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Why are good comparative studies of networks so rare? Practical lessons from a study on French clusters*

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Practical lessons from a study on French clusters

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Abstract: French "competitiveness clusters" were set up in 2005 to strengthen cooperation between small and large enterprises, and training and research institutions working on similar topics and located in the same geographical area, with the aim of making this area more competitive and attractive through enhanced innovation. Our analysis of this set of 71 apparently similar networks has given us an opportunity to investigate the factors explaining the differences in their performance.

In attempting this analysis, we encounter several difficulties, such as, how can we:

(1) measure a cluster's performance?
(2) characterize its context and resources?
(3) characterize the governance of the network and the actions it takes?
(4) deal with the fact that the network's boundaries evolve due to both the fluctuating commitment of some stakeholders and the implementation of the cluster's strategy, which changes the context and the available resources?
(5) deal with actors' learning at all levels (i.e., the cluster's members, organization, rulers and fund providers), which changes the rules of the game while the game is still being played?

Last but not least, the networks that we have taken to be homologous because they have been selected, labelled and regulated by the same rules, actually display significant qualitative differences. There may be different kinds of clusters following substantially different performance models. We could then define a cluster typology so that comparisons would be much more relevant between clusters of the same class. This could eventually lead us to create performance indicators adapted to the specificities of each class of clusters and improve the monitoring of individual clusters and of the national cluster policy.

Keywords: clusters, networks, network performance, context, innovation policy.

1 Introduction

In his conclusion to EGOS's 2009 annual conference's track on networks, Keith Provan (2009) expressed regret that there are still so few studies on the properties of networks as a whole, and especially comparative studies that can help us understand which factors contribute to a network's success. The main reason is the difficulty of finding a family of homologous networks, i.e. networks that share similar objectives and bring together members of a similar type, so that one can make a comparison of their performances and look for differences in their structure or in their resources that can explain the performance variations observed between networks.

The French policy on "competitiveness clusters" launched in 2004 by the French government appears to provide us an opportunity to contribute to Keith Provan's agenda and to improve our knowledge on networks. Indeed, we have access to a set of homologous networks – the 71 "competitiveness clusters" labelled by the French government[1] – and thanks to an original research set-up, we were able to collect a great deal of data on all of the networks, and highly detailed data on some of them. The expansion of cluster policies in many countries also provides opportunities to compare our observation of the French clusters to other similar set-ups abroad documented in an abundant literature.

The aim of our ongoing research program is to examine what fosters the success of clusters. Nevertheless, the purpose of the present paper is not to present our preliminary results, but to discuss the various difficulties we have to overcome in this quest. Most of the problems we face are common to many network studies. Before presenting these issues (§1.5), we briefly explain where our research stands in the field of cluster studies. In the second section, we will discuss the first kind of challenges related to the indicators characterizing the context, the action and the performance of the clusters. In the third section, we will discuss the problems of the instability of cluster boundaries and the rules of the game. We then consider in the fourth section how we could build performance models and discuss the consequences of

[1] 66 "competitiveness clusters" were labelled in 2005 and 5 more in 2007.

building a single universal model or trying to build a significant typology of clusters and look for local models suited to each class of this typology. In the fifth section, we discuss the expected benefits of our research program regarding both managing clusters and monitoring general cluster policy.

1.1 Existing clusters studies

Cluster policy is an attempt to stimulate cluster development through the deliberate actions of the State and territorial authorities. Published works have explained in detail why different cluster forms contribute to a territory's economic prosperity (Marshall, 1919; Piore & Sabel, 1984; Porter 1998). Emulating these examples of spontaneously emerged clusters, several countries have tried to organize the setting-up of clusters, or have helped embryonic clusters to take hold (Saublens, 2007).

Studies of clusters tend to be mostly theoretical or empirical (Texeira & Cruz, 2009). Theoretical studies sometimes discuss the transposition to clusters of general theories developed in other situations, related to the mechanisms of their contribution to growth (Porter, 1998; Veltz, 2000), or to factors like the form of network governance (Provan & Kennis, 2008; Ehlinger & al., 2007). Some of these studies translate mechanisms observed in similar settings in other countries or time periods. In this latter approach, historical knowledge on other kinds of clusters is used to understand the challenge of the focal cluster or prescribe action for it. This relies on the implicit assumption that there are some universally good practices on how to run a cluster (Arcessor & CMI, 2008). However, this assumption appears dubious, since Martin & Sunley (2003) have shown that we cannot even find a clear model of what a cluster is in the work of authors like Porter (1998). Furthermore, Weil (2009) has shown than there are multiple and conflicting interpretations of the success of clusters like Silicon Valley.

In contrast to theoretical studies, empirical studies on clusters are either case studies, giving a complex description of a single network (or a small sample of networks), or econometric studies, assessing the impact of a few factors on many networks. In the latter approach, if the number of independent variables observed is not small enough compared to the number of individual clusters, the statistical robustness of the results is jeopardized.

Since we have many data on about 70 clusters, we try to go beyond some of the limitations of studies that include either many data on few clusters or few data on many clusters.

1.2 Our sample: the French 'competitiveness clusters'

The networks we study are "pôles de compétitivité" (competitiveness clusters), which were set up in France in 2005. These clusters are associations that bring together in a single area, companies, research laboratories and higher education establishments focusing on the same domain. After a nationwide tender for offers launched in 2004, 71 of these clusters were selected (66 in 2005 and 5 more in 2007). In these clusters, an increase in cooperation involving local companies and research and education institutes was expected to cultivate innovation and regional competitiveness. Members of clusters were encouraged to submit cooperation projects, which might receive public funding (Weil & Fen-Chong, 2008a). This is different from other foreign cluster policies, like in Germany, Japan or Austria where funding is delegated to the cluster organization. After three years, all the French clusters and the cluster policy as a whole were evaluated by consultants (BCG & CMI, 2008). This was an occasion to collect significant data on each cluster, which we use in this study.

