The Life Cycle of Clusters: A New Perspective on the Implementation of S3

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Abstract. In recent years the urge to sharpen strategic public actions, in the way of boosting regional economic performances, has become an imperative. Accordingly, the concept of Smart Specialization Strategy (S3) has attracted growing consideration, by bringing to light an innovative, place-based policy framework for regional economic development. Although S3 policies has been widely examined by many scholars, nonetheless some implementation gaps remain under addressed. The key issue where the debate is still open relates to the operationalization of the Entrepreneurial Discovery Process (EDP). The EDP is a crucial stage in S3 policy design, since it drives to identify priorities by focusing on exploration and experimentation of new opportunities to transfer them in a clustering phase. Considering this backdrop, the paper seeks to contribute in bridging the S3 implementation gaps by investigating the potentials of the Cluster Life Cycle (CLC) analysis to guide the operationalization of the EDP. The paper presents and discusses a conceptual model towards highlighting if, and how stage-specific features of clusters (in terms of dynamism, cooperation among firms, diversity of knowledge and actors, and spatial significance) provide potential input in the operationalization of EDP, to enhance S3 implementation. Ultimately, the authors find that EDP implementation could significantly benefit the framework conditions of dynamism, cooperation, variety provided by some specific stages of the CLC.

Keywords: Cluster · Life cycle · Smart specialization
Entrepreneurial discovery

1 Emerging Challenges and Opportunities in the Implementation of S3

During the last twenty years the urge to sharpen strategic public actions, in the way of boosting regional economic performances, has become an imperative. In view of this emerging need, the concept of Smart Specialization Strategy (S3) has attracted growing consideration, by bringing to light an innovative, place-based policy framework for regional economic development. Accordingly, S3-oriented policies are meant to provide place-specific strategies, which aim at unleashing territorial economic potentials. Therefore, S3 policy construct focuses on the "vertical" identification of regional economic priorities aiming at: (i) producing smart, sustainable, and inclusive growth, (ii) promoting research potential, and (iii) maximizing the usage of innovations [1].

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Such a policy concept, which has been suddenly endorsed within the formal discourse on the EU 2020 innovation plan, roots in five policy principles, namely [1, 2]; (i) granularity, (ii) experimentation, (iii) inclusiveness, (iv) cyclic nature, and (v) entrepreneurial discovery. While all the principle mentioned above contribute remarkably towards defining the uniqueness of S3 policies, the entrepreneurial discovery holds a particular importance. Indeed, the entrepreneurial discovery process (EDP) is seen by Foray as both the conceptual and operational cornerstone of S3, enabling the identification of hidden economic potentials of territories. The EDP serves the collection of dispersed regional knowledge and supports the exploration and disclosure of novel domains of opportunity, towards paving the way for achieving innovation at the regional level. In this sense, the scope of EDP is very broad, since it does not refer to the identification of technological innovations per se, rather it aims at experimenting alternative ways to deploy innovative ideas. To sum up, it is possible to identify three stylized element which stay at the core of the EDP, namely: (i) integration of knowledge, (ii) engagement of stakeholders, and (iii) exploration of new economic domains. Ultimately, the logic is to combine, within a unique regional bundle, the entire set of science-, technology-, engineering-, and market-related knowledge available at the regional level by engaging multiple actors in the way of experimenting novel avenues of economic specialization and setting regional priorities.

Although the nature of S3 policies has been widely investigated by many scholars, nonetheless the practical avenues of S3's operationalization feature some underdressed issues. Recently, Capello and Kroll [3] have finely identified a set of emerging implementation gaps, and bottlenecks, referring to the lack of: (i) favourable framework condition for practice-based innovation at regional level, and (ii) social and political readiness to confront the paradigmatic shift embedded in the S3-oriented policy. In addition, the latter authors point out the scarce capability of certain regions (lagging regions) to engage actively in processes of regional entrepreneurial discovery. This element seems to be particularly problematic by hampering the effectiveness of S3 priority-setting process. The implementation difficulties pertaining to EDP do not surprise. Foray firstly, observed that the identification of entrepreneurial discoveries *"[is] not [an] easy empirical investigation"* [4]. Still on the EDP implementation difficulties, Gheorghiu, Andreescu, and Curaj [5], lamented the absence of a *"functional blueprint for the entrepreneurial discovery process"* (p. 2). On an analogous line of thoughts, Santini et al. [6], highlighted that entrepreneurial discovery gaps have contributed in the way of ratifying the failure of the EU research system. These evidences call for consideration from scholars and practitioners to disclose new opportunities and potential solutions to facilitate the operationalization of S3, and particularly of EDP. Notably, one of the major opportunities to further the effective implementation of S3, refers to the exploitation of EU regions' knowledge and experiences with cluster and cluster policies [1, 7, 8]. While much has been said on the role of cluster and cluster policies in supporting the implementation of S3, there are still very few pieces of work adequately considering the potential input of the cluster life cycle analysis. However, considering that clusters dynamics and spatial configurations change over time, it is expectable that the effectiveness of different policy measures vary over the life cycle of clusters. The latter idea seems to apply, to some extent, also to S3 and particularly EDP.

