FRANCE STRATÉGIE
ÉVALUER. ANTICIPER. DÉBATTRE. PROPOSER.

Competitiveness clusters: what outcomes since 2005?

NOTE DE SYNTHÈSE

AUG. 2020

The competitiveness clusters policy has been the subject of several impact assessments focusing on its ability to encourage companies to invest more in R&D. Yet, this policy also aims at developing partnerships between public and private actors to strengthen synergies promoting the creation of wealth and jobs. Evaluations conducted to this date have not addressed this second yet, central objective.

This note intends to shed a broader light on this matter through the spatial analysis of spillover effects within and between départements induced by these clusters. It also seeks to measure the clusters' ability to develop B2B (business-to-business) networks and assess their effects on companies' economic performance and their R&D spending. At the time of the realisation of this work, the available data had ended in 2015.

Results obtained in other studies confirmed the impact of clusters on companies' R&D spending: one euro of public subsidy received under this policy would have generated an average of 2.5 additional euros in R&D spending by beneficiary small and medium enterprises (SMEs). On the other hand, as in previous works, the analysis confirms the absence of measurable positive effects on R&D spending by medium-sized and large firms.

The analysis also seeks to measure the clusters' contribution to the structuring of innovation networks in which large companies could play a decisive role. The results obtained are contrasted. On the positive side, relations appear to be increasingly diversified within clusters, and their overall cohesion is progressing over time. On the negative side, the number of collaborations is declining. It cannot be ruled out that this might result from an increase in inter-cluster collaborations or the number of SMEs belonging to clusters, nor can it be excluded that it goes hand in hand with an improvement of these collaborations' quality. Still, the analysis does not allow us to conclude on this point.

From the point of view of spatial effects, a greater number of companies joining a cluster triggers a better dynamic of R&D spending within the territory where the cluster is located. On the other hand, no solid evidence of positive synergies with neighbouring territories has been demonstrated.

Overall, the analysis confirms that public policy in favour of competitiveness clusters has had positive effects on companies, networks, and territories. Still, these effects remain difficult to measure precisely, given the methodological fragilities related to the object of study.

The teams from the "Territoires d'industrie" (industrial territories) program and from the "Analyses et diagnostics territoriaux" (Territorial analyses and diagnostics) unit of the Directorate-General for Operational and Strategic Support (DGD AOS) of the National Agency for Territorial Cohesion (ANCT) have contributed to this note. The present results stem from a study conducted by EuroLIO Technopolis and co-financed by the General-Commissariat for Equality of Territories (CGET), which has integrated the ANCT, and entrusted by France Stratégie. Entitled *Impacts économiques et territoriaux des pôles de compétitivité selon les territoires (Territorial and economic impacts of competitiveness clusters across territories)* this study is available on the website of France Stratégie.

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INTRODUCTION

Phase IV of the competitiveness cluster policy was launched in 2019, with a reinforced demand for excellence and a European ambition. This European ambition does not question the objectives of "usine à projets" (project factory) and "usine à produit"(product factory) developed during the previous phases. Increasing the performance of clusters in terms of collaborative R&D project factories at the national level remains a topical issue, improving their territorial anchoring and their place in the innovative ecosystem.

However, the realignment of the cluster policy on integrating European innovation networks – phase IV's main objective for 2019-2022, emphasises considerations on the size of competitiveness clusters. The larger the cluster is, the lower the costs associated with research and the management of European funds are, which may lead to a gradual reduction in national subsidies. Therefore, the fourth phase encourages the merging of clusters and closer ties with other structures such as the Institutes for Technological Research (IRT) and the Institutes for Energy Transition (ITE). Targeting cutting-edge sectors and concentrating resources on a few clusters pursuing international development ambitions and cooperation gives large companies a decisive place within clusters.

The structuring role of large companies within clusters cannot be captured by standard economic efficiency measures generally used for SMEs. Indeed, large companies have a large stock of knowledge that can irrigate territories and companies' networks. Therefore, indirect positive effects are the expected effects of this cluster policy on large companies. In this regard, the scientific evaluations carried out during the first two phases of the cluster policy[1] still do not identify a conclusive effect on economic and R&D activities. These same evaluations show that belonging to a cluster translates into positive effects on R&D spending by SMEs. Still, the impact on their economic performance (turnover, exports, etc.) has not yet been firmly demonstrated.

Can we conclude that the third phase has resulted in measurable positive effects on companies' market performances? Can methodological problems explain, at least in part, the lack of positive results on large companies and positive but limited results on SMEs? The evaluation conducted by the EuroLIO-Technopolis consortium at the request of the General-Commissariat for Equality of Territories (CGET) and France Stratégie provides some answers to these questions. It offers an analysis based on more recent data than those previously examined. Its most significant originality lies in its overall conception of the evaluation of the cluster policy, with results that concern not only companies but also territories and the structuring of networks.

This study is a continuation of the evaluations carried out in France since the launch of this policy in 2005[2], with the additional objective of identifying territorial impacts and the levers likely to reinforce them. It focuses on the 65 competitiveness clusters that were labelled at the start of the scheme. It analyses their impact between 2007 and 2013, for the first part, focusing on microeconomic effects and between 2007 and 2015, for the second part, focusing on territorial effects. Given the unavailability of data on the research tax credit (CIR) after 2013, the first part is limited to 2007-2013, while the second part focuses on the territorial effects until 2015. Particular attention was paid to the effects of territorial diffusion and network structuring of this policy through collaborative projects.

Before presenting the EuroLIO-Technopolis study results and putting them into perspective with the new phase IV of the competitiveness clusters, this note recalls, based on results of previous scientific assessments, the assessment of the clusters' policy since its launch.