1.3 Examining what drives a cluster performance

Our research objective is to look at the relationship between (a) what characterizes the conditions in which a cluster develops, (b) the way it organizes its governance and chooses which actions to undertake, and (c) the network's results. A better understanding of this relationship enables the government to select cluster projects that appear well suited to the resources available to them (industrial potential, research potential of state institutions, presence of a suitable workforce for the industry's needs, infrastructure, existing tradition of cooperation, etc.). It also helps the organizations that were set up to run clusters to act more efficiently, and enables the state bodies responsible for the policy to judge their efforts.

1.4 An hybrid methodology

Our sample comprises 71 clusters, for which we have gathered around 300 parameters characterizing their conditions, governance, actions and outputs. The sample is too small to enable us to make multilinear regressions on so many variables with a sufficient degree of

confidence, and too large to be able to compare monographs on each individual. For this reason, we have implemented and cross-checked numerous approaches. First of all, we have set up a cluster observatory, where scholars from different backgrounds studying clusters participate in order to enrich our common data set. After three years spent investigating individual clusters and collecting material through about 30 seminars discussing real experiences in some clusters, we are now beginning to look at the key factors of performance through more systematic data analysis on the whole set of clusters. By combining these complementary approaches, we are trying to develop some interesting conjectures (Girin, 1989; March et al., 1981).

1.5 Some challenges

In doing so, we face three kinds of difficulty. The first is to find sound indicators to describe on the one hand the characteristics of each cluster, which may impact its performance (the independent variables) and on the other hand the results achieved by the cluster (the dependent variables) (§2). The second is related to the fuzziness and instability of the clusters' boundaries and of the rules of the national cluster policy (§3). The third arise in dealing with data that are too abundant for the modest size of our sample (70) but that nevertheless do not capture important features of the clusters. Finally, we face the question of whether we should try to build a "universal" model of clusters, or several "local" models of clusters sharing common significant features (§4).

We will first discuss the problems related to assessing cluster performance and of the significant indicators characterizing its context.

2 Relating performance to cluster context

Many authors have looked into what determines the success of clusters. Most of them have either focused on inherited resources or on the clusters' actions. For example, Porter (1998) outlines the conditions that are favourable to a cluster's development, without taking an interest in how they are managed. Conversely, many researchers and consultants have looked at the different forms of governance and management practices suited to clusters, without denying that abundant available resources contribute to a cluster's performance, but with a

practical focus on the effects of actions undertaken by the cluster's governance (Arcessor-CMI, 2008).

Some consulting firms and scholars have tried to identify a few good practices, supposedly universal, based on observations made of certain clusters. The government has encouraged these practices to be published and disseminated, and some clusters have adopted them spontaneously, without prior critical reflection on whether they are worthwhile. Nevertheless, our detailed observations of some clusters have led us to believe that several of these practices may be beneficial in one cluster, yet harmful in a different context.

The framework that we shall now present allows us to reflect on the validity of the worthwhile practices identified in certain clusters.

2.1 Our causal framework

We sort the different factors in three subsets:

- The *context* of the cluster characterizes the resources of the area before the formal building of the cluster (Storper, 2010). It includes the local scientific and technological resources, both in academia and industry, the specificities of the industry, the available infrastructure (e.g. transport, communication, educational and cultural institutions), traditions and cultures prone or adverse to cooperation, and local institutions, etc.
- The *governance* and formal organization of the cluster result from the initial choices made when applying for the cluster label (although this may be altered during the life of the cluster). It includes the definition of who is eligible to take part in the cluster, who are the initial members, who sits on the board, the steering committee and the committee deciding which projects will receive the cluster label. For example, local authorities often play an important role in setting up a cluster, but may or may not decide to be included in its governance bodies.
- A cluster organization may choose from a large array of possible *actions*, perhaps focussing on sponsoring events to help members get to know each other, steering the building of a common strategy, helping members build innovation projects, or helping them reach foreign markets, etc.

When applying for the cluster label, cluster promoters are free to decide on the governance and organization: from their perspective, they have a degree of freedom and they may choose different options. However, once the cluster project has been approved, its governance is part of the inherited context from the perspective of the cluster manager. Therefore, in our framework we have considered governance to be a separate set of factors that may be taken as either inherited or acquired.

