goal of exchanging or acquiring knowledge to support innovative activities (following Knoben and Oerlemans 2012). These partners could be firms, or other types of organizations (e.g. governmental institutions). We set a maximum number of connections as most firms only have a few innovation partners, and a small group of firms have a very large number of connections—risking non-response. The minimum frequency of contact was set at once a month, regardless of the communication medium. For linkages inside the cluster, we used a roster supplied by cluster managers (see Ter Wal and Boschma 2009). Outside linkages were entered freeform. Moreover, we asked firms about the extent to which they shared mutual trust with co-located firms.

To ensure the viability of our questions, we piloted the survey among eleven members of the WEAF cluster at a showcase event. Upon our confidence in the survey's quality, we distributed it among the six participating clusters (online-only Appendix A presents the full questionnaire for one of our clusters, namely Hamburg Aviation). This data collection took place between October 2016 and July 2017. The survey was sent to all types of organizations, although we filtered responses from non-firms for the purpose of our current study. For five of the six clusters, we depended on their managers to send electronic survey links to their member organizations. In the other case, we sent direct emails to the cluster members. These efforts, as well as reminders via email, did not lead to the desired response. Therefore, the first author attended trade exhibitions and cluster member gatherings with help from the cluster managers. As a result, the majority of surveys were administered in person.

Table 1 reports the breakdown of our response rates per cluster, and shows that we

gathered a total of 65 unique and useable responses.[2] Relatively low responses are a common issue in organizational research (Baruch and Holtom 2008), especially when capturing networks (Ter Wal and Boschma 2009). Although many firms were not willing to share the strategic information that we were interested in, we are confident that our data provides a basis for meaningful analysis. Our study is of an exploratory nature. Moreover, the method we utilize is ideally suited to uncovering whether multiple configurations of internal and external resources exist, even with a relatively small and unrepresentative sample (Greckhamer et al. 2013). As Fiss (2011, p. 402) explains, fsQCA does not require data to be drawn from particular probability distributions.

Insert Table 1 about here

Additionally, we used various secondary data to capture firms' geographical and institutional conditions. For the former, we used Eurostat (2019b, 2019c) population and structural business statistics. To measure formal institutions, we relied on data from the Quality of Government Institute of the University of Gothenburg (Charron et al. 2014, 2015).

3.2. FsQCA: main features and calibration

We used fsQCA to investigate our propositions (Ragin 2008). While it is beyond the purview of our paper to provide an extensive methodological overview of this method (for which we refer to Fiss 2007, 2011; Greckhamer et al. 2008), it is important to highlight some of its key characteristics and why it was suitable for our purposes.

First and foremost, fsQCA allowed us to analyze a medium number of cases with a

---

[2] In 6 cases, firms completed the survey twice. We discarded the least complete responses, and when this did not differ, this was done at random. It is worth noting that the data entered by firms in the duplicate responses were almost identical.

relatively large number of causal factors (Fiss et al. 2013; Greckhamer et al. 2013). It gave us the opportunity to uncover both necessary and sufficient conditions for firm-level innovation. Through its assumptions of conjunction, equifinality and asymmetry, fsQCA offered us the potential to understand the relationship between the different factors and the outcome, aligning well with our configurational thinking (Misangyi et al. 2017).

To analyze sub- and superset relationships, we calibrated the degree of membership in sets through three anchor points, as is customary in fsQCA (Ragin 2000, 2008). These denoted full membership, the crossover point (also known as the maximum point of ambiguity), and full non-membership. The respective scores of these thresholds were 1, 0.50, and 0. These points were then used to assign continuous set membership scores of firms, ranging between full membership and full non-membership. Following common practice in the literature, we based our calibration thresholds on external and theoretical criteria when these were available to us (e.g. Fiss 2011; Misangyi et al. 2017). Unfortunately, we could not always find clear indicators to guide our calibration. In these cases, we followed the practice of relying on sample statistics (e.g. percentile scores) (cf. Chappin et al. 2015). Finally, it is important to note that due to the methodological issues associated with a membership score of exactly 0.50, i.e. the point of maximum ambiguity, we added a constant of .001 to all calibrated scores below 1 (Fiss 2011; Hotho 2014).[3]

The calibration reported below and the analyses of set relationships discussed later in the paper were performed using the Fuzzy-Set/QCA 3.0 program (Ragin et al. 2017).

3.2.1. Outcome: innovation

Our measure of innovation captures the number of patents registered by individual firms

[3] This means that the supplementary analyses on the negation of high innovation, reported later in the text, have the constant of .001 deducted from membership scores instead.

with the European Patent Office (EPO) between 2013 and 2015. These numbers were reported in our survey and then cross-checked using the European Patent Register (EPO 2018). In this procedure, we entered the company names as the applicant and searched for priority dates (the earliest patent application for an innovation) in 2013, 2014, and 2015. As we considered recent innovations, we were not able to check whether patents had been approved. Such procedures often take more than 5 years. However, in order for patents to be granted, they must be non-trivial and useful (Trajtenberg 2001). With costs being incurred to apply for a patent, it can be expected that firms will only do so when they believe their innovation meets these criteria.

Patents are an imperfect measure of innovation (see e.g. Whittington et al. 2009), but they are a useful proxy for innovation in aerospace. The role of other mechanisms, such as secrecy, to protect knowledge has steadily declined since the post-war period and the increased importance of commercial value over defense interests (Ardito et al. 2016). Moreover, because aerospace relies on technological assets, patents are an ideal protection measure. This usefulness, as well as the practicality of patenting information being publicly available, has led to their frequent adoption as a measure of innovation in aerospace studies (ibid., p. 922).

For our calibration, it is important to note that the majority of firms opting to protect their knowledge through patents, even in aerospace, only hold a small number (Beaudry 2001). We assigned a score of 1 to firms with at least 2 patents in the group of high performers. Moreover, a sizeable segment of firms holds only one patent (ibid.). We coded such firms with 0.50—at the maximum point of ambiguity in the set. Firms without patents were coded as 0 and were, therefore, completely out of the set.

3.2.2. Selection criteria: internal resources

As identified earlier in our paper, technological resources are the principal determinant of internal resource strength in aerospace (Lefebvre and Lefebvre 1998; Prencipe 2002). Crucially, the level of internal resources does not only drive innovation directly but is likely to cohere with the effects of external resources on firms' innovation—resulting in complementarity or substitution. In the literature, it is contentious whether firms with weak, strong, or moderately strong internal resources benefit the most from external resources (Hervas-Oliver et al. 2018). While the two extreme categories are both linear, the argument that firms with moderate internal resources enjoy the greatest complementarities proposes an inverted U-shape relation. To capture this potential optimum, our analyses on the drivers of innovation were not only run over the entire sample (to provide a broad overview of set relationships), but also separately for firms with the three different levels of internal resources.

In line with the extant literature, we operationalized these resources through the percentage of sales invested in internal R&D during the years from 2013 to 2015 (Cohen and Levinthal 1990; Somaya et al. 2007; Dalziel et al. 2011; Kyläheiko et al. 2011; Love and Roper 2015; OECD 2018). This indicator is thus not dependent on firm size. The split of the sample into three parts was achieved through terciles. Weak firms invested less than 2% of their sales in R&D. Firms were moderately strong if they invested at least 2%, but less than 10%. Firms with strong internal resources invested at least 10% of their sales in R&D. Through this split, we could identify pathways for each type of firm, as opposed to only those with either the presence or absence of strong internal resources.

3.2.3. Causal conditions: internal resources

In addition to using internal resources as a selection mechanism, we created four sets denoting their relative strength. This was a set for the sample as a whole, and for weak,

strong, and moderately strong firms, enabling us to detect subtle differences in their impact within each analysis. The thresholds for the sets were based on the minimum and maximum R&D intensity of their respective group and the arithmetic average between these two points. In the analysis of the entire sample, firms were fully in the set of strong internal resources when they invested 100% of their sales in internal R&D, at the point of maximum ambiguity at 55%, and fully non-member at 10%. The same thresholds were used in the selection of firms with strong internal resources. For the moderately strong firms, the calibration points were set at 8% (the highest value in our data below 10%), 5%, and 2%, respectively. The membership thresholds for weak firms were set at 1% (the highest recorded value in this group), 0.50%, and 0%.

3.2.4. Causal conditions: geographic factors

For our geographical sets, it is important to note that the clusters we examined have varying regional scopes. These range from NUTS-0 (an entire country) to NUTS-2 (administrative regions) (see Table 1). These are defined by the clusters themselves, and are recognized by the EACP (2016). We used these self-defined borders, which we sourced through our interviews, to calculate the measures described below. Although it may seem that our clusters greatly differ in size, the only incidence of a country-level cluster is NAG in the Netherlands. Its geographical span is roughly similar to that of most other clusters—e.g. LR BW in Baden-Württemberg.

Our first geographical set captures strong urbanization economies. This represents (dis)advantages created by a diverse concentration of economic activities. As the best way to capture diversity is contentious, we combined two of the most commonly used indicators: population density and job density (e.g. Breschi and Lenzi 2016; Knoben et al. 2016). Both pertain to 2013. Eurostat (2019b) readily provides population density, but not job density. We

were able to calculate job density by dividing the total number of jobs in a NUTS area by the region's total area (Eurostat 2019c, 2019d).[4] Both population and job density were subsequently converted into percentile scores for all NUTS-0, NUTS-1 and NUTS-2 regions within the EU-28.[5] The scores for the relevant NUTS areas (denoting our clusters) were averaged and imputed to our analyses. Here, firms were coded inside the set of being in a highly diverse cluster if this score was at least in the 90th percentile, indicating the presence of very strong Jacobs' externalities. The crossover point was the 75th percentile, which indicates moderately strong urbanization. Firms were outside the set at or below the 62.5th percentile, which is only marginally above the median.