A MIXED RECORD OF THE FIRST TWO PHASES

Launched in 2004, the competitiveness cluster policy aims at fostering innovation and excellence within the French industry through the networking of companies, training centres and research units, public or private, within a single territory (generally at the region's level, although some clusters are interregional). These players ambition to work in synergy on a specific theme to implement innovative projects together[3].

1. Commission nationale d'évaluation des politiques d'innovation (2017), "Avis sur la politique des pôles de compétitivité", France Stratégie, February.
2. In 2016, the Directorate-General for Enterprises (DGE) and the Commissariat-General for Equality of Territories (CGET) initiated with competitiveness clusters a mid-term study on each cluster's scale. This essentially involved qualitative monitoring of performance over the 2013-2015 period. This mission was entrusted to the consortium E&Y, Erdyn and Technopolis ITD. This work made it possible to initiate more detailed monitoring at each cluster's level, which was useful for the evaluation exercises that followed.
3. For more information on the competitiveness clusters, their objectives, and their profiles see: https://competitivite.gouv.fr

Conducted jointly by Datar, and then by the General-Commissariat for Equality of Territories (CGET)[4] and the Directorate-General for Enterprises (DGE)[5], this interministerial policy was implemented in several phases, whose functioning, funding and orientations have undergone evolutions:

- **phase I** – Labelling and structuring the clusters (2005-2008);
- **phase II** – Strengthening the coordination and strategic management of the clusters (2009-2012);
- **phase III** – Support for innovative projects until their launch on the market (2013-2018);
- **phase IV** – Outreach at the European level, with the ambition to aim for excellence in high-potential sectors for the future (2019-2022).

Box 1 shows the eligibility criteria for the 56 clusters labelled in phase IV and their geographical location.

First phase: an increase in R&D spending to keep up with distributed public subsidies

The first phase of the cluster policy, which covers the period 2005-2009, was initially the subject of a rather qualitative evaluation (Boston Consulting Group & CM International, 2008). The INSEE study (Bellégo and Dortet-Bernadet, 2014)[6] was the first to offer an assessment using a scientific approach based on evaluation econometrics. Its main result is that the enhancement of R&D, innovation and the pooling of skills fostered by cooperation projects takes time. Indeed, the study shows that companies' subsidies have been entirely spent on R&D projects without, however, inciting them to invest more of their own funds. During this first phase, the windfall and leverage effects of subsidies have offset each other. The association of several companies and public laboratories around collaborative R&D projects did not allow to produce a spillover effect of public subsidies on private spending during these first four years. The first phase seems to rather correspond to a period of deployment of the clusters during which the value of collaborative R&D projects cannot be measured conclusively. The second phase (2009-2012) was intended to encourage companies to increase private funding of R&D and collaborative projects.

Second phase: a positive leverage effect on R&D activities, but not yet on market performance

The lack of a knock-on effect of the competitiveness cluster policy on R&D spending is confirmed by France Stratégie's study (Ben Hassine and Mathieu, 2017)[7] regarding the first phase. Using the same econometric approach, this study evaluates the first two phases of the competitiveness cluster policy. It highlights for the first time a positive leverage effect on private funding as from 2009, the year of the start of the second phase. Compared to companies with the same observable characteristics but remaining outside clusters, cluster firms have increased their R&D activities beyond the public aid received (direct and indirect aids). A company belonging to a cluster received an average of €160,000 in public aid for innovation in 2012 and increased its research spending by an average of €465,000 in the same year, of which nearly €305,000 thus stems from self-financing. In other words, one euro of public aid received implies almost two euros of self-financed R&D expenditure on average.

However, as in the INSEE study, the France Stratégie study still finds no significant effect on so-called market variables (employment, turnover, export, etc.). The conversion of R&D projects into real industrial programs enabling the clusters to become "factories of products of the future" is one of the main objectives of the third phase of the clusters' policy (2013-2018). Other objectives include creating synergies, particularly around collaborative research projects and the increased role attributed to regions in steering the cluster policy and collaborative funding projects. Due to a lack of available data, these dimensions could not be considered in the evaluations conducted to this date. This is precisely the recent study's objective entrusted to the EuroLIO-Technopolis consortium by France Stratégie and the CGET, whose results are presented here.

4. Established in 2014 from the merger of the Délégation à l'aménagement du territoire et à l'action régionale (Datar), the Secrétariat général du Comité interministériel des villes (SG-CIV) and the Agence nationale pour la cohésion sociale et l'égalité des chances. The General-Commissariat for Equality of Territories (CGET) was replaced by the National Agency for Territorial Cohesion (ANCT) as of January 2020.
5. Direction générale des entreprises (DGE), formerly (until 2014) Direction générale de la compétitivité, de l'industrie et des services (DGCIS).
6. Bellégo C. and Dortet-Bernadet V. (2014), "L'impact de la participation aux pôles de compétitivité sur les PME et les ETI", *Économie et Statistique*, No. 471, Insee, October, pp. 65-83.
7. Ben Hassine H. and Mathieu C. (2017), « Évaluation de la politique des pôles de compétitivité : la fin d'une malédiction ? » *Working Paper*, No. 2017-03, France Stratégie, February.