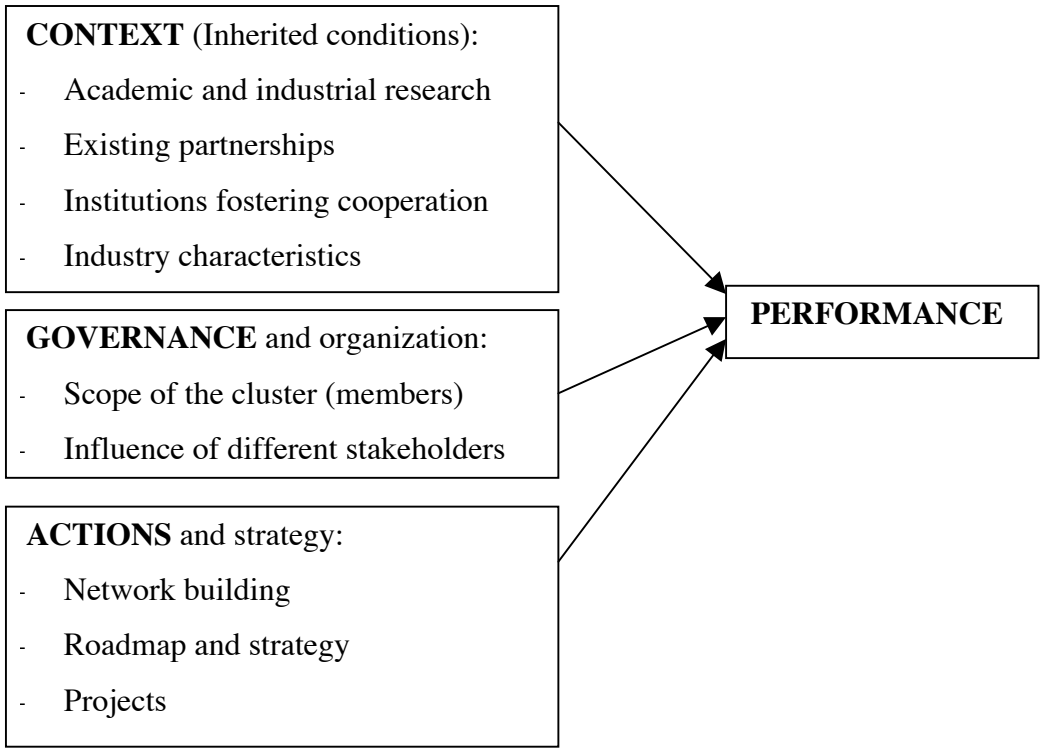

Figure 1: Framework of our investigations: we sort the factors that could impact the performance of a cluster into three subsets: the inherited context and resources of the cluster, the choices of governance and steering organization, and the actions undertaken under the cluster umbrella.

Before discussing in more detail which indicators we should take to describe the context (§2.3), the governance (§2.4) and the actions (§2.5), we will first discuss how we assess the performance of a cluster (§2.2).

2.2 Problems in assessing a cluster's performance

Many evaluations of clusters have been undertaken (BIPE, 2007), and they may have different goals.

First, there are many existing examples of evaluating the effectiveness and efficiency of a *cluster policy* (Fixari & al., 2009). These examples focus on determining whether it was worthwhile attributing certain resources to clusters, even if these clusters can claim some achievements. For example, even when a funded project leads to a fruitful cooperation, public money might have been better spent elsewhere, or might even have had a more favourable macroeconomic impact had it not been spent at all. Instead, the money could have been used to lighten the tax burden for all companies (Duranton & al., 2008). This is even more likely if we consider not only the money directly spent by the budget, but all of the transaction costs involved (e.g. costs of preparing, presenting and selecting projects, even for projects that are finally not approved). This question is outside the scope of the present paper, though a better understanding of cluster performance should eventually contribute to better adapting cluster policies. Also note that the evaluation of some clusters and the added value they bring is usually a step in evaluating policies as a whole. However, evaluating a cluster policy is more than gathering individual evaluation of all the concerned clusters.

If we focus on the evaluation of a single cluster, we may either consider its *outcome* (does it meet its goals? §2.2.1), or surmise what part of this outcome can be attributed to the fact that local actors have organized their actions into setting up a cluster (§2.2.3). We will now discuss both issues, as well as the fact that significant outcomes are often slow to unfold, meaning that the evaluator will have to rely on questionable proxies (§2.2.2), which may be the cluster's intermediary *outputs* (Herranz, 2009).

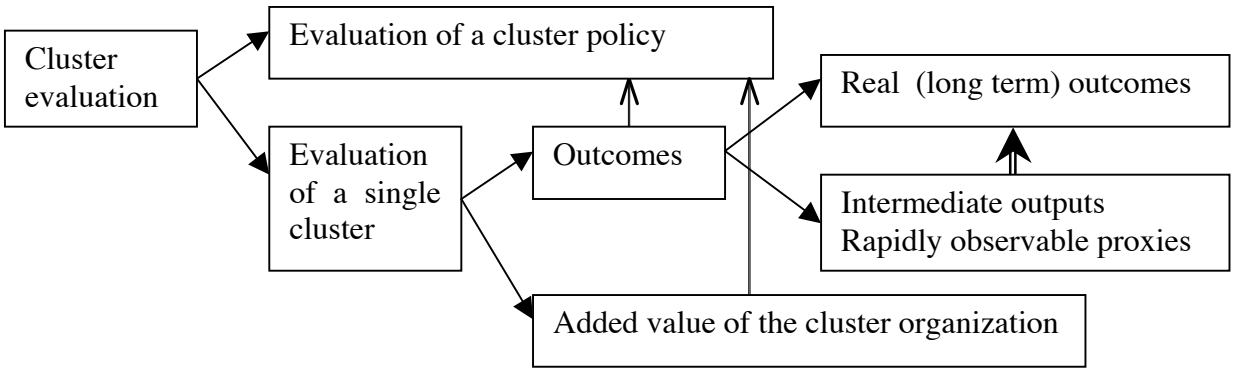

Fig.2 Different aspects of cluster evaluation: Evaluation may focus on a cluster policy or on individual clusters. In the later case, one can either look at the absolute impact of the cluster (or more rapidly observable outputs supposedly predicting its future impact) or to the contribution of the cluster organization (i.e. the difference of what happened and what would have happened spontaneously without the formal building of a cluster and the action of a dedicated organization.

2.2.1 Evaluating a cluster's final outcome

A cluster's objectives are not always clear and free from ambiguity, making even the choice of indicators a controversial one.

The objective of cluster policy is to increase companies' competitiveness on the cluster's territory, thus encouraging growth and full employment. The final indicators are therefore logically the GDP and the number of jobs. We can measure absolute figures (i.e. added value and the cumulated jobs of all stakeholders in the cluster), or their growth rate, or we can compare them to outside references (e.g. growth differential in relation to the rest of the national / sector economy, or to other clusters in France, Europe or elsewhere).

Scope of measurement

Before talking about the actual performance of a cluster, we need to determine the perimeter of the measurement. If we are primarily interested in the benefits for the network building the cluster, we will focus on the cluster's member institutions. However, many institutions have several branches, and some of these, although they are outside the cluster's geographical zone, may benefit from collaborations linked to the cluster or bring in precious resources. Should they be included?

Moreover, local authorities are interested in the spillover effects the cluster has on the local economy, and are thus more likely to consider wealth and employment created in the area as a whole, even if a link to the cluster does not always exist. In the case of clusters that formed spontaneously without the creation of a formal network, like Silicon Valley, and which are sometimes compared to clusters resulting from a deliberate, organized action, we only have access to data on the sector or area as a whole. This problem of defining a suitable perimeter comes up in many network studies (Callon & al., 2009; Nauwelaers & Pellegrin, 2004).