Our second geographical set captures strong localization economies, which emerge due to concentrations of similar activities. Similar to our other geographical construct, there is an ongoing debate regarding its measurement. One group of scholars argues that the degree of specialization (e.g. a location quotient) best captures the density of interaction between firms (e.g. Glaeser et al. 1992). Another argument holds that the absolute number of co-located similar firms is key (Wennberg and Lindqvist 2010). We believe that the latter captures localization more directly, as it coheres with the available pool of specialized labor, and access to specialized services (Beaudry and Schiffauerova 2009). It is not distorted by the presence of other types of firms. We therefore used the count of clusters' member firms as our measurement for localization. These data were sourced from EACP documentation and their website (EACP 2014, 2016, 2019), and discussed during our interviews with the participating clusters. Overall, we were able to ascertain the membership of 21 clusters. Their figures are strongly skewed to the right, averaging at approximately 106 firms with a median of 78. The

[4] More precisely, we divided the total number of jobs for persons aged 15 or older by the total area size in square kilometers. The total number of jobs was only available in the NUTS 2016 classification. However, the total area size for each region in 2013 was only available in the incompatible NUTS 2013 classification. Therefore, we used the 2016 area size, which was available in the proper classification. This is unlikely to have an impact, as EU regions' borders rarely change.

[5] Some population data were missing. Here, we used the nearest year. For FRA (NUTS-1); FRA5 (NUTS-2) we used 2015 data. For FRA1; SI03; SI04 (NUTS-2) we used 2014 data. Population data change slowly over time, and taking data from subsequent years is unlikely to impose a significant measurement error.

75th percentile was measured at 128 firms. These estimates seem fairly accurate given that the EACP (2019) reports that there were circa 4,300 companies spread over their 42 partner clusters in 2019. We rounded our figures for the calibration. Firms were coded as being subject to strong localization economies if their cluster had at least 125 members. Such firms have a relatively large number of co-located aerospace firms. 100 members was taken as the crossover point, indicating the presence of some localization economies. Firms were outside the set if their cluster had 75 or fewer members.

3.2.5. Causal conditions: network factors

In addition to geographical sets, we distinguished between strong local and non-local linkages. Local linkages occur within clusters, and non-local linkages are outside the cluster. Our operationalization of both is a count of the number of organizations. The set membership thresholds for local and non-local connections differed, as firms tend to keep more local connections. For local connectivity, the full set membership threshold was set at 6, the crossover point at 3, and full non-membership at 0. These values correspond to the 75th, 50th (median) and 25th percentiles. For non-local connectivity, the thresholds were set at 3, 1, and 0, respectively. It should be noted that, here, the median value is 0.

3.2.6. Causal conditions: institutional factors

Our conceptualization of institutions is twofold. First, we captured the strength of formal institutions. Second, we constructed a set of strong informal institutions.

Given that both the national and regional institutional quality shape firms' opportunity and constraint structures, we aimed to capture institutional quality at both levels. We utilized the Quality of Government (QoG) index developed by Charron et al. (2014, 2015) at the Quality of Government Institute of the University of Gothenburg. This index provides a

summary valuation of regional service quality, impartiality, and lack of corruption. It interpolates these data with six principal country-level Worldwide Governance Indicators (WGI) to generate the QoG index (see Charron et al. 2013, 2014, 2015 for technical details). We used the normalized index for 2013, with values ranging between 0 and 100, to create a set for high quality formal institutions. A score of 1 was assigned to clusters in regions with a QoG index score of 80 or above. Rodriguez-Pose & Di Cataldo (2015, pp. 689-690) note that this is the threshold value above which a higher institutional quality is no longer associated with increased patenting. The crossover point was chosen at a score of 65, and firms were fully out of the set when their region scored at or below 50 (i.e. the mean).

Finally, informal institutions were captured by the perceived localized trust. In our survey, we asked firms to what extent they shared mutual trust with firms in their cluster on a 4-point Likert scale. Firms which answered 'to a great extent' were coded as fully in the set (a score of 4). 'Somewhat' was coded as the point of maximum ambiguity (a score of 3). Finally, 'not at all' (a score of 1) was coded as fully outside the set.

Table 2 displays a summary of our set operationalizations.

Insert Table 2 about here

3.3. Uncovering Causal Pathways with fsQCA

An important methodological step in uncovering the causal pathways to high innovation performance was to create four truth tables. Each pertained to a selection of firms, i.e. our full sample, as well as firms with weak, strong, and moderately strong internal resources. Truth tables consist of 2^k rows, where *k* denotes the number of causal conditions (Fiss 2011). In these tables, each row represents a specific combination of causal factors which are either true (1) or untrue (0). The rows detail how many cases have these characteristics, and what their

consistency is.

In the use of these truth tables to understand causal paths, we reduced the number of rows of each table by determining a minimum number of cases, and a minimum consistency value to retain a solution. Here, consistency refers to the extent to which cases correspond to the relationships expressed in a solution. We set our minimum solution frequency at one, due to our modest sample size (see Ragin 2017, p. 53). Following this, we set our consistency threshold at a minimum of 0.80. This minimum consistency was met by two, six, and three cases respectively for firms with weak, strong, and moderately strong internal resources, and two cases in the full sample.

The final step in this procedure was to further reduce the truth table to simplified combinations of conditions which lead to the outcome, using the algorithm described by Ragin (2017). We employed the parsimonious and intermediate solutions (Fiss 2011; Kim 2013). Each addresses limited diversity (i.e. logical configurations, or remainders, not in our dataset) in a distinct way, with the parsimonious solution using each logical remainder, and the intermediate solution only relying on 'easy' counterfactuals. Easy counterfactuals are added to a set of causal conditions which lead to the outcome (i.e. high innovation performance in our case). Difficult counterfactuals pertain to the removal of a condition from a combination of causal conditions which lead to the outcome (see Fiss 2011).

With these two solution types, we were able to identify both core and peripheral conditions. Core conditions are part of both the intermediate and parsimonious solutions, while peripheral conditions only appear in the intermediate solution. This means that the evidence for causal relationships is the strongest for core conditions, which are therefore the focal point of our analyses. In the configurational tables reported in the results below, ● represents the presence of core conditions, and ⊗ their absence. Peripheral conditions are denoted by smaller circles, i.e. ● and ⊗. Conditions which are not important are indicated by

blank spaces. Coverage and consistency values are presented at the bottom of the tables, representing the empirical relevance and strength of configurations (Schneider and Wagemann 2012). More precisely, coverage is the proportion of cases encompassed, and consistency denotes the correspondence between the cases and the relationships in a configuration (ibid.). Raw and unique coverage values are provided for each configuration. Raw coverage pertains to the total share, and unique coverage only to the share covered exclusively by a particular configuration (Greckhamer et al. 2013). The overall solution coverage and consistency pertain to combinations of pathways.

4. Results

Table 3 presents descriptive statistics of our measures for the four selections of firms, i.e. our full sample, and weak, strong, and moderately strong firms (full sample correlations are presented in Table 4). Firm strength is denoted by the level internal resources (i.e. technological know-how) and proxied by internal R&D investment. We observe that the stronger internal resources are, the more firms innovate. As expected, weak firms have the smallest local and non-local networks. There is no notable variation regarding firms' presence in urbanized and specialized clusters between the samples. Finally, it is noteworthy that the standard deviations are substantial, indicating large heterogeneity in how firms score on the different measures within these groupings.

Insert Tables 3 & 4 about here

The configurations of firm-internal and external resources leading to high innovation performance are shown in Table 5. Importantly, when all firms are grouped together, we only uncover a single pathway containing 16% of innovators. This analysis only distinguishes

between the presence and absence of very strong internal resources. Our separate analyses of weak, strong, and moderately strong firms each capture multiple paths and explain considerably more variance. This amounts to 71% of the innovation among weak firms, and 35% among strong and moderately strong firms. This not only indicates that all firms can become innovative, but that there are resource trade-offs shaped by different firm strengths. We therefore focus on patterns of substitutive and complementary relationships between resources within these more informative analyses.

Insert Table 5 about here

4.1. Weak firms: agglomerated and networked innovators

Table 5 shows two configurations through which weak firms can compensate for their lack of internal resources, i.e. solutions 2 and 3. Although they are characterized by their reliance on either agglomerations or networks respectively, the presence of some investment in internal R&D (between 0.50% and 1% of sales) is peripheral in both. At the core of solution 2 is the presence of many similar firms, and a well-developed formal and informal environment. This complementarity is not surprising. Institutional protection mitigates negative consequences from knowledge leakage, and co-located firms who trust one another may do little to stem outward flows of knowledge. It is more difficult to utilize learning opportunities that occur in strongly urbanized environments, as well as through non-local networks, rendering these peripheral absent conditions. After all, if these contingencies do not have noticeable positive effects but still increase costs, it is better if they are absent. This is quite different for the networked innovators in pathway 3. They have strong urbanization, localization, and non-local networks at the core of their innovation performance. Being able to rely on extra-local expertise seems to strengthen their ability to make use of the knowledge

spillovers in urbanized environments. That an extensive local network is a peripheral present condition can be explained by this offering few additional benefits over localization. Being subject to strong informal institutions is also a peripheral present condition, assuming less importance than in solution 2. Although it still boosts the development of localized spillovers, extra-regional networks are not directly affected by localized trust.

The importance of knowledge spillovers from geographic localization, core to both solutions 2 and 3, was corroborated by the cluster managers supporting firms. In our interviews, they indicated that facilitating the co-location of similar firms is an important development strategy. Such a strategy typically starts with an investment in research, often in public organizations. As one cluster manager explained:

> *"We have to compete with innovation. This is kind of red line that goes through most political decisions. (...) When we invest, we invest in new production technology, we invest in research. And the idea behind it is inducing cluster-like developments—that you have spillover effects that are serving both the industrial partner and the supply chain."*

Our interviews also substantiate the importance of networks in pathway 3. Even though it is not the only viable innovation strategy, many weak firms become a member of a cluster in order to gain access to collaborative partners. As one cluster manager told us:

> *"Especially at the moment, you can see this situation in the aerospace supply chain. Firms find each other and say: 'Oh, if I do my business on my own, I maybe have to stop in five years, because I can't handle it. But if we work together with two, three or five firms, we will handle it.' (...) Our role is to give them the platform to find each other."*

This networking takes place locally and internationally, with firms actively requesting cluster managers to link them to foreign organizations. Sometimes this is in the context of research projects, which can give access to funding and provide the means to develop novel knowledge. As another cluster manager and his colleague explained:

"What we do for EU calls or for projects [is the following]: through our office the question comes and is distributed into the network. (…) Our cluster, over the years, also issued some four of five letters of intent with other international clusters. This with the idea that the exchange between companies could be done more easily…"

"But we also do that much more concretely, as we are doing delegation trips, taking some companies with us to provide them direct contact with companies in the visited areas. Also, the other way around, if we are having companies from, for example, the Netherlands coming and looking for specific companies, we try to link them."