Box – Eligibility and selection of competitiveness clusters for the Phase IV

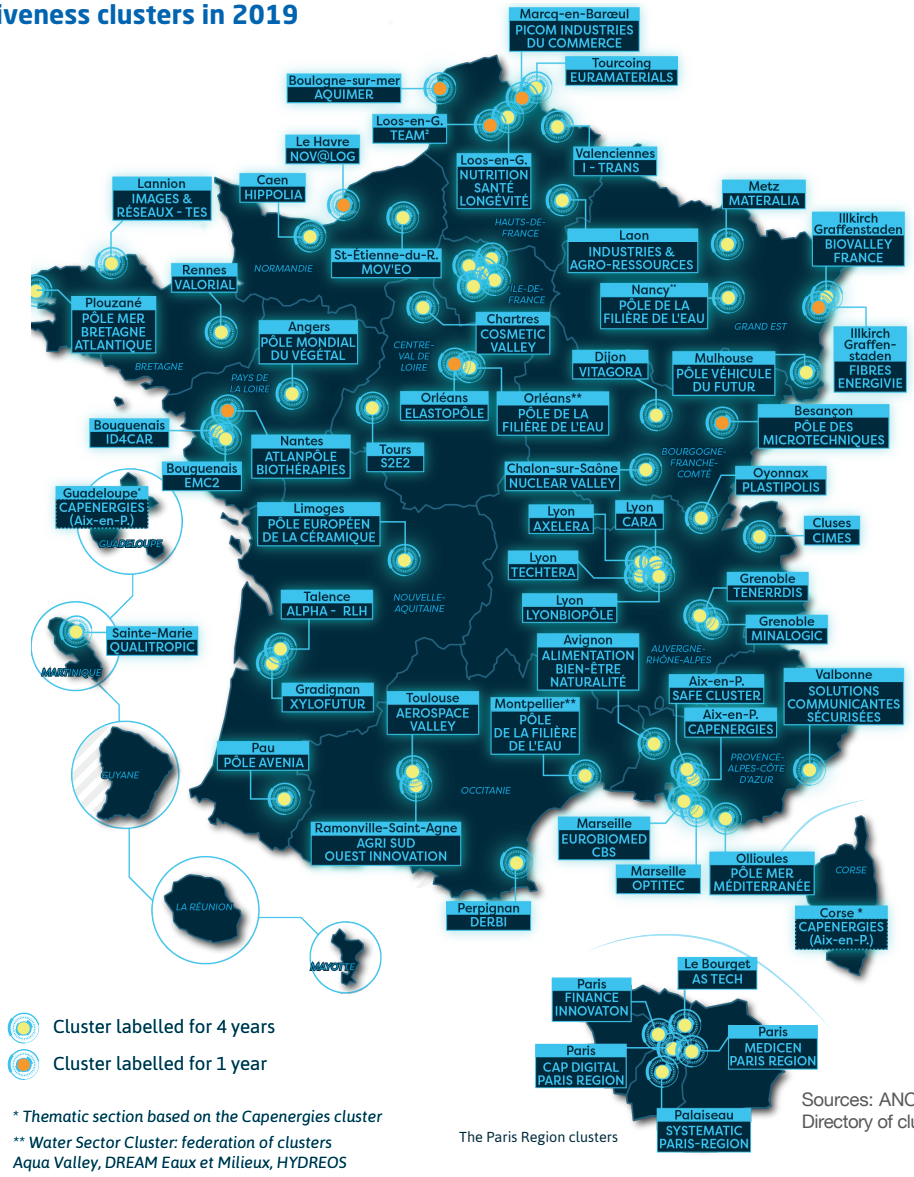
Following the phase IV call for applications (2019-2022) of the competitiveness cluster policy, open from 27 July to 19 October 2018, a total of 56 competitiveness clusters were labelled as such in February 2019 (see map).

The applications were examined by the State, the Regions and by strategic committees of the relevant sectors. The Innovation Council was consulted on 13 December 2018. For the record, specifications have set out objectives of this call for proposals, aiming to select competitiveness clusters in the capacity of fulfilling the European ambition of phase IV. In this context, the merger or partnership of clusters between themselves or with other structures was encouraged.

The eligibility criteria for applications were as follows: an existing competitiveness cluster; several existing competitiveness clusters presenting a merger project; a grouping of competitiveness clusters with other types of structures (clusters, IRT, ITE, etc.) presenting a joint project.

The selection criteria were as follows: having achieved the objectives set by performance contracts of phase III; to be the driving force behind cutting-edge innovation ecosystems, reaching a certain critical mass; to be based on a solid business model and governance; to be a successful R&D collaborative project factory in strategic sectors ; to have a strong European and international dimension or a high potential.