Object of measurement

Most of the time an area's health is measured in terms of GDP. However, an area's wealth and attractiveness also depends on its natural assets (e.g. mining, energy, or agronomic resources, quality of the environment), infrastructure (transport, access to high-speed communications, cultural and educational resources) and cultural traditions conducive to

partnerships, trade and industry. For example, when Motorola took the decision in 2001 to set up a major research centre near Grenoble, the existence of an international secondary school where the children of Texan researchers transferred to Grenoble could easily continue their studies was one of the deciding factors. Yet, the variations of the numerous components that make up local assets are not accounted for in the GDP. Thus, just as a company whose EBITDA is positive but below the depreciation or amortization values of its production facility does not get richer, the wealth of an area is not linked to its GDP alone.

Relationships created from working together on cluster labelled projects give cluster members the chance to get to know each other. These projects create trust and show what can be gained from collaborating. The social capital increases and constitutes a new resource that will not show up in GDP the year it is created (even if we might hope that it will have a long-term impact on the area's GDP).

Similarly, the number of jobs does not indicate whether they correspond to the skills of workers present in the area, i.e. whether companies can find the staff they need nearby, or whether inhabitants are able to find work locally.

Assessing local prosperity may require taking account of other externalities, for example looking at indicators of sustainable development, such as the quantity of greenhouse gases emitted per GDP unit or its evolution. We could even try to evaluate the actual satisfaction of the population in the cluster's area. But subjective indicators, possibly correlated to the propensity of the area's inhabitants to re-elect their representatives – a parameter to which the latter are highly sensitive – are themselves subject to numerous biases. These may be cultural (e.g. the French like to complain and are less likely to declare themselves satisfied than other nationalities) or dynamic: we are more sensitive to changes in our situation than to its objective level (Gilbert, 2005).

A time horizon out of pace with decision-making

Before a cluster's impact on the wealth of an area can be assessed, many years have to pass. Therefore, the questions raised above are relevant for comparing prosperity and long-term patterns of established clusters like Silicon Valley and the regions of Boston, San Diego, Cambridge, Munich, Grenoble and Toulouse. They are useful in analyzing the impact of mature clusters and former public policies; however, they are not yet worth focusing on for

our study. For competitiveness clusters (established in 2005), we cannot expect to observe a significant impact on stakeholder prosperity in the time scale for which data are available. We must therefore work with indicators that appear to be correlated to a cluster's future performance.

2.2.2 Indicators correlated to a cluster's future performance

Given the amount of public funds devoted to competitiveness clusters, it is understandable that the government wishes to assess the return on its efforts. But as we have just seen, the beneficial effects of a cluster cannot be expected before a number of years have passed. Therefore, we must content ourselves with intermediate outputs, which should in the long-term lead to an area's prosperity.

Some of the outputs that can be observed in the short term are objectives fixed by the cluster policy, e.g.:

- Improved relationships between network members and stronger network structure;
- Innovation by cluster stakeholders, especially joint innovation;
- R&D investments in SMEs;
- Business creation and attraction of company branches;
- Proportion of graduates employed in companies;
- Local availability of graduates in the cluster's domains;
- Area's efforts to market and improve its image;
- Development of international relations;
- etc.

However, taking these intermediate outputs of the cluster action as a measure of success is only sound if we can believe in the theory (or sometimes the ideology) that claims that they are good predictors of future performance! Yet the succession of contradictory policies framing public action, (Weil & Fen-Chong, 2008a) illustrates that there is no stable consensus on the matter. Theories linking identifiable actions to future performance remain controversial.

It is, for example, reasonable to think that organizing missions abroad to promote a cluster's SMEs or facilitate their contacts will have a positive impact on their exports and capacity for joining international networks and so give them access to good suppliers or new clients. However, the impact of missions of this kind can vary considerably, and is especially dependent on the organizers' level of professionalism. Generally, the only thing that will be

measured is the expenditure earmarked for the action, or the amount of participants, or at best the number of cooperation agreements signed, even though it is hard to appreciate the actual scope and impact the agreements will have.

Similarly, joint research projects can have very different impacts: sometimes these are immediately visible, when they rapidly lead to an innovation that is commercially successful; sometimes they are more subtle, when they facilitate the creation of a network between complementary stakeholders who can work together and generate significant capacity for innovation, without immediate results. At other times, opportunist coalitions will occur between stakeholders delighted to find complementary funding for actions that they were hoping to carry out anyway and that do not create new relationships. Thus, some projects associate an SME or a public laboratory with a project in a fairly artificial way to increase their chances of receiving labelling and funding. On the other hand, some projects result in intense collaborations on promising subjects that participants would have been unable to tackle on their own.

The indicators that we are measuring correspond more to the intermediate outputs of the network's operations than to the final expected outcomes, and are therefore highly imperfect proxies of the latter. Aware of these imperfections, we can at best limit the damage by underlining each individual intermediate indicator's limitations and by maintaining a multidimensional assessment, avoiding the aggregated synthetic indicators that ranking enthusiasts are so fond of.

2.2.3 Measuring a cluster's management performance

Clusters emerge either spontaneously or are stimulated by a determined, organized action. French competitiveness clusters belong to the second category and are run by an association[2]

[2] This formal structure has no implication on the network's actual governance. The association may be broadly autonomous, i.e. have an NAO-type governance (network administrative organization), to use the terminology of Provan & Kenis (2008), as is generally the case in most mature clusters. Yet it can also be a cover for a dominant firm controlling its means and decisions (Chabault, 2009), or simply the strong arm of a deliberative assembly in which most members involved in the network are active.

gathering their members. Therefore, we can wonder how efficient the governance structure of this association is in developing the potential of the cluster. What is its *added value*, i.e. the difference between the actual achievements and what the cluster's members would have done without the stimulation from the cluster governance structure?