Based on the above, and with the caveat that this coincides with a marginal investment in internal resources, we propose the following:

Proposition 1: Weak firms can substitute internal resources and innovate through i) localization and the complementarity between strong formal and informal institutions, as well as ii) urbanization, localization and non-local networks.

4.2. Strong firms: non-local and local innovators

We observe two configurations for firms investing at least 10% of their sales into R&D, with solution 4 consisting of non-local innovators and solution 5 capturing local innovators. These firms experience strikingly different complementarities between their strong internal resource base and external resources. Firms in solution 4 avoid local embeddedness and rely on extensive non-local networks and urbanization for learning—the former being at the core of the configuration, and the latter taking on an ancillary role. These non-local innovators avoid co-locating with many similar firms (denoted as the absence of strong localization in Table 5) and are subject to strong informal institutions. The conjunction of these conditions likely limits negative effects of knowledge leakage to potential competitors and is complemented by strong formal institutions. However, this indicator of regulatory strength

and stability is not core to the pathway, signaling a less pronounced effect. In contrast, solution 5 demonstrates that local embeddedness can enable innovation. At its core are the absence of extensive non-local networks, and the presence of strong urbanization and local networks. Pervasive localization, and the informal institution of localized mutual trust are peripheral present conditions. The same is true for relatively strong internal resources within this group of firms, further distinguishing them from non-local innovators. The accompanying increase in absorptive capacity, and thus ability to absorb dissimilar knowledge, provides insight into urbanization becoming a core factor. Moreover, it can explain why institutions take on a less pivotal role than in solution 4, with firms better able to navigate their environment. Finally, local innovators likely contribute to co-located firms' performance, making it less likely that they will risk future gains for temporary free-riding advantages.

Our interviews underline the importance of localized trust for strong firms in solution 4. Almost every cluster manager indicated the negative consequences for innovation of firms and other organizations mistrusting one another. Considerable effort is spent on resolving frictions. One of the most common issues they signaled was the hesitation on the part of small firms to collaborate with bigger firms (the latter tending to have the greatest internal resource strength) for fear of being exploited and losing intellectual property. This is not to say that only strong firms are mistrusted. Small firms are frequently mistrustful of one another, most notably when they are in direct competition. Even universities can have reservations about collaborating. One cluster manager recalled his experiences setting up collaborative research projects when he was working at a large aerospace firm:

> *"There it was astonishing for me that there was really a lack of trust between the small ones and the big ones. (…) The small ones always feel like the big ones take their intellectual property and then vanish and use it for other things. What was more astonishing to me was that, between different research institutes, there was a very, very*

strong mistrust. (…) Between universities and big players, it's partially similar, because the intellectual property discussion is always the same. (…) The way to overcome that was, first, to have multiple talks, meetings, networking events, where you then not only talk about business but also about your wives, your hobbies, or your holidays, or your employees. On the other hand, it was working specifically in projects, where you can then after one-two-three years see how beneficial it was for everybody. This creates trust and sets a good example..."

Based on these configurations, we propose the following:

Proposition 2: Strong firms can complement their internal resources and innovate through i) non-local networks and strong informal institutions, as well as ii) urbanization and local networks.

4.3. Moderately strong firms: localized, urbanized and linchpin innovators

Firms with moderately strong resources, investing between 2% and 10% of their sales in internal R&D, display three pathways to innovation. These are localized, urbanized, and linchpin innovators—solutions 6a, 6b and 7. The first two configurations are related, and closely match that of the weak firms in pathway 2 relying on agglomeration. Solutions 6a and 6b share the absence of extensive networks and the presence of well-developed formal institutions as core conditions, with relatively strong internal resources and informal institutions being peripheral. The paths mirror the peripheral absence of urbanization and the presence of localization, which shows that they offer equally viable means to innovate. Urbanization seems to carry fewer risks, however, with the solution consistency for path 6b (0.96) being higher than that of 6a (0.83). In contrast, the linchpin innovators in solution 7 are characterized by the presence of relatively strong internal resources and large local and non-local networks as core conditions. The lack of pervasive localization, an absent core

condition, closely matches solution 7 to the configuration of strong firms leveraging non-local networks (solution 4) but distinguishes it from the weak firms with extensive networks (solution 3) that benefit from its presence. Risks associated with knowledge leakage thus seem to increase with resource strength. Firms in solution 7 are aided by the ancillary presence of strong urbanization, and formal and informal institutions. Complementarity between these two types of institutions occurs in five solutions and coincides with the absence of localization in three of them (4, 6b, and 7). This could indicate that very strong institutions lead to increased homogeneity between cluster firms, reducing benefits from localization for firms with at least moderately strong internal resources—a conjecture we return to in our discussion.

We propose:

Proposition 3a: Moderately strong firms eschewing networks can complement their internal resources and innovate through the complementarity between strong formal institutions and i) localization, or ii) urbanization.[6]

Proposition 3b: Moderately strong firms with relatively high R&D investments can innovate through the complementarity between local and non-local networks.

4.4. Robustness checks

In addition to using our interviews to corroborate and interpret our findings, we conducted several robustness checks (see online Appendix B and C). First, we checked whether or not there were any non-trivial necessary conditions for high innovation. These can create problems if included in the truth table minimization process to generate configurational tables (Ragin 2008). The degrees of necessity we find are all below the critical threshold of 0.90 suggested by Schneider & Wagemann (2012) and used in recent QCA studies (e.g.

[6] Please note that although localization and urbanization are present peripheral conditions, they are the only empirically relevant conditions to distinguish solutions 6a and 6b. We therefore based proposition 3a on them.

Schiehll et al. 2018), with the exception of localization in the sample of weak firms (Table B.1). However, due to its low coverage value of 0.28, this is a trivial necessary condition. Further checks indicated that it emerges based on a total of two cases and is, thus, likely an artefact of our small sample size. We reran this analysis for the inverse of high innovation performance (i.e. low performance), finding no necessary conditions (Table B.2).

Second, we conducted additional fsQCA analyses to uncover causal pathways to low innovation performance. Our set-theoretic approach assumes causal asymmetry (Fiss 2011). In other words, the paths leading to high innovation are not simply the inverse of those leading to the negation of the outcome. We ensured that, in addition to having no necessary conditions, there were no occurrences of conditions consistently appearing significant for both the presence and absence of high innovation. Online Appendix C (Tables C.1 through C.4) shows that our analyses are robust in this respect. These additional analyses strengthen our conjecture that external resources carry the potential for negative innovation consequences.

5. Discussion and conclusion

Our study of firms in European aerospace clusters contributes to the literature on clusters in two ways. First, our configurational analysis demonstrates that there are multiple pathways to innovation for firms of varying internal resources, and that neither firm-internal nor external resources are sufficient in isolation. Where weak firms can substitute internal resources through different complementary combinations of geographical, network, and institutional resources, these external resources can complement both strong and moderately strong firms' internal assets. These findings provide a first step to reconciling the disparate assumptions and evidence on which types of firms benefit from clusters (Frenken et al. 2015; Hervas-Oliver et al. 2018). Our second contribution concerns the impact of individual external resources, and we show that what works in one configuration often becomes unimportant or

detrimental in another. This sheds light on the confusion regarding whether innovation is driven by geographic diversity (urbanization) or specialization (localization) (Beaudry and Schiffauerova 2009; Van Oort 2015), being located in a cluster or having extra-local networks (Bathelt et al. 2004; Fitjar and Rodriguez-Pose 2011), or through formal or informal institutions (Rodríguez-Pose and Storper 2006).

Our study points to considerable complexity in how firms with different levels of internal resources benefit from clusters, disclosing informative patterns of complementarity and substitution between internal and external resources as well as between external resources. It is notable that the two pathways to innovation for weak firms feature marginal investments in internal resources (i.e. R&D expenses between 0.50% and 1% of sales). This is in line with the absorptive capacity argument (Cohen and Levinthal 1990), but runs counter to claims in the literature that strong or moderately strong resources are required to benefit from external resources (Frenken et al. 2015). For weak firms using clusters to substitute their limited internal resources, strong networks and urbanization are complementary. The know-how of collaborators strengthens the benefits accrued from geographically bounded knowledge spillovers. Localization appears in both pathways to innovation for weak firms, in line with the argument that less diverse spillovers are still useful to them (Van Der Panne 2004; Frenken et al. 2015). This is different for firms with stronger internal resource bases, who risk leaking knowledge and often find the accessed knowledge redundant (Breschi and Lissoni 2001; Beaudry and Schiffauerova 2009; Frenken et al. 2015). Strong firms only benefit from localization when they have many local partners, and the cluster they are part of is urbanized. This local embeddedness in diverse clusters can limit negative effects from leaking to co-located firms and provides access to knowledge complementing internal know-how. Although they can take on the role of hub firms (Dhanaraj and Parkhe 2006), other strong firms tend to act as external stars by building non-local networks (Morrison et al. 2013). These external

stars are in environments lacking geographical localization, and for them local networking is not useful. In contrast, moderately strong firms avoiding concentrations of similar firms have more to gain from strong local networks, and their complementarity with non-local networks enables innovation. Finally, when moderately strong firms do not have extensive networks, they can benefit from either urbanization or localization. These act as substitutes and are equally conducive to innovation, again underlining that there are multiple viable pathways to innovation.