MAP – The 56 labelled French competitiveness clusters in 2019



MICROECONOMIC EFFECTS OF THE CLUSTER POLICY

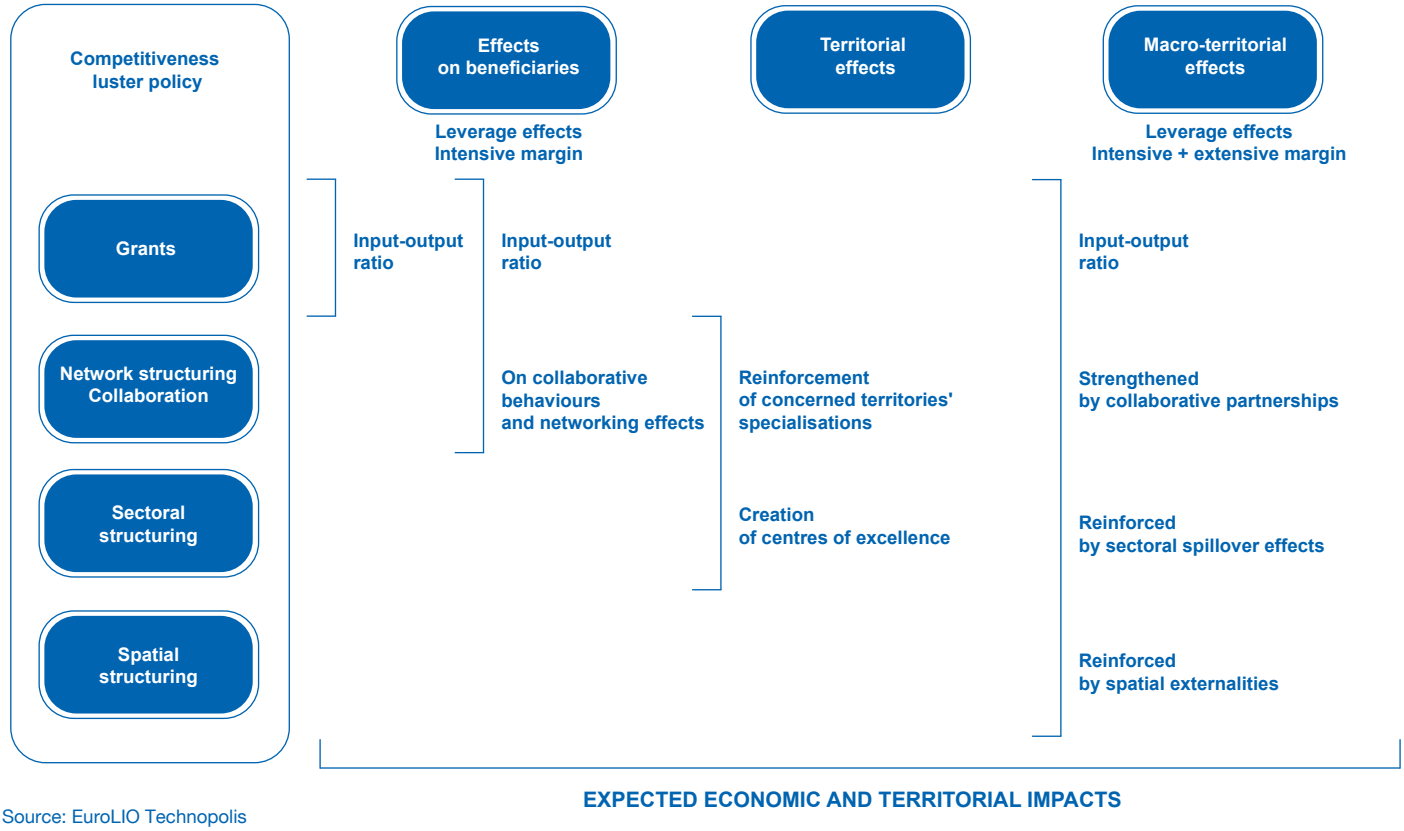
The study offers a new assessment of the cluster policy with two methods for identifying beneficiary companies: cluster membership and participation in collaborative projects financed by the single interministerial fund (FUI). Compared with the two previous econometric evaluations conducted by INSEE and France Stratégie, results solely based on cluster membership are presented in this section.

Box 2 – Evaluation of the "EuroLIO-Technopolis" consortium

The competitiveness cluster policy uses several levers to promote business innovation. The study identifies two main leverages: a financial one (through subsidies) and a lever for structuring the ecosystem, through i) collaborative networks, ii) an influence on the sectorial specialisation of the cluster's territory, and iii) the spatial concentration of the cluster's members (see Figure 1). The objective is to measure the effects of these levers on:

- *the beneficiaries of the cluster policy, by measuring the effects on the resources used by companies to innovate (inputs) and the results in terms of innovation and economic performance (outputs) as well as on collaborative behaviour and networking effects;*
- *the territories concerned by the cluster policy (territorial effects), by measuring the effects on the strengthening of specialisations of the concerned territories and the emergence or development of clusters of excellence ;*
- *the country as a whole by measuring direct and indirect spillover effects on R&D spending and patent applications by beneficiaries and non-beneficiaries of the cluster policy. The interest here lies in the ability to take into account both the intensive margin (increase in the intensity of activity in existing firms) and extensive margin (creation of new activities), even if the two effects cannot be distinguished*

Figure 1 – Expected effects of the competitiveness cluster policy



Source: EuroLIO Technopolis

A confirmation of previous studies' results

The new study confirms the positive results demonstrated in the France Stratégie study on the cluster policy's effects on the R&D activities of SMEs. Cluster membership leads to an increase in their R&D spending effort: 35,000 euros of additional expenditure on average, net of the research tax credit (CIR) and exemptions for young innovative companies, are observed in 2009-2013. Over the same period, the amount of subsidies granted by the State to cluster member SMEs *via* the FUI is around 10,000 euros on average[8]. A leverage effect on R&D spending by SMEs is therefore observed: an additional 2.5 euros are spent for every euro of subsidy. This leverage effect is very similar to that of the France Stratégie study, which highlights a threefold increase in R&D spending for each euro of public aid received in 2012.

At first glance, SMEs do not seem to be the only winners of this policy since these positive effects on R&D activities are also observed in companies of more than 250 employees (medium-sized and large companies). Indeed, cluster membership implies an increase of around 840,000 euros on average in cumulative R&D expenditure over the period 2005-2013[9] compared to non-member companies. However, these effects are mainly due to the greater use of the research tax credit (CIR) by these companies. Once the CIR effect is neutralised, the leverage effect on R&D is no longer significant for this category of companies. Here again, these results are consistent with those of France Stratégie, which concludes that there is no positive effect on the R&D activities of companies with more than 250 employees (medium-sized and large companies).