The French education system has been doing something similar for several years, since it no longer publishes the final exam results for every single high school, but rather the difference between its exam success rates and what could have been expected statistically in that high school, based on pupils' social backgrounds and education levels when entering the school. However, although a great deal of high schools share the same aim of educating large groups of pupils that can be characterized by a few simple parameters, the several dozen competitiveness clusters work in much more diverse conditions, making their "free path" (the trajectory they would have followed, had they had no interaction with the cluster organization) highly hypothetical. Whereas a secondary school follows a clearly identified process, a cluster works more like a catalyst, facilitating meetings and exchanges. It may, for example, encourage partnerships that would have spontaneously started anyway, but possibly much later on, or with more limited aims and means, or without involving certain useful contributors.

Determining a benchmark to compare with the actual results of the cluster is especially difficult, since the cluster is often an extension of some pre-existing networks. This is, for example, the case of the Minalogic microelectronic cluster in Grenoble, where several major public and private stakeholders were already working together and receiving considerable public subsidies (e.g. the Minatec innovation campus in micro and nanotechnologies, and Crolles 2, the local industrial technological platform).

Despite this lack of benchmark, there is often a local consensus to attribute particular events to a cluster's action. This might take the form of launching R&D projects (when the idea for the project sprung from the cluster's theme-focused commissions, or during meetings organized by the cluster, or even following canvassing by a cluster representative, etc.). It might involve publications or joint patents arising from partnerships: this is only the tip of the iceberg compared to the innovation potential of an underlying members' network, and these outcomes appear way after the start of the partnership, but they are easy to measure. We

might consider the international image of the cluster and its companies when specific communication actions are made to promote the cluster. We might also look at the densification of links between cluster stakeholders (e.g. by measuring increases in their contractual relations, their joint responses to offers for tender, staff exchanges, co-publications, etc.). We might also wonder whether the cluster has facilitated enterprise creation and access to funding for businesses.

As in the preceding section, the indicators considered are often "proxies" for outcomes that are more complex to assess or that emerge later. For example, we can consider public funding obtained by the cluster's projects. Yet as we saw above, not all of these projects lead to innovations or new and promising relationships.

2.3 Characterizing the inherited context

To better appreciate the contribution of the way governance is organized and the cluster is run, we need to be able to take into account the more or less favourable local circumstances. If we were able to identify and measure the characteristics of current or inherited conditions and assess their impact on the performances, we could discern the effect of choices in governance and coordination. We shall therefore examine now which different characteristics are likely to explain a cluster's success.

2.3.1 Scientific, technological and industrial resources

We have attempted to draw up indicators for evaluating resources like the territory's public and industrial research potential. This issue gives rise to considerable perimeter problems, since clusters are sometimes defined by highly crosscutting technologies like "embedded software" (found in missiles, medical devices or cars). It is particularly difficult to identify relevant disciplines and technologies and the laboratories that can be mobilized based on a description of researchers' activities by discipline and technique, without counting resources far removed from the cluster's interests. Nevertheless, we try to characterize for each cluster: the scientific disciplines mobilized, the technologies linked to the cluster's activity, and the economic sectors concerned, based on the intermediate-level nomenclature of the

Observatoire des Sciences et Techniques, into 34 (or 170) scientific sub-disciplines, 27 industrial sectors, and 30 technological sub-domains (OST, 2008, appendix A).

We distinguish three concentric perimeters to describe the cluster. The core perimeter corresponds to the agenda displayed by the cluster, its core business. A more comprehensive perimeter includes domains that can be involved in some of the projects of the cluster or be significant for some stakeholders. A third, even larger perimeter includes domains that could be useful for the cluster agenda but have not been identified and leveraged so far by the cluster.

We could then use regionalized data on publications, patents and the industrial specialization of the economic network. This theme-based characterization of clusters is published on the observatory's website so that the clusters concerned can check information and suggest any amendments[3]. The perimeter of the pooling procedure (clusters' region(s)) is not satisfactory, because it extends beyond the perimeter of the cluster's stakeholders, and yet does not take into account the long-distance resources that a cluster can sometimes mobilize. For example, some valuable contributors might also be located in distant establishments and will be unduly discarded.

An alternative approach (Eurolio, 2010) consists in listing the production of the cluster's members (which sometimes may not be in the cluster area). But within a cluster member institution (a laboratory or company), few people might be working on the cluster's themes[4]. Nevertheless, all staff members will often be considered as doing so.

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[3] Our first attempts to define the thematic perimeter of clusters were based on the advice of experts for each cluster. We now try to use data-mining tools to extract the perimeters from queries on the web.

[4] For example, authors using this approach include in their statistics all the patents and PhDs from a research institute of about 100 scientists, which is formally an affiliated member of the cluster, but in which only 2 or 3 scientists work on a theme of interest for the cluster. In the same way, some government statistics consider the potential of banks that applied to join? a cluster to show their involvement in the area, in the same way as they might support the local

The ‘Observatoire des Sciences et Techniques’ would like to undertake a more subtle study based on lists of cluster members, project participants, and research themes, but this approach cannot be extended to cover 71 clusters without a significant budget.

2.3.2 Other context indicators

We also use discrete indicators to code for:

- the industry structure (e.g. SMEs working for a major contractor, like in aeronautics or nuclear power; global, high-tech SMEs, like in biotechnology; low-tech SMEs that use local know-how and resources, like perfume industries, etc.),
- the nature of the innovation (e.g. innovation of integration by systems constructors, like cars or power plants; innovation linked to scientific progress in biotechnology; innovation linked to equipment used in some manufacturing companies, etc.),
- whether the cluster defines itself as mostly “market-oriented” or “technology-oriented”,
- whether the cluster is included in a single administrative ‘region’ or spreads over several regions,
- whether it declares to have had formal, informal or no previous significant collaboration between some members.

These indicators are unrefined. For example, in many cases there had been some kind of significant cooperation between some of the cluster founders. However, the cluster extended far beyond the initial clique of collaborating actors.

2.3.3 Characterizing network structure

In our case, because of the number of networks being compared and their complexity, we cannot envisage calculating each network’s structural parameters – especially since they are

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football team (and they count its national revenue so that this sleeping member appears to be one of the cluster’s main resources).

instable, one of the characteristics of networks being their plasticity and capacity to reconfigure themselves, as we will see in §3. We do, however, consider looking at some indicators of cluster members' heterogeneity and network connectivity.