Furthermore, our findings shed light on the role of formal and informal institutions, i.e. the regulatory environment, and the norms and habits facilitating local trust (Moulaert and Sekia 2003; Boschma 2005; Kaufmann et al. 2009; Rodriguez-Pose and Di Cataldo 2015). Strong formal and informal institutions are complements, occurring together in five of the seven relevant pathways to innovation. The other two paths are characterized by the sole presence of well-developed informal institutions, and the insignificance of formal institutions. In other words, informal institutions can substitute formal institutions, aligning with debates in the institutional voids literature (Doh et al. 2017). It could be argued that the stronger the institutions, the more their stability enables firms to benefit from other external resources (Sirmon et al. 2007). However, our findings indicate an increased potential for negative effects from geographical resources and local networks. Each of the paths to innovation featuring the absence of local networks, urbanization, or localization also have both strong formal and informal institutions. It may be that the increased spillovers in clusters with strong institutions lead to homogeneity in available knowledge (Whittington et al. 2009; Hassink 2010). In addition, institutions can become rigid, and multiple groups of densely connected firms can emerge with little intergroup interaction (Rodríguez-Pose 2013). Among other issues, this can generate insider-outsider problems and rent-seeking (ibid.). Our results only hint at this. Hence, it is worthwhile for future research to supplement our additional analyses

of low innovation performance to advance our understanding (Appendix C).

5.1. Practical implications

Our findings hold practical relevance. They offer recipes for when managers can rely on internal firm resources and external geographical, network, and institutional conditions. There are multiple trajectories to strategizing for innovation. Even a marginal investment in internal resources opens up pathways to innovation. This can then be achieved by internalizing local knowledge spillovers from similar firms, as well as local and non-local networks. Moreover, managers should be aware of the potentially negative impact of geographic and network resources. This means avoiding the assumption that characterized the scholarship until relatively recently, namely that firms are uniformly positively impacted by the conditions in clusters (McCann and Folta 2011). For instance, where internal resources are weak, firms may especially suffer from networks. Firms with a stronger research focus risk losing out due to localized knowledge leakages. Consequently, managers should adopt strategies for innovation that fit with their heterogeneous internal and external resources.

For regional policy makers our work is equally important. Strong formal and informal institutions are an important driver of innovation for almost all types of firms. Our findings indicate that in the absence of a strong regulatory environment, trust-based relationships offer a viable substitute. Hence, where the reliability of regulations cannot be enhanced, policy makers can nurture informal institutions to facilitate innovation. Finally, given our finding that some R&D investment opens up pathways to innovation, policy makers could look to incentivize this where it is lacking.

5.2. Limitations and future research

Our study is not without its limitations. Future work could enrich our measurements. For

example, although R&D intensity as a percentage of sales is a common proxy for internal resources (Cohen and Levinthal 1990), more fine-grained measures may be used. These could, for instance, capture employees' technical expertise and upper-level managerial skills relating to the coordination and integration of firms' various activities (Lefebvre and Lefebvre 1998). Furthermore, adding structural characteristics of networks could prove interesting, and provide the means to more adequately study whether strong institutional conditions have the potential to dampen innovation. We suspect that triadic closure between different actors within a cluster, without cross-group links, may be associated with this, but we were not able to gather such data (Ter Wal and Boschma 2009).

In addition, we were limited in our ability to maintain a time difference between our causal conditions and outcome. Internal resources were measured between 2013 and 2015—the same time period as our innovation outcome. The surveyed firms could not provide a reliable estimate of their R&D expenditure further in the past. Our network and informal institutional measures have a similar limitation. We asked firms to report ongoing linkages, and their perception of trust in their environment at the time the survey was administered. Nevertheless, most of these factors tend to be stable over time (see Briscoe and Tsai 2011; Levinthal 2017).

Finally, the nature of the fsQCA method is that differences in set calibrations can influence results. We based our calibration on external and theoretical criteria whenever possible, and sample statistics in all other cases, limiting this concern (Fiss 2011; Chappin et al. 2015; Misangyi et al. 2017). We hope that more cluster studies will utilize a set-based approach, deepening and broadening the available information on which to base calibrations.

5.3. Conclusion

Our study opens up possibilities for more detailed theorizing and testing of relationships

between different types of resources in clusters. It shows the importance of assessing the contribution of clusters to firm innovation through configurational thinking. Innovation is the result of many different factors and their complex interrelationships. There are multiple pathways to high innovation for firms with weak, strong and moderately strong internal assets. If such possibilities are dismissed, it is likely that disagreements such as over which types of firms benefit from particular resources will continue to exist. Our application of a configurational analysis avoids this pitfall, providing a first step to reconciling seemingly conflicting points of view. We hope that future cluster studies will also utilize the unique advantages of this approach and, consequently, improve our knowledge of how performance outcomes such as innovation emerge.

References

Alcácer, J., and Chung, W. 2007. Location strategies and knowledge spillovers. *Management Science*, **53**(5), pp. 760–776.

Alcácer, J., and Chung, W. 2014. Location strategies for agglomeration economies. *Strategic Management Journal*, **35**, pp. 1749–1761.

Allen, M.M.C. 2013. Comparative capitalisms and the institutional embeddedness of innovative capabilities. *Socio-Economic Review*, **11**(4), pp. 771–794.

Ardito, L., Petruzzelli, A.M., and Panniello, U. 2016. Unveiling the breakthrough potential of established technologies: an empirical investigation in the aerospace industry. *Technology Analysis and Strategic Management*, **28**(8), pp. 916–934.

Arman, H., and Foden, J. 2010. Combining methods in the technology intelligence process: application in an aerospace manufacturing firm. *R&D Management*, **40**(2), pp. 181–194.

Arya, B., and Lin, Z. (John). 2007. Understanding collaboration outcomes from an extended resource-based view perspective: the roles of organizational characteristics, partner attributes, and network structures. *Journal of Management*, **33**(5), pp. 697–723.

Bakar, L.J.A., and Ahmad, H. 2010. Assessing the relationship between firm resources and product innovation performance: a resource-based view. *Business Process Management Journal*, **16**(3), pp. 420–435.

Barney, J.B. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, **17**(1), pp. 99–100.

Barney, J.B., Wright, M., and Ketchen, D.J.J. 2001. The resource-based view of the firm: ten years after 1991. *Journal of Management*, **27**, pp. 625–641.

Barney, J.B. 1995. Looking inside for competitive advantage. *Academy of Management Executive*, **9**(4), pp. 49–61.

Barney, J.B., Ketchen, D.J.J., and Wright, M. 2011. The future of resource-based theory. *Journal of Management*, **37**(5), pp. 1299–1315.

Baruch, Y., and Holtom, B.C. 2008. Survey response rate levels and trends in organizational research. *Human Relations*, **61**(8), pp. 1139–1160.

Bathelt, H., Malmberg, A., and Maskell, P. 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, **28**(1), pp. 31–56.

Baum, J.A.C., Calabrese, T., and Silverman, B.S. 2000. Don't go it alone: alliance network composition and startups' performance in canadian biotechnology. *Strategic Management Journal*, **21**(3), pp. 267–294.

Beaudry, C. 2001. Entry, growth and patenting in industrial clusters: a study of the aerospace industry in the UK. *International Journal of the Economics of Business*, **8**(3), pp. 405–436.

Beaudry, C., and Schiffauerova, A. 2009. Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy*, **38**(2), pp. 318–337.

Belussi, F., and Sedita, S.R. 2012. Industrial districts as open learning systems: combining emergent and deliberate knowledge structures. *Regional Studies*, **46**(2), pp. 165–184.

Biggiero, L., and Sammarra, A. 2010. Does geographical proximity enhance knowledge exchange? The case of the aerospace industrial cluster of centre Italy. *International Journal of Technology Transfer and Commercialisation*, **9**(4), pp. 283–305.

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

Boschma, R., and Frenken, K. 2011. The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, **11**(2), pp. 295–307.

Boschma, R., and Ter Wal, A.L.J. 2007. Knowledge networks and innovative performance in an industrial district: the case of a footwear district in the south of Italy. *Industry & Innovation*, **14**(2), pp. 177–199.

Breschi, S., and Lenzi, C. 2016. Co-invention networks and inventive productivity in US cities. *Journal of Urban Economics*, **92**, pp. 66–75.

Breschi, S., and Lissoni, F. 2001. Knowledge spillovers and local innovation systems: a critical survey. *Industrial and Corporate Change*, **10**(4), pp. 975–1005.

Briscoe, F., and Tsai, W. 2011. Overcoming relational inertia: how organizational members respond to acquisition events in a law firm. *Administrative Science Quarterly*, **56**(3), pp. 408–440.

Brouthers, K.D., Brouthers, L.E., and Werner, S. 2008. Resource-based advantages in an international context. *Journal of Management*, **34**(2), pp. 189–217.

Casper, S., and Whitley, R. 2004. Managing competences in entrepreneurial technology firms: a comparative institutional analysis of Germany, Sweden and the UK. *Research Policy*, **33**(1), pp. 89–106.

Chappin, M.M.H., Cambré, B., Vermeulen, P.A.M., and Lozano, R. 2015. Internalizing sustainable practices: a configurational approach on sustainable forest management of the Dutch wood trade and timber industry. *Journal of Cleaner Production*, **107**, pp. 760–774.

Charron, N., Dijkstra, L., and Lapuente, V. 2013. *Codebook for the european QoG index: 2010 and 2013*. Gothenburg: University of Gothenburg.

Charron, N., Dijkstra, L., and Lapuente, V. 2014. Regional governance matters: quality of government within European Union member states. *Regional Studies*, **48**(1), pp. 68–90.

Charron, N., Dijkstra, L., and Lapuente, V. 2015. Mapping the regional divide in Europe: a measure for assessing quality of government in 206 European regions. *Social Indicators Research*, **122**(2), pp. 315–346.