A positive effect on employment in SMEs

The study data do not allow us to evaluate the effect of cluster membership on employment dedicated to R&D activities. However, total employment and its breakdown by socio-professional categories are used as economic performance variables. The results show that member SMEs recruited (or saved) over 2008-2013 period, 0.56 executives, 0.58 intermediate professionals and 0.28 additional employees on average compared to similar companies that were not part of a cluster[10]. On the other hand, no effect is observed on blue-collar workers. Apart from measurement errors, this implies a total increase of around 1.5 additional employees compared to non-member SMEs. These results naturally control for amounts received under the CIR and Young Innovative Enterprises (JEI) schemes. This is the first time a positive effect is found on total employment. The INSEE study only measures the effect on employment devoted to R&D, and the France Stratégie study, whose data only concerns the first two phases, did not find a significant effect for this variable.

As far as medium-sized and large companies are concerned, the lack of positive impact of the clusters on R&D spending leads to the anticipation of a zero effect on market variables such as sales and employment. This is the result highlighted in the study on these two categories of companies: the cluster policy did not encourage these companies to hire more people.

A consensus seems to be emerging that the competitiveness cluster policy's microeconomic effects are concentrated on companies with less than 250 employees. This result is not surprising as large firms' performance is more affected by global strategies developed at the firm level than by cluster-specific actions (collaborations, networks, etc.).

A positive influence on the export of medium-sized and large companies

The method, which consists of comparing all cluster member companies with non-member companies, is also applied to categories of relatively homogeneous clusters in terms of characteristics of their members, their collaborative projects, and their territories. The advantage of such a classification is that it makes it possible to account for the great diversity of cluster profiles (see Box 3). Tables 2 and 3 confirm that SMEs are the big winners from the cluster policy, particularly those belonging to clusters focused on international markets and, more specifically, those in class 9, which are also characterised by higher R&D activities than the national average.

On the other hand, very few variables show a positive impact of cluster membership for intermediate-sized and large companies. However, one notable result is the positive impact on their exports, particularly for clusters belonging to the "international-oriented clusters" and "over-representation of the ICT sector" classes.

8. France Strategy, based on data from the DGE.
9. This study benefits from the DGE and the National Research Agency (ANR) data over the considered period.
10. Sources: DADS, DIANE, GECIR, EuroLIO calculations.

Box 3 – Cluster classes

A Principal Component Analysis (PCA) associated with an Ascending Hierarchical Classification (AHC) made it possible, based on a large number of variables (26 characterisation variables), to group the clusters into 10 relatively homogeneous classes. The PCA makes it possible to reduce the number of variables required to characterise the clusters by using axes (factors) that summarise most of the initial variables' information. PCA thus allows, through a factorial analysis based on the correlation structure of the variables, to distinguish the main trends in the organisation of clusters according to different dimensions (collaboration, characteristics of territories, R&D, etc.). The AHC then uses an algorithm, allowing cluster grouping based on a criterion that measures the increase in intra-class variance. The clusters of a given class have similar characteristics that the grouping makes this variance increase only slightly[11].

Table 1 – The 10 classes of competitiveness clusters of the EuroLIO-Technopolis study

CLASS	CHARACTERISTICS OF CLUSTERS' CLASS
1	The average number of members and projects is within the national average. The R&D activities of companies and operating budgets are relatively limited, with a location in areas of low economic and scientific activity.
2	The average number of members is within the national average, but projects are relatively few. The member companies, following geographical and sectoral concentrations, are oriented towards international markets and contribute to a significant part of the territory's R&D.
3	The average number of members and projects is lower than the national average. Companies are oriented towards international markets, and collaboration networks are less connected than the average.
4	Very small businesses (VSEs) are over-represented, and the cluster's operating budgets are high. With a location in economically dense areas, member companies' R&D activities constitute a relatively small part of the territory's R&D.
5	The average number of members and projects is lower than the national average, but this class heterogeneity is strong. Research and training organisations are somewhat over-represented. Companies' R&D activities constitute a significant part of the territory's R&D.
6	The average number of members and projects is slightly below the national average. Research and training organisations are under-represented and very small enterprises are over-represented, markets are rather local, and the R&D activities of member companies are lower than average but represent a significant weight in the territory's R&D.
7	The average number of members and projects is higher than the national average. The information and communication sector is over-represented, the cluster is frequently a leader, and projects are more numerous and more often co-labelled than the national average.
8	The average number of members, projects, R&D activities and animation budgets are well above the national average, the information and communication technology sector is over-represented.
9	The average number of members and projects is higher than the national average. The companies have more international markets and higher than average R&D activities, but the latter represents a small share of the territory's R&D.
10	The average number of members and projects is lower than the national average, and the animation budgets are relatively limited. Located in territories with low research activity, the R&D activities of member companies are lower than the average and represent a lower than average weight in the territory's R&D

11. Pour plus de détails sur les indicateurs qui justifient le choix de dix classes, voir l'étude EuroLio-Technopolis sur le site de France Stratégie.

Tableau 2 – Impact on R&D and economic performance of companies of less than 250 employees, depending on their cluster class

Principales caractéristiques	Classes (number of clusters)	R&D	Turnover	Expor-tation	Commercial margin rate	Economic profitability*	Total number	Executive employees	Intermediate occupations	Employees	Workers
Clusters with lower-than-average R&D activities	1(7)	+	NS	NS	NS	-	+	+	+	NS	NS
	4(3)	NS	NS	NS	NS	NS	+	+	NS	NS	NS
	10(11)	+	NS	NS	NS	-	+	NS	+	NS	NS
Clusters focused on international markets	2(9)	+	NS	NS	NS	NS	+	NS	+	+	NS
	3(9)	+	NS	NS	NS	NS	NS	NS	NS	+	NS
	9(10)	+	+	+	NS	NS	+	+	+	+	NS
Over-representation of research and training organisations	5(3)	+	NS	NS	NS	NS	NS	NS	NS	+	NS
	6(6)	NS	NS	NS	NS	NS	+	+	+	NS	NS
Over-representation of the ICT sector	7(5)	NS	NS	NS	NS	NS	+	+	NS	NS	NS
	8(2)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
All classes	(65)	+	NS	+	NS	NS	+	NS	+	+	NS

* Difference between operating income and operating expenses.