2.4 Characterizing the governance of the network

We know the number of SMEs, large companies, academic laboratories, and 'other actors' among the individual member of each cluster, the board members, the steering committee members, the committee granting the cluster label to submitted projects, and the prime investigators of funded projects. However, our field studies show that these numbers are an imperfect indication of the real weight that the different kinds of actors have in significant decision processes. The 'other actors' category is highly varied, and might include local authorities (city, county or regional), professional associations representing their members, local development agencies, etc.. Academics sometimes have a strong influence without being formal members. However the levels of weight wielded by different actors in the various governing bodies are fairly correlated, with the most significant factor (explaining most of the dispersion of the sample) being the respective weight of large versus small companies. A secondary factor is the weight of education and research actors inside the steering committee (Glaser & al., 2010).

2.5 Characterizing a cluster's actions

Cluster central teams can devote highly varied efforts to different kinds of action, e.g. building a denser network by sponsoring many events where the members (or potential members) can meet and discuss issues of common interest; helping members design a common strategy; helping them build research and innovation projects and submit them to funding agencies; monitoring projects; forecasting resources that risk becoming scarce and taking action (for example fostering new education curricula in local schools and universities); attracting investors; developing relationships with other clusters; facilitating access to foreign markets, and so on. One indicator could be the staff devoted to each of these tasks, but job descriptions and titles are not standardized, making it difficult to go beyond the qualitative appreciation that a task is performed more or less actively in a cluster.

3 Unstable, ill-defined boundaries and rules

Former attempts to characterize the context, resources, organization, actions and outcome of a cluster implicitly assume that the boundaries of the cluster are well known and stable, and that rules of the game are well defined (e.g. the criteria for granting funds to cluster projects). This is not the case for at least two reasons:

- one of the outcomes of the strategic process implemented in the cluster is to redefine its scope and membership
- the learning process of cluster members, cluster staff and other stakeholders means that the 'rules of the game' are constantly evolving.

Thus, unlike that suggested by figure 1, causal relationships are not simply one-way. Indeed, one of the characteristics of a properly functioning network is its capacity to reconfigure itself and learn from its actions.

3.1 When a cluster's action retroacts on its characteristics

A cluster's perimeter is constantly evolving (Fen-Chong, 2009). For example, some institutions may have had reservations when the cluster was created, but after a certain time the institutions become convinced by the way the cluster works and ask to become members. Thus, a strategic analysis of the cluster's members or governance structure may lead the cluster to modify its geographical scope or the scope of its themes to fill in the gaps or take advantage of these new resources.

Hereafter are three examples of evolving French clusters:

- Cap Digital added "robotics" to its themes so that it could include a dynamic company (Aldebaran Robotics) in its area.
- System@tic added the theme "open source software", in order to attract small companies that were considering setting up their own, overlapping cluster
- The nuclear cluster in Burgundy became aware that its dependence on a single contractor (Areva) was making it vulnerable and so spread to encompass the neighbouring Free County where a large contractor in the railroad sector (Alstom) is located.

All of these modifications in scope usually lead to alterations in governance. These alterations may also arise from a need to give greater space to members that were somewhat neglected in the beginning, like SMEs and local authorities, and so encourage their involvement. One consequence of these reconfigurations is that they render obsolete the initial mapping of the resources that can be mobilized by the cluster (its inherited conditions).

Structural characteristics evolve in a similar way. A network that wants to interest new members but was built around a dominant focal company or an initial "clique" is often led to set up an independent organization to manage the network and guarantee fair rights for members. Thus the boundary between explanatory variables in figure 1 and explained variables turns out to be unclear, because one of the outcomes of poles' action is to modify the supposedly explanatory variables.

3.2 Unclear perimeter

Defining a cluster's perimeter on which data have to be collected is very difficult and depends on numerous factors. Take, for example, the research resources a cluster is able to mobilize. Should we count all the researchers in the cluster's member institutions, even though many of them may be working on very different subjects? Should we only include the researchers present in the area, despite the fact that some institutions may mobilize scientists working in branches located elsewhere? What should we do when a cluster's area does not correspond to the geographical perimeter for which we have data, usually at regional level? How can we demarcate relevant technological fields when one of the cluster's actions is to encourage cross-fertilization?

The set of resources we find out when trying to identify the background of the cluster development might change significantly depending upon the inclusion or exclusion of certain members, or if we consider a smaller or larger geographical area. The relevant boundaries depend upon our scope and perspective. National governments might wish to include other factors than regional governments or scientific researchers. In the end, the person conducting the cluster study has the final responsibility to clearly state the reasons for the perimeter used and the implications this decision might have on the results.

3.3 Interwoven learning processes

Another factor of instability is linked to interferences between the learning processes of different stakeholders. The government's departments implementing the cluster's policy clarify their expectations and the functioning of the funding system while cluster's member organizations learn to reap more benefits from the cluster. Therefore, the organization governing the cluster has to adapt to a fluctuating environment in which the rules that lead to success are not stabilized. The target is constantly moving (Weil & Fen-Chong, 2008b).

4 Building models of performance

4.1 Choosing relevant variables

We are overwhelmed by the abundant, albeit not always clean and robust, data on our networks. Some of these data are collected for all networks, like the 300 data of the 2008 evaluation (BCG & CMI, 2008), which we were allowed to use under a confidentiality agreement. Thus we have a 'complete' set of data, although a more thorough look shows that some questions were interpreted in different ways by some clusters, or were answered inconsistently, so that data required a lot of testing, cleaning and checking (and sometimes had to be dropped or considered unavailable or insignificant). We also have more precise data from other sources, but often only on a specific part of the clusters (and not always the same ones).