Cohen, W.M., and Levinthal, D.A. 1990. Absorptive capacity: a new perspective on learning

and innovation. *Administrative Science Quarterly*, **35**(1), pp. 128–152.
Cuervo-Cazurra, A., and Un, C.A. 2010. Why some firms never invest in formal R&D. *Strategic Management Journal*, **836**(31), pp. 759–779.
Dalziel, T., Gentry, R.J., and Bowerman, M. 2011. An integrated agency-resource dependence view of the influence of directors' human and relational capital on firms' R&D spending. *Journal of Management Studies*, **48**(6), pp. 1217–1242.
Dei Ottati, G. 1994. Trust, interlinking and credit in the industrial district. *Cambridge Journal of Economics*, **18**(6), pp. 529–546.
Denk, T., and Lehtinen, S. 2013. Contextual analyses with QCA-methods. *Quality & Quantity*, **48**(6), pp. 3475–3487.
Dhanaraj, C., and Parkhe, A. 2006. Orchestrating innovation networks. *Academy of Management Journal*, **31**(3), pp. 659–669.
Doh, J., Rodrigues, S., Saka-Helmhout, A., and Makhija, M. 2017. International business responses to institutional voids. *Journal of International Business Studies*, **48**(3), pp. 293–307.
Dyer, J.H., and Singh, H. 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, **23**(4), pp. 660–679.
EACP. 2014. *Stronger together: connecting aerospace clusters*. Hamburg: European Aerospace Cluster Partnership (EACP).
EACP. 2016. Members of the european aerospace cluster partnership. Retrieved October 2, 2016, from http://www.eacp-aero.eu/index.php?eID=tx_cms_showpic&file=uploads%2Fpics%2FEACP_members_chart_4-2015_updated.pdf
EACP. 2017. Members. Retrieved August 24, 2017, from http://www.eacp-aero.eu/index.php?id=4
EACP. 2019. EACP member: the EACP strengthens the position of the european aerospace industry in the world market. Retrieved May 6, 2019, from http://www.eacp-aero.eu/members.html
ECORYS. 2009. *FWC sector competitiveness studies - competitiveness of the EU aerospace industry with focus on: aeronautics industry*. Rotterdam: ECORYS.
Eisenhardt, K.M., and Schoonhoven, C.B. 1996. Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms. *Organization Science*, **7**(2), pp. 136–150.
EPO. 2018. European patent register. Retrieved January 29, 2018, from https://www.epo.org/searching-for-patents/legal/register.html#tab-1
European Cluster Observatory. 2015. Cluster observatory scoreboard. Retrieved August 19, 2015, from http://www.clusterobservatory.eu/index.html#!view=scoreboard;url=/scoreboard/
Eurostat. 2019a. Community innovation survey (CIS). Retrieved April 10, 2019, from https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey
Eurostat. 2019b. Population change - demographic balance and crude rates at regional level (NUTS 3) (demo_r_gind3). Retrieved May 3, 2019, from https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm
Eurostat. 2019c. Regional labour market statistics (reg_lmk). Retrieved May 3, 2019, from https://ec.europa.eu/eurostat/cache/metadata/en/reg_lmk_esms.htm
Eurostat. 2019d. Area by NUTS 3 region (reg_area3). Retrieved May 3, 2019, from https://ec.europa.eu/eurostat/cache/metadata/en/reg_area3_esms.htm
Feldman, M.P. 1999. The new economics of innovation, spillovers and agglomeration: a

review of empirical studies. *Economics of Innovation and New Technology*, **8**(1–2), pp. 5–25.
Fiss, P.C. 2007. A set-theoretical approach to organizational configurations. *Academy of Management Review*, **32**(4), pp. 1180–1198.
Fiss, P.C. 2011. Building better causal theories: a fuzzy set approach to typologies in organization research. *Academy of Management Journal*, **54**(2), pp. 393–420.
Fiss, P.C., Marx, A., and Cambré, B. 2013. Configurational theory and methods in organizational research: introduction. In P. C. Fiss, A. Marx, & B. Cambré (Eds.), *Configurational Theory and Methods in Organizational Research* (pp. 1–22). Bingley: Emerald Group Publishing Limited.
Fitjar, R.D., and Huber, F. 2015. Global pipelines for innovation: insights from the case of Norway. *Journal of Economic Geography*, **15**(3), pp. 561–583.
Fitjar, R.D., and Rodriguez-Pose, A. 2011. When local interaction does not suffice: sources of firm innovation in urban Norway. *Environment and Planning A*, **43**(6), pp. 1248–1267.
Frenken, K., Cefis, E., and Stam, E. 2015. Industrial dynamics and clusters: a survey. *Regional Studies*, **49**(1), pp. 10–27.
Fritsch, M., and Kublina, S. 2018. Related variety, unrelated variety and regional growth: the role of absorptive capacity and entrepreneurship. *Regional Studies*, **52**(10), pp. 1360–1371.
Galliano, D., Magrini, M.-B., and Triboulet, P. 2015. Marshall's versus Jacobs' externalities in firm innovation performance: the case of French industry. *Regional Studies*, **49**(11), pp. 1840–1858.
Glaeser, E.L., Kallal, H.D., Scheinkman, J.A., and Shleifer, A. 1992. Growth in cities. *Journal of Political Economy*, **100**(6), pp. 1126–1152.
Gordon, I., and McCann, P. 2000. Industrial clusters: complexes, agglomeration and/or social networks? *Urban Studies*, **37**(3), pp. 513–532.
Greckhamer, T., Misangyi, V.F., Elms, H., and Lacey, R. 2008. Using qualitative comparative analysis in strategic management research. *Organizational Research Methods*, **11**(4), pp. 695–726.
Greckhamer, T., Misangyi, V.F., and Fiss, P.C. 2013. The two QCAs: from a small-N to a large-N set theoretic approach. In P. C. Fiss, A. Marx, & B. Cambré (Eds.), *Configurational Theory and Methods in Organizational Research* (pp. 49–75). Bingley: Emerald Group Publishing Limited.
Grillitsch, M., and Nilsson, M. 2017. Firm performance in the periphery: on the relation between firm-internal knowledge and local knowledge spillovers. *Regional Studies* , **51**(8), pp. 1219–1231.
Grillitsch, M., and Nilsson, M. 2019. Knowledge externalities and firm heterogeneity: effects on high and low growth firms. *Papers in Regional Science*, **98**(1), pp. 93–114.
Hall, P.A., and Soskice, D. 2001. *Varieties of capitalism: the institutional foundations of comparative advantage*. Oxford: Oxford University Press.
Hassink, R. 2010. Locked in decline? On the role of regional lock-ins in old industrial areas. In R. Boschma & R. Martin (Eds.), *The Handbook of Evolutionary Economic Geography* (pp. 450–470). Cheltenham: Edward Elgar.
Hervas-Oliver, J.-L., Gonzalez, G., Caja, P., and Sempere-Ripoll, F. 2015. Clusters and industrial districts: where is the literature going? Identifying emerging sub-fields of research. *European Planning Studies*, **23**(9), pp. 1827–1872.
Hervas-Oliver, J.-L., Sempere-Ripoll, F., Rojas Alvarado, R., and Estelles-Miguel, S. 2018. Agglomerations and firm performance: who benefits and how much? *Regional Studies*, **52**(3), pp. 338–349.

Hervas-Oliver, J.L., and Albors-Garrigos, J. 2009. The role of the firm's internal and relational capabilities in clusters: when distance and embeddedness are not enough to explain innovation. *Journal of Economic Geography*, **9**(2), pp. 263–283.

Hickie, D. 2006. Knowledge and competitiveness in the aerospace industry: the cases of Toulouse, Seattle and North-West England. *European Planning Studies*, **14**(5), pp. 697–716.

Hotho, J.J. 2014. From typology to taxonomy: a configurational analysis of national business systems and their explanatory power. *Organization Studies*, **35**(5), pp. 671–702.

Howells, J. 2002. Tacit knowledge, innovation and economic geography. *Urban Studies*, **39**(5–6), pp. 871–884.

Huggins, R., and Thompson, P. 2013. A network-based view of regional growth. *Journal of Economic Geography*, **14**(3), pp. 511–545.

Jacobs, J. 1969. *The economy of cities*. Random House: New York.

Kalnins, A., and Chung, W. 2004. Resource-seeking agglomeration: a study of market entry in the lodging industry. *Strategic Management Journal*, **25**(7), pp. 689–699.

Kaufmann, D., Kraay, A., and Mastruzzi, M. 2009. Governance matters VIII: aggregate and individual governance indicators. *Policy Research Working Paper*, **21**(June), pp. 1–105.

Khanna, T., and Palepu, K.G. 1997. Why focused strategies may be wrong for emerging markets. *Harvard Business Review*, **75**(4), pp. 41–51.

Khanna, T., and Palepu, K.G. 2000. The future of business groups in emerging markets: long-run evidence from Chile. *Academy of Management Journal*, **43**, pp. 268–285.

Kim, M. 2013. Many roads lead to Rome: implications of geographic scope as a source of isolating mechanisms. *Journal of International Business Studies*, **44**(9), pp. 898–921.

Knoben, J. 2008. Localized inter-organizational linkages, agglomeration effects, and the innovative performance of firms. *The Annals of Regional Science*, **43**(3), pp. 757–779.

Knoben, J., Arikan, A.T., van Oort, F., and Raspe, O. 2016. Agglomeration and firm performance: one firm's medicine is another firm's poison. *Environment and Planning A*, **48**(1), pp. 132–153.

Knoben, J., and Oerlemans, L.A.G. 2012. Configurations of inter-organizational knowledge links: does spatial embeddedness still matter? *Regional Studies*, **46**(8), pp. 1005–1021.

Kogut, B., and Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, **3**(3), pp. 383–397.

Kostopoulos, K.C., Spanos, Y.E., and Prastacos, G.P. 2002. The resource-based view of the firm and innovation: identification of critical linkages. *EURAM Second Annual Conference "Innovative Research in Management"*. Stockholm.

Kraaijenbrink, J., Spender, J.-C., and Groen, A.J. 2010. The resource-based view: a review and assessment of its critiques. *Journal of Management*, **36**(1), pp. 349–372.

Krugman, P. 1991. Increasing returns and economic geography. *The Journal of Politial Economy*, **99**(3), pp. 483–499.

Kyläheiko, K., Jantunen, A., Puumalainen, K., Saarenketo, S., and Tuppura, A. 2011. Innovation and internationalization as growth strategies: the role of technological capabilities and appropriability. *International Business Review*, **20**(5), pp. 508–520.

Lavie, D. 2006. The competitive advantage of interconnected firms: an extension of the resource-based view. *Academy of Management Review*, **31**(3), pp. 638–658.

Lavie, D., and Drori, I. 2011. Collaborating for knowledge creation and application: the case of nanotechnology research programs. *Organization Science*, **23**(3), pp. 704–724.

Lazzeretti, L., Sedita, S.R., and Caloffi, A. 2014. Founders and disseminators of cluster research. *Journal of Economic Geography*, **14**(1), pp. 21–43.