Note: + indicates a significantly positive result; - a significantly negative result and NS an insignificant result.

Reading: Companies' adherence to cluster class 1 (which contains 7 clusters and whose main characteristic corresponds to a lower than average R&D activity) implies a positive effect on the following variables: R&D expenditure, total workforce, managers and intermediate professions. On the other hand, it has a negative effect on economic profitability and an insignificant effect on the other variables (turnover, exports, sales margin rate, employees and workers). The estimate of these effects is corrected for the CIR and the IJE exemptions for 2008-2013.

Source: EuroLIO Technopolis

Tableau 3 – Impact of cluster membership on R&D and economic performance of companies with more than 250 employees, corrected by the CIR, for 2008-2013

Main features	Classes (number of clusters)	R&D	Turnover	Expor -tation	Commercial margin rate	Economic profitability*	Total number	Executive employees	Intermediate occupations	Employees	Workers
Clusters with lower-than-average R&D activities	1(7)	+	NS	+	NS	NS	NS	NS	NS	NS	NS
	4(3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10(11)	+	NS	NS	NS	NS	NS	NS	NS	NS	NS
Clusters focused on international markets	2(9)	NS	NS	+	NS	NS	NS	NS	NS	NS	NS
	3(9)	NS	NS	+	NS	+	NS	NS	NS	NS	NS
	9(10)	NS	NS	NS	NS	NS					
Over-representation of research and training organisations	5(3)	+	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6(6)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Over-representation of the ICT sector	7(5)	NS	NS	+	NS	NS	NS	NS	NS	NS	NS
	8(2)	NS	NS	+	NS	NS	NS	NS	NS	NS	NS
All classes	(65)	NS	NS	+	NS	NS	NS	NS	NS	NS	NS

(1) Difference between operating income and operating expenses.

Note: + indicates a significantly positive result; - indicates a significantly negative result, and NS indicates a non-significant result.

Reading: Companies' adherence to cluster class 1 (which contains 7 clusters and whose main characteristic corresponds to a lower than average R&D activity) implies a positive effect on the following variables: R&D expenditure, total workforce, managers and intermediate professions. On the other hand, it has a negative effect on economic profitability and an insignificant effect on the other variables (turnover, exports, sales margin rate, employees and workers). The estimate of these effects is corrected for the CIR and the IJE exemptions for 2008-2013.

Source: EuroLIO Technopolis

Thus, the expected microeconomic effects of the cluster policy on large companies are not necessarily direct. Their leader position and their own knowledge diversity give these firms a structuring role in territories and collaboration networks and generate consequently positive externalities that benefit firms located in their territories or belonging to their clusters. Therefore, indirect effects are rather expected, effects that standard evaluation methods do not allow us to measure. The present study offers an approach at the scale of territories and networks that enables us to consider this type of impact.

WHAT IMPACT ON TERRITORIES?

First, the diffusion effects in the départements belonging to clusters and in adjacent départements are studied. The articulation of the cluster policy with the national, regional and European levels is then analysed.

A contrasting effect in the départements to which the cluster belongs. The study examines whether the existence of a competitiveness cluster in a département has an impact on R&D spending and patent applications in the département itself (direct effect) and neighbouring départements (indirect effect). A département to which the cluster belongs is defined as a département where institutions belonging to the cluster in question are located. A cluster may cover several départements. The direct effect of the cluster policy on a territory is measured using a standard econometric estimate that relates two measures of innovation (R&D spending and the number of patents filed) in a given département to the number of cluster members in that département. The indirect effect is measured by a matrix that describes spatial proximity (contiguity), measured by the number of départements that share a common border with a given département. The main results of the study on this point can be summarised as follows:

- The higher the proportion of companies in a French département that join a cluster, the higher the département's R&D spending. All other things being equal, a 10% increase in the number of members would translate into a 3% increase in the département's private R&D spending, assuming that the reverse causality bias has been adequately controlled[12]. The more companies in a French département join a cluster, the higher the département's R&D spending.

- We note the absence of a spillover effect (indirect effect) of private R&D spending between neighbouring départements.

- Concerning the ability of inventors located in a given département to file patents, no direct effect of clusters is observed other than an increase in R&D spending.

- The study shows that competitiveness clusters have made it possible to increase départements' R&D investments without resulting in more patents. This result confirms previous studies based on individual companies' data. These converging results of micro-econometric and macro-territorial analyses on the direct effects of cluster policy can be interpreted to confirm its effects on member companies. Nevertheless, major challenges to overcome remain, notably regarding a better consideration of spillover effects. These, despite the different data and methods used in this study, remain fragile and need to be confirmed.

WHAT ARTICULATION WITH THE REGIONAL, NATIONAL AND EUROPEAN LEVEL?

The study also seeks to verify whether the increase in the number of members of a competitiveness cluster associated with an increase in the amount of regional subsidies received by companies in a given département results in an increase in R&D spending in that same département. Taken separately, these two types of policies have a positive impact on R&D investment. The interaction of the two policies, on the other hand, results in windfall effects since part of the public funding substitutes for private funding.