We are currently scrutinizing the data and looking at correlations, redundancy and dispersion, in order to select fewer significant indicators. To do this, we use traditional data analysis methods (like MCA, PCA and classification) as well as some more sophisticated ones (like setting constraints on classifications to take into account data which are known only for some clusters but provide precious indications regarding their relative closeness or remoteness) thanks to a new cooperation with the datamining team of CNRS at Orsay University.

Some very preliminary results indicate that the following data may either help to distinguish clusters from each other or explain a significant part of their performance:

- Cooperation preceding the constitution of the cluster

- Relative weight of small and large companies
- Technology vs. market orientation of the cluster
- Local resources in R&D, especially industrial R&D

4.2 *Universal or local cluster models?*

The straightforward approach to explaining the performance of clusters from some cleverly selected factors consists in searching for a universal model.

$$\text{Performance}_k(\text{cluster}_i) = \Phi_k(R_i, S_i, G_i) + \partial_{k,I} \qquad (1)$$

where the performance is assessed on several dimensions k (see §2.2), R_i and S_i are vectors of data describing the context of cluster i, respectively connected to the amount of resources and to the structure of the industry and pre-existing networks, and G_i describes the governance and actions run by the cluster. Φ is a function that captures the performance model, ∂ a remainder which should ideally be small, accounted for by both some noise and factors that we were not able to identify or codify in measurable indicators.

The lack of data as well as conventional laziness and software availability encourages us to severely restrict our investigations to linear models, such as:

$$\text{Performance}_k(\text{cluster}_i) = \sum_j a_{kj} R_{i,j} + \sum_j b_{kj} S_{i,j} + \sum_j c_{kj} G_{i,j} + \partial_{k,i} \qquad (2)$$

As we indicated earlier, our observations on the field have led us to doubt the universality of some practices identified as favourable by various parties. These practices may be beneficial in one cluster, yet harmful in a different context.

Our search for a model that makes a link between cluster performance and inherited or chosen characteristics gives us an opportunity to test this hypothesis. If best practices depend on context, then a model that links a cluster's performance to its inherited resources and the choices of governance and actions, cannot be a simple linear combination of the characteristics of both its context and its governance structure. Supposing that such an econometric performance model could be found – which is what we are currently trying to investigate - some coefficients of variables that characterize the structure would depend on the type of context. We expect a generic model to look like:

$$\text{Performance}_k(\text{cluster}_i) = \sum_j a_{kj} R_{i,j} + \sum_j b_{kj} S_{i,j} + \sum_j c_{kj}(S) G_{i,j} + \partial_{k,i} \qquad (3)$$

where the coefficients c_{kj} depend on S (or preferably on a class of possible structures to which S belongs). In other words, the most efficient model on how to steer the cluster depends on the cluster's structure.

To give the reader an idea of the difference between equations (2) and (3), let us consider a mock example, where an indicator j of performance is plotted against explanation factor i:

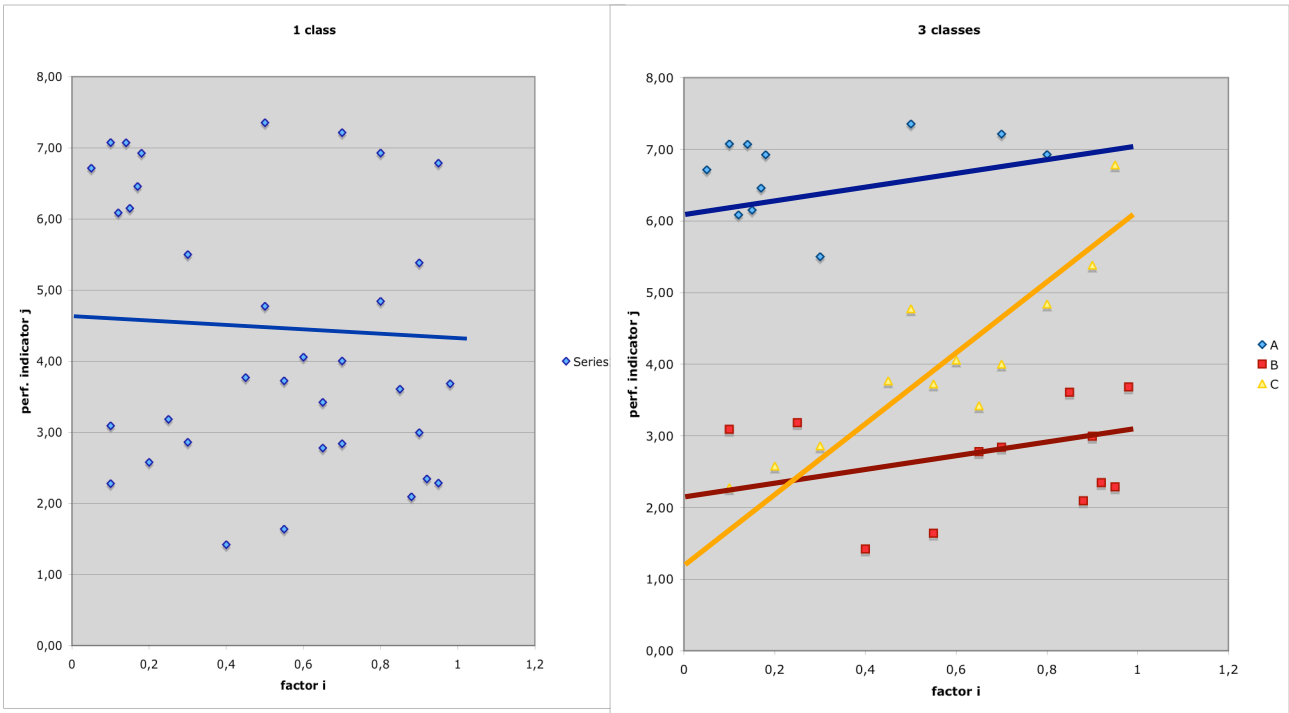

Figure 3: For the same set of 35 clusters, the two figures plot performance index j against factor i. On the left hand side, a regression is made for the whole set. A slightly negative, insignificant correlation appears (y=4,53-0,26x). On the right hand side, 3 subsets of clusters were distinguished. All three correspond to significant correlations (class A: y=6+x, class B: y=2+x, class C: y=1+5x). Factor i is for example the investment dedicated by the cluster to foster international contacts, and index j indicates the intensity of international relationships. Clusters in classes A and B include large actors who already have many international contacts, so that efforts from the cluster do little to help them find new partners. However actors of A have a lot of resources to share with potential partners and can easily defend their background intellectual property, while actors of B have fewer resources to share or are deterred by some legal problems. Clusters in class C gather SMEs, which may benefit significantly from international relationships but need the help of the cluster to identify interesting partners and get access to them (therefore they are highly sensitive to factor i).