Lefebvre, É., and Lefebvre, L.A. 1998. Global strategic benchmarking, critical capabilities

and performance of aerospace subcontractors. *Technovation*, **18**(4), pp. 223–234.
Levinthal, D.A. 2017. Resource allocation and firm boundaries. *Journal of Management*, **43**(8), pp. 2580–2587.
Love, J.H., and Roper, S. 2015. SME innovation, exporting and growth: a review of existing evidence. *International Small Business Journal*, **33**(1), pp. 28–48.
Marshall, A. 1920. *Principles of economics* (8th ed.). London: Macmillan and Co.
Martin, R., and Sunley, P. 2003. Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography*, **3**, pp. 5–35.
McCann, B.T., and Folta, T.B. 2008. Location matters: where we have been and where we might go in agglomeration research. *Journal of Management*, **34**(3), pp. 532–565.
McCann, B.T., and Folta, T.B. 2011. Performance differentials within geographic clusters. *Journal of Business Venturing*, **26**(1), pp. 104–123.
Michalisin, M.D., D, S.R., and M, K.D. 1997. In search of strategic assets. *The International Journal of Organizational Analysis*, **5**(4), pp. 360–387.
Misangyi, V.F., Greckhamer, T., Furnari, S., Fiss, P.C., Crilly, D., and Aguilera, R. 2017. Embracing causal complexity: the emergence of a neo-configurational perspective. *Journal of Management*, **43**(1), pp. 255–282.
Morrison, A., Rabellotti, R., and Zirulia, L. 2013. When do global pipelines enhance the diffusion of knowledge in clusters? *Economic Geography*, **89**(1), pp. 77–96.
Moulaert, F., and Sekia, F. 2003. Territorial innovation models: a critical survey. *Regional Studies*, **37**(3), pp. 289–302.
OECD. 2010. *The OECD innovation strategy: innovation to strengthen growth and address global and social challenges - key findings*. Paris. Retrieved from www.oecd.org/innovation/strategy
OECD. 2018. *Main science and technology indicators 2018-1*. Paris. Retrieved from http://oe.cd/frascati
Oliver, C. 1997. Sustainable competitive advantage: combining institutional and resource-based views. *Strategic Management Journal*, **18**(9), pp. 697–713.
Oltra, M.J., and Flor, M. 2003. The impact of technological opportunities and innovative capabilities on firms' output innovation. *Creativity and Innovation Management*, **12**(3), pp. 137–144.
Peteraf, M.A. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*, **14**(3), pp. 179–191.
Pittaway, L., Robertson, M., Munir, K., Denyer, D., and Neely, A. 2004. Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews*, **5**–**6**(3–4), pp. 137–168.
Porter, M.E. 1990a. The competitive advantage of nations. *Harvard Business Review*, **68**(2), pp. 73–93.
Porter, M.E. 1990b. *The competitive advantage of nations*. New York: Free Press.
Porter, M.E. 1998. *On competition*. Boston: Harvard Business School Press.
Porter, M.E. 2000. Location, competition and economic development: local clusters in a globalized economy. *Economic Development Quarterly*, **14**(1), pp. 15–34.
Prencipe, A. 2002. Exploiting and nurturing in-house technological capabilities: lessons from the aerospace industry. *International Journal of Innovation Management*, **05**(03), pp. 299–321.
Ragin, C.C. 1987. *The comparative method: moving beyond qualitative and quantitative strategies*. Los Angeles: University of California Press.
Ragin, C.C. 2000. *Fuzzy-set social science*. Chicago: Chicago University Press.
Ragin, C.C. 2008. *Redesigning social inquiry: fuzzy sets and beyond*. Chicago: Chicago

University Press.
Ragin, C.C. 2017. *User's guide to fuzzy-set / qualitative comparative analysis* (fsQCA 3.0.). Irvine, CA: University of California, Irvine.
Ragin, C.C., Drass, K.A., and Davey, S. 2017. Fuzzy-set / qualitative comparative analysis 3.0. Irvine, CA: University of California, Irvine.
Rigby, D.L., and Brown, W.M. 2015. Who benefits from agglomeration? *Regional Studies*, **49**(1), pp. 28–43.
Rodríguez-Pose, A. 2013. Do institutions matter for regional development? *Regional Studies*, **47**(7), pp. 1034–1047.
Rodriguez-Pose, A., and Di Cataldo, M. 2015. Quality of government and innovative performance in the regions of Europe. *Journal of Economic Geography*, **15**(4), pp. 673–706.
Rodríguez-Pose, A., and Storper, M. 2006. Better rules or stronger communities? On the social foundations of institutional change and its economic effects.
Rose-Anderssen, C., Baldwin, J.S., Ridgway, K., Allen, P.M., and Varga, L. 2008. Aerospace supply chains as evolutionary networks of activities: innovation via risk-sharing partnerships. *Creativity & Innovation Management*, **17**(4), pp. 304–318.
Schiehll, E., Lewellyn, K.B., and Muller-Kahle, M.I. 2018. Pilot, pivot and advisory boards: the role of governance configurations in innovation commitment. *Organization Studies*, **39**(10), pp. 1449–172.
Schneider, C., and Wagemann, C. 2012. *Set-theoretic methods for the social sciences: a guide to qualitative comparative analysis*. Cambridge: Cambridge University Press.
Shaver, J.M., and Flyer, F. 2000. Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States. *Strategic Management Journal*, **21**(12), pp. 1175–1193.
Sirmon, D.G., Hitt, M.A., and Ireland, R.D. 2007. Managing firm resources in dynamic environments to create value: looking inside the black box. *Academy of Management Review*, **32**(1), pp. 273–292.
Somaya, D., Williamson, I.O., and Zhang, X. 2007. Combining patent law expertise with R&D for patenting performance. *Organization Science*, **18**(6), pp. 922–937.
Sorenson, O., and Audia, P.G. 2000. The social structure of entrepreneurial activity: geographic concentration of footwear production in the United States, 1940-1989. *American Journal of Sociology*, **10**(2), pp. 424–462.
Speldekamp, D., Saka-Helmhout, A., and Knoben, J. 2019. Reconciling perspectives on clusters: an integrative review and research agenda. *International Journal of Management Reviews*, **forthcoming**, pp. 1–24.
Tallman, S., Jenkins, M., Henry, N., and Pinch, S. 2004. Knowledge, clusters, and competitive advantage. *Academy of Management Review*, **29**(2), pp. 258–271.
Ter Wal, A.L.J., and Boschma, R. 2009. Applying social network analysis in economic geography: framing some key analytic issues. *The Annals of Regional Science*, **43**(3), pp. 739–756.
Ter Wal, A.L.J., and Boschma, R. 2011. Co-evolution of firms, industries and networks in space. *Regional Studies*, **45**(7), pp. 919–933.
Trajtenberg, M. 2001. Innovation in israel 1968-1997: a comparative analysis using patent data. *Research Policy*, **30**(3), pp. 363–389.
Turkina, E., Van Assche, A., and Kali, R. 2016. Structure and evolution of global cluster networks: evidence from the aerospace industry. *Journal of Economic Geography*, **16**, pp. 1211–1234.
Van Der Panne, G. 2004. Agglomeration externalities: Marshall versus Jacobs. *Journal of*

Evolutionary Economics, **14**(5), pp. 593–604.

Van Oort, F. 2015. Unity in variety? Agglomeration economics beyond the specialization-diversity controversy. In C. Karlsson, M. Andersson, & T. Norman (Eds.), *Handbook of Research Methods and Applications in Economic Geography* (pp. 259–271). Cheltenham: Edward Elgar.

Verbeke, A., and Kano, L. 2013. The transaction cost economics (TCE) theory of trading favors. *Asia Pacific Journal of Management*, **30**(2), pp. 409–431.

Von Hippel, E. 1998. Economics of product development by users: impact of "sticky" local information. *Management Science*, **44**(5), pp. 629–644.

Voudouris, I., Lioukas, S., Iatrelli, M., and Caloghirou, Y. 2012. Effectiveness of technology investment: impact of internal technological capability, networking and investment's strategic importance. *Technovation*, **32**(6), pp. 400–414.

Wennberg, K., and Lindqvist, G. 2010. The effect of clusters on the survival and performance of new firms. *Small Business Economics*, **34**(3), pp. 221–241.

Whitley, R. 2007. *Business systems and organisational capabilities: the institutional structuring of competitive competences*. Oxford: Oxford University Press.

Whittington, K.B., Owen-smith, J., and Powell, W.W. 2009. Networks, propinquity, and innovation in knowledge-intensive industries. *Administrative Science Quarterly*, **54**(1), pp. 90–122.

Wolman, H., and Hincapie, D. 2014. Clusters and cluster-based development policy. *Economic Development Quarterly*, **29**(2), pp. 135–149.

Table 1

Cluster composition and survey response breakdown.

Cluster	Corresponding NUTS region	N cluster members[ab]	N cluster member firms[b]	N survey responses
Hamburg Aviation	DE6 (NUTS-1)	133	121	21
Niedersachsen Aviation	DE9 (NUTS-1)	306[c]	250[c]	15
LR BW	DE1 (NUTS-1)	85	84	7
NAG	NL (NUTS-0)	104	88	14
Madrid Network	ES3 (NUTS-1)	64	51	3
DAC	ITF3 (NUTS-2)	164	135	2
Total		1172	729	62

[a] These membership numbers include non-firms.
[b] These figures are based on a combination of the EACP (2016) website, interviews with the cluster managers, cluster presentations, and membership lists provided to us.
[c] These are estimates due to this cluster's lack of formal membership.

Table 2

Causal condition operationalization and set calibration.