The same analysis is carried out on the interaction between the number of participants in collaborative projects and national grants on the one hand and European grants on the other. An increase in the number of participants in collaborative projects combined with larger amounts of national

12. Estimating such a model is likely to pose an inverse causality problem. The generalised instrumental variable estimator proposed by Bramoullé et al. (2009) is used to overcome this endogeneity bias. The interaction between neighbouring departments is instrumented by indirect and intransitive interactions between non-contiguous departments neighbouring departments. In other words, Bramoullé *et al.* (2009) consider that if i is affected by j and j is affected by k, but i is not affected by k, then k is an instrument for j. This instrument makes it possible to estimate, without reverse causality bias, the effect of j on i. Thus, k is correlated with i but not with the model's error term. These two conditions satisfy the two criteria for the validity of a "good" instrument.

grants results in positive spillover effects between départements on R&D expenditure. On the other hand, the association between participation in collaborative projects and European grants results in a decrease in R&D expenditure in neighbouring départements (territorial competition effects). This can be explained by the fact that national grants are often accompanied by an incentive to cooperate with other national partners, whereas European grants instead encourage cooperation with partners from other European countries.

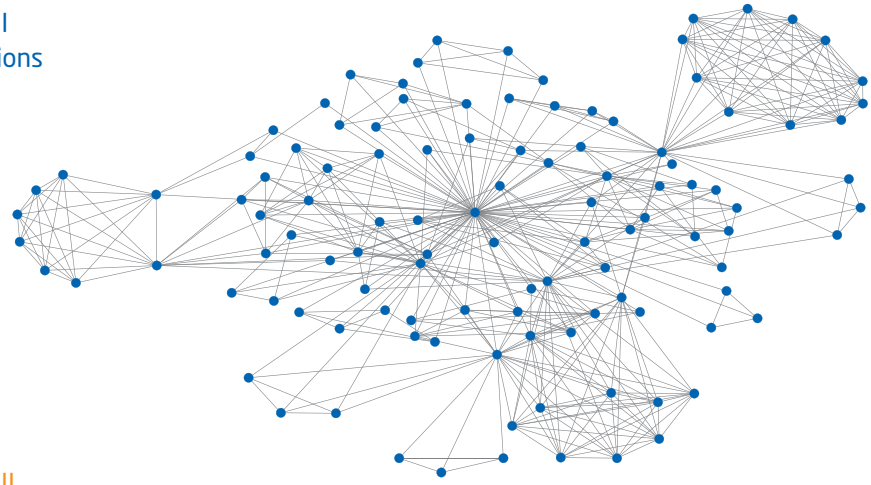
These results show that the number of members is an important factor in deploying the cluster policy, but not the only one. Participation in collaborative projects is also a positive determinant of its impact. It should be recalled that spillover effects between innovation players via cooperation networks are also an objective of the cluster policy. However, this dimension of clusters as creators of networks has been little studied to this date.

WHAT IS THE ROLE PLAYED BY CLUSTERS IN THE STRUCTURING OF INNOVATION NETWORKS?

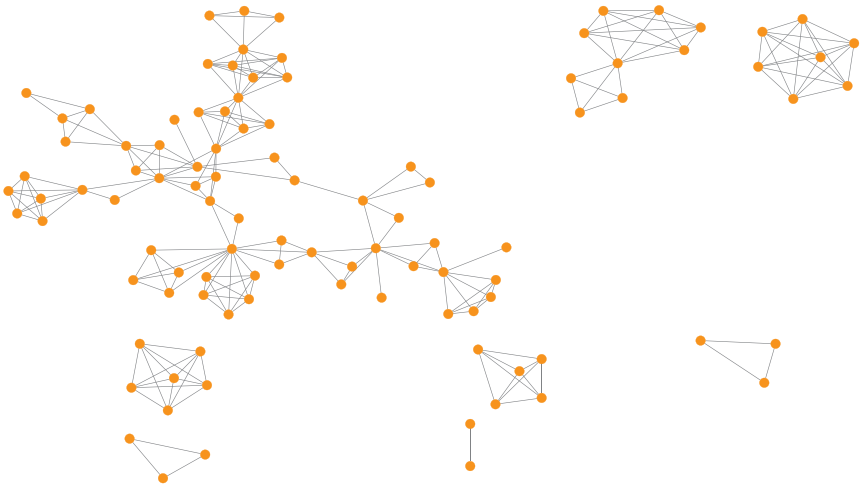
The study also examines the question of the role played by clusters in structuring innovation networks. Each cluster is analysed here as a network measured by the number, intensity and quality of collaborative projects and their evolution during the three analysed policy implementation phases (2006-2008, 2009-2011 and 2012-2015). The aim is to assess the impact of public incentives to collaborate on the implementation of innovative ecosystems, notably through their degree of connectivity[13] and their capacity to ensure the circulation of knowledge within clusters. For example, cluster B in Figure 2 comprises several components and has shortcomings in the circulation of knowledge within itself. On the other hand, there is always a "path" linking all possible pairs of organisations within pole A, which *a priori* favours a good circulation of knowledge.

Figure 2 – Examples of visualisation of network structures within clusters

Pole A, phase II
113 organisations



Pole B, phase III
102 organisations



Source: EuroLIO Technopolis

13. The notion of connectivity refers to a situation where organisations are linked by collaborative projects, either directly by participating in the same project or indirectly, when they participate in two different projects, but both involve the same third-party organisation.

Among the set of structural properties of the networks constituted by the clusters, five were analysed more specifically (Table 4). The first reflects the intensity of the collaborations, the next three reflect the level of coordination of the actors and the last one the capacity to circulate knowledge within each cluster.

- **Intensity of relationships:** this indicator translates for each cluster the average number of collaborations with active members involved in at least one project. The results show a downward trend over time in the number of active entities' collaborations within the clusters. This could result from a greater number of VSE/SMEs among cluster members due to their lesser ability to maintain a sufficiently developed and sustainable network of relationships compared to large companies.