Note that equation (3) as well as equation (2) are specific cases of the more general equation (1). Deciding to use local simple models rather than a general universal one is thus mostly a question of convenience, to find the tool that is easiest to use. One can even imagine

situations where a single universal linear model would lead to different prescriptions depending on the context, if for example the cost of increasing a factor varies significantly (e.g. it may be much cheaper to increase a factor from 0.1 to 0.2 than from 0.8 to 0.9). Then the dependence on the different factors may be linear, while the best way to allocate a budget to increase performance depends on the initial value of factors. Although local linear models may then derive from local linearization of a general model, we have no clue about this general model and have to derive the model(s) tediously from classification and fitting.

We are currently analyzing the impact of different factors on performance, looking both for universal trends and for more accurate context-specific models. We are also looking at criteria to assess the added value of local models (e.g. do they give better explanations, of course taking into account the effect of the sample size?).

4.3 In search of the hidden factors

Even if we succeed in finding good models, i.e. models that show that network performance is significantly dependent on identified relevant factors, we still see some variations in cluster performance from the predicted value (the $\partial_{k,i}$ in the former equations).

These discrepancies can either be random effects, or can be explained by neglected factors. Those factors may either have been overlooked or simply too difficult to measure. A close look at the significant discrepancies (clusters performing much better or worse than expectations) might give us clues about the factors we have unduly neglected. This can lead to an iterative improvement of the former model (by finding out more significant factors), or to qualitative assumptions about important aspects for which we have not found good indicators.

Our field observations, as well as literature, suggest than among the factors that we cannot easily capture through simple indicators but that may influence the outcome of a network, we will see how well the cluster manages to transform a loose initial network of sceptical participants into a cohesive, cooperative, tightly knit community.

4.4 Tuning the management of clusters to the local context

If we succeed in finding a set of good cluster performance models and characterizing the context where each model applies, we can both help the management of an individual cluster

improve its action, and assist the (national and regional) authorities to better monitor their overall cluster policy. We then avoid unsuitable prescriptions related to improper models, while maintaining the possibility of accumulating knowledge from the experience of clusters in a similar context. Even if we do not succeed in finding convincing causal models, as long as the classification makes sense, we will at least have fostered relevant comparisons between similar clusters. Clusters from the same family share more similar conditions and are more likely to learn from how another cluster reacts to similar challenges and compare their directions. Within each family, we hope to note stronger relationships between the style of organization and the network's actions and its outcomes, although based on a more restricted sample[5]. We expect that no single universal "best way" exists independent of the type of cluster, but that there are different "good ways" for each type of cluster.

Note again that the classification itself probably depends on the dimension of performance considered. By making explicit the factors of context that should be considered in relation to a given goal for collective action, clusters find it easier to pinpoint relevant benchmarks for improving their practice related to this goal.

Clusters may have different, sometimes conflicting goals and priorities. Some of these goals may be more relevant in certain contexts. For example, a cluster of SMEs may need greater access to academic or foreign partners. Therefore a cluster's mission may depend on the circumstances and the stakeholders, as well as the indicators used to evaluate the cluster's success.

French cluster policy will be evaluated again in 2012. Meanwhile, we hope that we have succeeded in proposing a framework for analyzing clusters and evaluating their achievements that will contribute to the quality of this evaluation. Reciprocally, the results of this evaluation will confirm or challenge our classification and our assumptions of what drives the cluster performance.

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[5] We can attempt to partially compensate for difficulties linked to the small size of each family by observing examples of foreign clusters under similar conditions (although in general the data are not totally comparable).

5 Conclusions

At first sight, the simultaneous creation of several dozen competitiveness clusters sharing a mission to develop the competitiveness of members and enhance the attraction of their area through partnerships for developing innovation, appears to be a highly privileged opportunity to study homologous networks and look for factors that affect their performance. Yet we have encountered numerous difficulties.

The purpose of this paper was to discuss some of these difficulties, which may explain why comparative studies of networks are so rare. In our case, we could not find a satisfactory measurement of clusters' performance, especially if we are interested in the added value resulting from deliberately setting up an association that organizes relationships between cluster members. We therefore have to rely on questionable proxies. Finding a reasonably small set of indicators characterizing a cluster's specific situation and development potential is another challenge. These last two issues are obviously common to a lot of other network studies. In our case, we also have to deal with the fact that our networks are fluid meta-organizations, with fluctuating membership and erratic involvement from many stakeholders. A cluster's organization may change its scope and the pool of available members and resources. The French cluster policy is still in its infancy and the rules of participation and funding are unstable.

In trying to understand how to improve the performance of clusters, we cannot rely on mere data analysis. Even if we have many data, some important characteristics of the clusters are not well represented by these indicators. Furthermore, the sample is too small to make robust inferences. We thus use a hybrid approach, taking advantage of both our many former clinical studies on different French and foreign clusters and our analysis of the structure of quantitative and qualitative data collected (classification and correlation with performance indicators), to go back and forth in order to express plausible conjectures and make a critical analysis of them.

We are at the very beginning of this research program. We hope that this paper will help us to receive valuable advice on the way to overcome the numerous methodological difficulties discussed.

Our main intuition, grounded in field studies, is that we can identify several families of more homogenous clusters so that we may better understand the conditions for efficiency of particular practices. This should lead to improvements in the steering of both individual clusters and national cluster policy.

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