Causal conditions		Measure		Fuzzy-set calibration		
				Fully in	**Crossover**	**Fully out**
Outcome	Innovation	EPO patents with priority dates in 2013, 2014, or 2015.		2	1	0
Internal resources	Technological strength	Percentage of sales invested in internal R&D, 2013–2015. The sample was 1) run for the full sample, and split in three parts via terciles into firms with: 2) weak, 3) strong, and 4) moderate internal resources.	1) 0 to 100%	100	55	10
			2) < 2%	1[a]	0.50	0
			3) ≥ 10% investment	100	55	10
			4) 2% to 10%	8[a]	5	2
Geography	Urbanization	Average of population and job density percentiles in 2013 at the respective NUTS level.		90	75	62.50
	Localization	N member firms of the respective cluster in 2016/2017.[b]		164	105	76
Networks	Local	N innovation partners within the cluster with which firms engage with the primary goal of exchanging or acquiring knowledge to support their innovative activities in 2016/2017.[b]		6	3	0
	Non-local	As above, but regarding partners outside the cluster.[b]		3	1	0
Institutions	Formal	Normalized Quality of Government (QoG) index in 2013.		80	65	50
	Informal	The extent of mutual trust with firms in their cluster on a 4-point Likert scale in 2016/2017.[b]		4	3	1

[a] These are the highest recorded values in the respective selections.
[b] This was measured at the time of our survey, namely between October 2016 and July 2017.

Table 3

Sample descriptive statistics.

	All internal resources				**Weak internal resources**				**Strong internal resources**				**Moderate internal resources**			
Variables	**Mean**	**S.D.**	**Max**	**Min**	**Mean**	**S.D.**	**Max**	**Min**	**Mean**	**S.D.**	**Max**	**Min**	**Mean**	**S.D.**	**Max**	**Min**
1. Innovation	5.20	16.90	100.00	0.00	0.20	0.62	2.00	0.00	11.08	25.90	100.00	0.00	3.24	8.42	35.00	0.00
2. Internal resources	14.21	25.47	100.00	0.00	0.28	0.44	1.00	0.00	34.17	33.67	100.00	10.00	4.67	2.14	8.00	2.00
3. Urbanization	84.54	15.34	97.03	59.82	88.11	15.11	97.03	59.82	81.34	16.10	97.03	59.82	84.79	14.58	97.03	59.82
4. Localization	135.17	66.21	250.00	51.00	128.25	65.09	250.00	51.00	149.50	67.93	250.00	84.00	125.38	65.60	250.00	51.00
5. Local linkages	3.58	3.64	10.00	0.00	2.50	3.19	10.00	0.00	4.08	4.02	10.00	0.00	4.05	3.54	10.00	0.00
6. Non-local linkages	1.85	2.64	10.00	0.00	1.45	2.19	7.00	0.00	1.96	3.09	10.00	0.00	2.10	2.57	10.00	0.00
7. Formal institutions	65.04	11.21	73.25	7.65	68.04	5.16	73.25	56.57	61.88	17.04	73.25	7.65	65.80	4.62	73.25	56.57
8. Informal institutions	2.25	0.71	3.00	0.00	2.05	0.83	3.00	0.00	2.38	0.65	3.00	1.00	2.29	0.64	3.00	1.00
	N = 65				**N = 20**				**N = 24**				**N = 21**			

Table 4

Correlations for the full sample.

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Innovation							
2. Internal resources	**0.43**						
3. Urbanization	-0.03	-0.19					
4. Localization	-0.07	**0.29**	**-0.25**				
5. Local linkages	0.08	0.20	-0.24	0.06			
6. Non-local linkages	0.13	0.00	-0.12	**-.32**	**0.47**		
7. Formal institutions	-0.13	-0.15	**0.41**	-0.01	-0.06	0.02	
8. Informal institutions	0.18	0.24	-0.12	**-0.04**	0.16	**0.24**	0.08

Notes: The reported coefficients are calculated using Spearman rank correlation coefficient. All values greater than 0.24 and lower than -0.24 are significant at ≤ .05 and are **bold**. Correlations for the sample selections are available upon request.

Table 5

Configurations for high innovation performance.

Causal conditions		**All**	**Weak**		**Strong**		**Moderate**		
		1	**2 Agglomerated innovators**	**3 Networked innovators**	**4 Non-local innovators**	**5 Local innovators**	**6a Localized innovators**	**6b Urbanized innovators**	**7 Linchpin innovators**
Internal resources	Technological strength	●	•	•		•	•	•	●
Geography	Urbanization	•	⊗	●	•	●	⊗	•	•
	Localization	•	●	●	⊗	•	•	⊗	⊗
Networks	Local	●	⊗	•		●	⊗	⊗	●
	Non-local		⊗	●	●	⊗	⊗	⊗	●
Institutions	Formal		●		•		●	●	•
	Informal	•	●	•	●	•	•	•	•
Raw coverage		0.16	0.31	0.48	0.23	0.16	0.16	0.19	0.20
Unique coverage		0.16	0.24	0.40	0.19	0.12	0.08	0.06	0.08
Consistency		0.94	0.80	0.86	0.95	0.91	0.83	0.96	0.95
Firms in solution		2	1	1	4	2	1	1	1
Overall solution coverage		**0.16**	**0.71**		**0.35**		**0.35**		
Overall solution consistency		**0.94**	**0.82**		**0.93**		**0.88**		

Notes: ● = core condition (present); ⊗ = core condition (absent); • = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = the causal conditions may be present or absent.

Appendix A

The survey instrument (version: Hamburg Aviation)

Please note that the introductory and final statements are redacted from the survey below, because they include information identifying the authors of this paper.

Start of Block: Block 2

Please note that most of the questions in this survey may be skipped in case you do not want to disclose the requested information.

The following questions are about your role in the organisation and its general characteristics.

2.1 Are you part of the senior managerial staff?

- o Yes
- o No

2.2 In what year was your organisation founded?

▼ Before 1920 ... 2016

2.3 In which industry is your organisation active?

▼ Accommodation ... Other (any unlisted industry)

2.4 Which organisational type best describes your organisation?

- o For-profit organisation
- o Governmental education institution (for instance a university)
- o Non-educational governmental institution (for instance a chamber of commerce)
- o Other type of non-profit organisation

2.5 Which option best describes your organisation's main goal?

- o Achieve stability
- o Grow quickly
- o Become market leader
- o Become more innovative
- o Serve the public good
- o Other (please specify) _____

Display This Question:

If 2.3 In which industry is your organisation active? = Other (any unlisted industry)

2.6 In a previous question you listed your organisation's industry as 'other'. Please specify what industry your organisation is active in.

_____

Display This Question:

If 2.4 Which organisational type best describes your organisation? = For-profit organisation

Or 2.4 Which organisational type best describes your organisation? = Other type of non-profit organisation

2.7 At the end of 2015, was your organisation 50% or more German owned?

- o Yes
- o No

2.8 In which geographic markets did your organisation sell goods and/or services during the three years from 2013 to 2015? Several answers are possible.

- ☐ Germany
- ☐ Other European Union or associated countries
- ☐ Countries not associated with or in the European Union

2.9 Which of these geographic areas was your organisation's largest market in terms of sales during the three years from 2013 to 2015?

- o Germany
- o Other European Union or associated countries
- o Countries not associated with or in the European Union

The following questions are about your organisation's size.

*An FTE (full-time equivalent) of 1.0 is equivalent to a full-time worker, while an FTE of 0.5 signals half of a full work load.
Please note that the questions below may be skipped in case you do not want to disclose the requested information.

2.10 At the end of 2013, how many employees did your organisation have **in full-time equivalent***?

_____

2.11 At the end of 2015, how many employees did your organisation have **in full-time equivalent***?

_____

2.12 At the end of 2015, what was the value of your organisation’s total assets **in millions of euros**?

_____

End of Block: Block 2

Start of Block: Block 3

The following questions are about your organisation's product (good or service) innovations.

A **product innovation** is the **market introduction** of a **new or significantly improved good or service** with respect to its capabilities, user friendliness, components or sub-systems.

- Product innovations (new or improved) must be **new to your organisation**, but they **do not need to be new to your market**.
- Product innovations could have been originally developed by your organisation or by other organisations (including institutions).

A good is usually a **tangible** object such as an engine, cabin or software system. Individual components of such objects are also products. **A service** is usually **intangible**, such as consulting, insurance, educational courses, air travel, etc. Maintenance, repair, and operations/overhaul (MRO) activities are also a service.

3.1 During the three years from 2013 to 2015, did your organisation introduce any product innovations?

- o Yes
- o No

Display This Question:

If 3.1 During the three years from 2013 to 2015, did your organisation introduce any product innovat... = Yes

Please note that this question may be skipped in case you do not want to disclose the requested information.

3.2 Please give the **percentage breakdown to a total of 100%** of your total sales in 2015 from:

	% of total sales
New or significantly improved products introduced during the three years 2013 to 2015 that were **new to your market**	
New or significantly improved products introduced during the three years 2013 to 2015 that were **only new to your organisation**	
Products that were **unchanged or only marginally modified** during the three years 2013 to 2015 (include the resale of new products purchased from other organisation)	
Total	

Display This Question:

If 3.1 During the three years from 2013 to 2015, did your organisation introduce any product innovat... = Yes

3.3 During the three years from 2013 to 2015, did your organisation introduce any innovative product that was a world first?

- o Yes
- o No

End of Block: Block 3

Start of Block: Block 4

The following questions are about process innovations.

A **process innovation** is the **implementation** of a **new or significantly improved** production process, distribution method, or supporting activity. Process innovations must be **new to your organisation**, but they **do not need to be new to your market**. The innovation could have been originally developed by your organisation or by other organisations (including institutions).

4.1 During the three years from 2013 to 2015, did your organisation introduce new or significantly improved methods of manufacturing or producing goods or services?

- o Yes
- o No

4.2 During the three years from 2013 to 2015, did your organisation introduce new or significantly improved logistics, delivery or distribution methods for your inputs, goods or services?

- o Yes
- o No

4.3 During the three years from 2013 to 2015, did your organisation introduce new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing?

- o Yes
- o No

End of Block: Block 4

Start of Block: Block 5

The following questions are about your organisation's current connections to other organisations.

5.1 Does your organisation **currently maintain relations** with other organisations with the **aim of exchanging or acquiring knowledge to support innovative activities?** A relation implies having contact at least once a month regardless of communication medium.

- o Yes
- o No

Skip To: End of Block If 5.1 Does your organisation currently maintain relations with other organisations with the aim of... = No

Below Hamburg Aviation's members are listed. Please **select the ten most important organisations** with whom your organisation maintains such relations. **Please note that on the next page, you'll be able to list non-members.**

5.2 Partner 1

▼...