- **Structuring:** It is defined by a cluster's capacity to generate a "core/periphery" structure allowing the emergence of central players capable of coordinating and driving peripheral members' actions. This property refers to a particular form of network composed of a central entity, which controls the entire project and supervises coordination, and a certain number of organisations called upon to collaborate on one or more projects. This indicator is measured by the sum of the differences between the number of collaborations of the most connected organisation and the number of other organisations' collaborations within the cluster. A fragmented form of a network (value close to 0) indicates a competitiveness cluster in its emerging phase. On the opposite, a form grouped around a few central actors (value close to -1) suggests that the cluster has reached maturity since the network structure reveals the existence of one or more companies developing important coordination capacities. The average values in Table 4 show the relative stability of this indicator over time. Some clusters nevertheless show levels close to -1, revealing the existence of firms capable of coordinating the network's actions, and others with an indicator equal to zero, indicating one (or more) cluster(s) characterised by relatively homogeneous members, without central actors.

- **The diversity of relationships:** this indicator measures the degree to which the most central players in a cluster cooperate with other less central (peripheral) players in the same cluster. The characteristic on which this degree of diversity is judged is the number of cooperations maintained by each actor according to its relational capacity and size. This indicator is measured by the dependency (correlation) between the number of direct relationships of the different organisations within a given cluster. Between -1 and 1, this diversity indicator measures the extent to which most central actors establish relationships with peripheral actors. The diversity of relationships is all the more important, the closer the value of the indicator is to -1. The decrease in this indicator's average value (see Table 4) over time reveals increasingly diverse relationships.

- **Clustering:** this indicator expresses the degree of cohesion within each cluster. A network is perfectly cohesive when two organisations connected (i.e. participating in the same collaborative project) to the same third-party organisation are also connected to each other. The clustering coefficient is constructed by relating the number of triads having collaborative projects between them to the number of possible triads (triad: three actors connected to each other). This indicator is between 0 and 1. A value close to 1 implies the absence of companies capable of ensuring the ecosystem's overall connectivity. On the other hand, a value close to 0 reflects the existence of "gateways" between projects and better dissemination of knowledge between actors. The drop in the average value of this indicator indicates an improvement in cohesion within the competitiveness clusters.

Table 4 – Structural properties of clusters over the three periods from 2006 to 2015

		Intensity	Structuring	Diversity of Relationships	Clustering	Connection %
2006-2008	Average	7.54	-0.407	0.324	0.776	78.38
	Minimum		-0.726	-0.333	0.397	31.82
	Maximum	21.22	0	1		100
2009-2011	Average	6.74	-0.506	0.238	0.724	76.56
	Minimum	2.40	-0.809	-0.500	0.290	24.32
	Maximum	17.02	0	1		100
2012-2015	Average	5.96	-0.435	0.237	0.694	73.28
	Minimum		-0.741	-0.5	0.264	25.81
	Maximum	10.45	0	1		100

Note: each relationship between the different members of a cluster is defined here as the existence of a collaborative project selected within the framework of the calls for projects of the FUI (previously labelled by the competitiveness cluster) or the ANR and bringing together at least two companies and a research or training organisation.

Source: DGE-ANR-EuroLIO, EuroLIO calculations

The connection degree, expressed in percentage, reflects the share of organisations (among all those involved in at least one project) between which there is a direct or indirect collaborative link. When a component (a company) of the clusters has no link, even indirect, the network structure becomes discontinuous with the rest of the organisations, resulting in unconnected sub-networks that hinder the circulation of knowledge within clusters. The observed drop of this indicator could be explained by a substitution effect favouring inter-cluster collaboration to the detriment of intra-cluster collaboration. This substitution effect would contribute to the redeployment of collaboration strategies on broader scales, reducing each cluster's connectivity. When clusters are located in neighbouring départements, this substitution effect could encourage interdepartmental spillover effects.

To summarize, the results of these structural properties of networks are mixed. On the one hand, clusters show a stable level of maturity over time (see structuring indicator), increasingly diversified relationships, and improved overall cohesion. On the other hand, there is a downward trend in the number of collaborations between active entities within clusters. SMEs' increasingly important place in various clusters could be the first explanation (CNEPI, 2017). The second would be the more important collaboration between organisations belonging to different clusters to the detriment of intra-cluster collaborations. This substitution effect could be at the origin of the spillover effects highlighted above on patent applications, especially when members are located in neighbouring départements.

CONCLUSION

Despite methodological weaknesses inherent to the subject of study and the available data, the analysis confirms that public policy promoting competitiveness clusters has positive effects on companies, networks and territories. To further reinforce the positive results highlighted, a few avenues worth exploring should be considered.

In the first place, it could be useful to encourage mergers between clusters that are insufficiently structured (or in their emerging phase) with those that have developed significant coordination capacities. Secondly, it might be wise to use Technological Research Institutes (IRTs) and Strategic Sector Committees (CSFs) of the National Industry Council (CNI) to intensify cooperation between cluster members. Finally, the involvement of small and medium-sized companies and public research organisations in cluster activities could be encouraged to increase the intensity and quality of cooperation.

These possibilities of exploration are in part those being pursued as part of Phase IV of the competitiveness cluster policy, which began in 2019 and will result in a reconfiguration of the cluster landscape. To gain in efficiency, its ambition is notably to aim for a better articulation of national and regional public policy favouring innovation and competitiveness by relying on local actors' networks. Its purpose is also to bring more projects to the European level by making better use of the "Horizon 2020" framework program and its successor "Horizon Europe" over the period 2021-2027.

Keywords: competitiveness cluster, innovation, R&D spending, network structuring, impact assessment, evaluation

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