5.3 Partner 2

▼...

5.4 Partner 3

▼...

5.5 Partner 4

▼...

5.6 Partner 5

▼...

5.7 Partner 6

▼...

5.8 Partner 7

▼...

5.9 Partner 8

▼...

5.10 Partner 9

▼...

5.11 Partner 10

▼...

Page Break

5.12 Does your organisation maintain this type of connection to any organisation that you could not list in the previous question? These organisations may be foreign or domestic.

- o Yes
- o No

Skip To: End of Block If 5.12 Does your organisation maintain this type of connection to any organisation that you could n... = No

5.13 Please fill in the names of the **ten most important organisations** with whom your organisation maintains such relations (including foreign organisations).

- o Partner 1 _____
- o Partner 2 _____
- o Partner 3 _____
- o Partner 4 _____
- o Partner 5 _____
- o Partner 6 _____
- o Partner 7 _____
- o Partner 8 _____
- o Partner 9 _____
- o Partner 10 _____

End of Block: Block 5

Start of Block: Block 6

The following questions are about your organisation's relation with Hamburg Aviation.

6.1 When did your organisation join Hamburg Aviation?

▼ 2011 ... 2016

6.2 What was the main reason for your organisation to join Hamburg Aviation?

- o To foster connections to other organisations
- o To participate in project calls (for instance European Union funds)
- o To increase contact with government officials
- o Other (please specify) _____

6.3 To what degree do you feel that your organisation's interests are being represented by Hamburg Aviation?

- o To a great extent
- o Somewhat
- o Very little
- o Not at all

6.4 To what extent has Hamburg Aviation facilitated achieving your organisation's goals?

- o To a great extent
- o Somewhat
- o Very little
- o Not at all

6.5 To what extent do you and the organisations that are **part of** Hamburg Aviation share a high level of mutual trust?

- o To a great extent
- o Somewhat
- o Very little
- o Not at all

6.6 To what extent do you and the organisations that are **not part of** Hamburg Aviation share a high level of mutual trust?

- o To a great extent
- o Somewhat
- o Very little
- o Not at all

End of Block: Block 6

Start of Block: Block 7

The following questions are about your organisation's R&D activities.

In-house R&D can be described as Research and Development activities **undertaken by your organisation** to **create new knowledge** or to solve scientific or technical problems. **External R&D** is **contracting** such activities out to other organisations including affiliated organisations.

7.1 During the three years from 2013 to 2015, how much did your organisation spend on **in-house R&D** as a **percentage** of sales? If your organisation did not invest in this type of R&D, please enter 0.

_____

7.2 During the three years from 2013 to 2015 how much did your organisation spend on contracting out **external R&D** as a **percentage** of sales? If your organisation did not invest in this type of R&D, please enter 0.

_____

End of Block: Block 7

Start of Block: Block 8

The following questions are about your organisation's patenting, sales and profits.
Please note that the questions below may be skipped in case you do not want to disclose the requested information.

8.1 During the three years from 2013 to 2015 how many **patents** did your organisation register with the European Patent Office (**EPO**)? If your organisation did not register any patents, please enter 0.

_____

8.2 During the three years from 2013 to 2015, what was the **percentage change** in your organisation's yearly **sales revenue**? Please indicate increase or decrease with + or -.

_____

Display This Question:

If 2.4 Which organisational type best describes your organisation? = For-profit organisation

8.3 During the three years from 2013 to 2015, what was the **percentage change** in your organisation's yearly **profit after taxes**? Please indicate profit or loss with + or -.

_____

End of Block: Block 8

Start of Block: Block 9

The following question is about your organisation's name.

Finally, we would like to know your organisation's name for academic reasons. It would help us understand why certain inter-organisational collaborations are more successful than others. We will not share your information with other parties. Furthermore, no individually identifiable information of any sort will be published.

Please note that this question may be skipped in case you do not want to disclose the requested information.

9.1 What is your organisation's legal name?

_____

End of Block: Block 9

Start of Block: Block 10

This is the end of the survey.

End of Block: Block 10

Appendix B

Table B.1

Analysis of necessary conditions for high innovation performance.

Causal conditions		All internal resources		Weak internal resources		Strong internal resources		Moderate internal resources	
		Consistency	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
Internal resources	Technological strength	0.23	0.69	0.84	0.40	0.31	0.63	0.56	0.40
Geography	Urbanization	0.74	0.37	0.65	0.12	0.72	0.64	0.81	0.36
	Localization	0.63	0.36	0.98	0.24	0.67	0.51	0.41	0.23
Networks	Local	0.60	0.42	0.68	0.24	0.60	0.63	0.56	0.30
	Non-local	0.58	0.46	0.68	0.26	0.51	0.68	0.69	0.40
Institutions	Formal	0.61	0.38	0.70	0.16	0.57	0.60	0.64	0.38
	Informal	0.78	0.43	0.84	0.21	0.77	0.63	0.78	0.39

Notes: consistency values greater than 0.90 indicate a substantial degree of necessity.

Table B.2

Analysis of necessary conditions for low innovation performance.

Causal conditions		All internal resources		Weak internal resources		Strong internal resources		Moderate internal resources	
		Consistency	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
Internal resources	Technological strength	0.11	0.61	0.27	0.77	0.34	0.57	0.45	0.68
Geography	Urbanization	0.71	0.66	0.82	0.90	0.54	0.39	0.71	0.67
	Localization	0.67	0.69	0.45	0.82	0.85	0.52	0.57	0.83
Networks	Local	0.51	0.65	0.40	0.87	0.49	0.42	0.65	0.75
	Non-local	0.44	0.64	0.37	0.85	0.40	0.44	0.54	0.67
Institutions	Formal	0.64	0.74	0.67	0.92	0.67	0.56	0.57	0.73
	Informal	0.66	0.67	0.58	0.88	0.73	0.48	0.70	0.74

Notes: consistency values greater than 0.90 indicate a substantial degree of necessity.

Appendix C

Table C.1

Configurations for low innovation performance –

all levels of internal resources.

Causal conditions		**1a**[a]	**1b**	**2a**	**2b**	**3**	**4**[a]	**5**	**6**	**7**
Internal resources	Technological strength	●	●	⊗	⊗		⊗	⊗	⊗	
Geography	Urbanization	⊗				⊗		⊗		⊗
	Localization				⊗		⊗	•	⊗	●
Networks	Local	⊗	⊗	●	●	⊗		•		⊗
	Non-local		⊗	⊗	⊗					●
Institutions	Formal		⊗	⊗		•	●	•	⊗	●
	Informal					⊗	⊗	•	⊗	
Raw coverage		0.05	0.06	0.15	0.08	0.09	0.17	0.14	0.24	0.07
Unique coverage		0.01	0.01	0.01	0.02	0.01	0.09	0.04	0.08	0.00[b]
Consistency		0.74	0.86	0.84	0.87	0.85	0.78	0.85	0.87	0.89
Firms in solution		2	1	2	2	1	3	10	2	2
Overall solution coverage						**0.51**				
Overall solution consistency						**0.84**				

Notes: ● = core condition (present); ⊗ = core condition (absent); • = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = the causal conditions may be present or absent.

[a] Pathways 1a and 4 are just below the 0.80 consistency threshold, indicating uncertainty.

[b] Pathway 7's unique coverage is 0.002, indicating that few cases are unique to it.

Table C.2

Configurations for low innovation performance –

firms with weak internal resources.

Causal conditions		**1a**	**1b**	**2a**	**2b**	**2c**	**3**
Internal resources	Technological strength			⊗	⊗	⊗	
Geography	Urbanization	●	●	●	⊗	⊗	⊗
	Localization	⊗	⊗				
Networks	Local	⊗	●		●	⊗	●
	Non-local	⊗	●	⊗	●	⊗	⊗
Institutions	Formal			⊗			●
	Informal					⊗	
Raw coverage		0.26	0.26	0.23	0.05	0.06	0.05
Unique coverage		0.20	0.22	0.15	0.03	0.04	0.04
Consistency		1.00	1.00[a]	1.00	1.00	1.00	1.00[b]
Firms in solution		5	5	5	1	1	1
Overall solution coverage		**0.76**					
Overall solution consistency		**1.00**[b]					

Notes: ● = core condition (present); ⊗ = core condition (absent); ● = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = the causal conditions may be present or absent.

[a] Rounded from 0.996.

[b] Rounded from 0.998.

Table C.3

Configurations for low innovation performance – firms with strong internal resources.

Causal conditions		**1a**	**1b**
Internal resources	Technological strength	●	●
Geography	Urbanization	⊗	•
	Localization	•	•
Networks	Local	⊗	⊗
	Non-local	•	⊗
Institutions	Formal		⊗
	Informal		
Raw coverage		0.14	0.10
Unique coverage		0.12	0.08
Consistency		0.90	0.83
Firms in solution		2	1
Overall solution coverage		**0.23**	
Overall solution consistency		**0.89**	

Notes: ● = core condition (present); ⊗ = core condition (absent); • = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = the causal conditions may be present or absent.

Table C.4

Configurations for low innovation performance –

firms with moderate internal resources.

Causal conditions		**1**	**2**[a]	**3a**	**3b**	**4**
Internal resources	Technological strength	●	⊗	⊗	⊗	
Geography	Urbanization	⊗	●	●	●	●
	Localization		⊗	⬤	⬤	⊗
Networks	Local	⬤	⬤	⊗	●	⬤
	Non-local			⊗	●	⊗
Institutions	Formal		⬤	⊗	⊗	⬤
	Informal				⊗	
Raw coverage		0.15	0.16	0.13	0.12	0.13
Unique coverage		0.12	0.07	0.08	0.06	0.05
Consistency		0.82	0.76	0.86	0.90	0.85
Firms in solution		3	2	1	1	2
Overall solution coverage				**0.48**		
Overall solution consistency				**0.86**		

Notes: ⬤ = core condition (present); ⊗ = core condition (absent); ● = peripheral condition (present); ⊗ = peripheral condition (absent); blank space = the causal conditions may be present or absent.

[a] Pathway 2 is below the 0.80 consistency threshold, indicating considerable uncertainty.