Considering this backdrop, this paper aims at contributing to the debate on the role of clusters in the arduous implementation of S3, towards investigating the potentials of the CLC analysis to guide the operationalization of S3, and in particular EDP. The work is structured as follows. Firstly, the study of the literature on the CLC allows the authors to understand which are the leading indicators accounting for the evolution of clusters. Secondly, the indicators drawn from the literature study, are used to build a conceptual model representing the evolution of clusters. Thirdly, the discussion on the model highlights how stage-specific features of clusters (in term of innovative dynamism, cooperation among firms, diversity of knowledge and actors, and spatial significance) can potentially input the operationalization of S3 and in particular EDP.

2 CLC Inputs on the Implementation of S3

By drawing insights from the literature, this article describes the CLC, according to a three-stage taxonomy, including the phases of (i) emergence, (ii) development and (iii) maturity of clusters.

Clusters usually emerges because of the trigger-effect of an exogenous economic shock [9]. The exogenous shock induces the take-off of the clustering process, and consequently drives a limited number of small-sized companies to co-locate in certain geographical areas [10, 11]. Such early agglomeration phenomenon manifest through a scattered spatial configuration and lacks consistency because the locational benefits are not evident yet [9]. At this stage, the flow of knowledge and information between cluster insiders is mainly involuntary and informal as it does rely nor on structured networks neither on consolidated partnerships. Despite the lack of sharpened inter-firm organisational forms, nonetheless, a stock of heterogeneous knowledge circulates among insider businesses [11]. This explorative stage of the CLC is also characterised by significant Venture Capital (VC) and Research and Development (R&D) investments. To summarise, the emergence is a very early, upstream, and explorative phase of the CLC and it is featured by a marked tendency of firms towards innovativeness. The role of start-ups, as well as the values of creativity, and willingness to risk added by entrepreneurs, are crucial to further the prosperity of clusters. The benefits deriving from network activities and knowledge spillovers are somehow available, and the stock of accessible knowledge is highly heterogeneous.

Developing clusters expand through a substantial proliferation of the companies entering the market, and a significant increase in employment. The locational benefits become high towards encouraging co-location. Accordingly, the profitability of insider businesses rises, reaching its peak. In this phase, the agglomeration economies, theorised by Marshall, are the key engine enabling the endogenous growth of the cluster [9]. Consequently, many positive externalities take place, including (i) specialised labour pooling; (ii) interactions among stakeholder, and (iii) knowledge spillovers. In addition to the Marshallian externalities, another factor contributing to the cluster prosperity is the medium/high level of heterogeneity of available knowledge within the clusters' environment [11]. Tersely, the success of clusters at this stage seems boldly rooted in regional self-reinforcing processes (such as networking activities, interactions, and cooperation) occurring among local firms and institutions. The number of

Start-ups and entrepreneurs is still relevant but no longer crucial to further the cluster's development. The R&D and VC investments remain significant as well as the level of heterogeneity of accessible knowledge.

Mature clusters reach a stable configuration, towards focusing on specific business segments, consolidating networks' structure, and acquiring cooperative routines [11, 12]. This state of quasi-equilibrium of clusters features a severe decrease in frequency and number of entries, which in turn makes the clusters' growth rate dropping down. At this point, although locational benefits and self-reinforcing effects are still somehow accessible, however they tend inevitably to dissolve [11]. Moreover, mature clusters usually features high specialisation (if not over-specialisation), as a consequence both the variety of economic activities and the heterogeneity of available knowledge narrow down [11]. Concisely, mature clusters reach the maximum size, have a well-shaped network structure, and a precisely-defined core business. In this context, the entry of Start-ups in the clusters becomes irrelevant, R&D and VC investments decrease, and the knowledge accessible becomes homogeneous.

2.1 A Conceptual Model to Disclose the Potential of CLC Analysis Towards Inputting EDP Operationalization

Drawing on the study of literature it is reasonable to claim that clusters evolution can be explained, to some extent, by variations in certain cluster's dimensions, namely: (i) dynamism, indicated through R&D investment, VC investment, new firms (start-ups) birth rate; cooperation, indicated by intensity of network activities; variety, signalled by heterogeneity of available knowledge; spatial significance, indicated through specialization and agglomeration. The dimensions of clusters' evolution as well as the indicators are framed in Table 1, which also defines the literature sources the indicators have been retrieved from.

Table 1. The selected indicators.

Dimension	Indicator	Literature source
Dynamism	**R&D investment**	Keeble and Wilkinson, 1999 | Brenner, 2000 | Bergman, 2008 | Brenner and Schlump, 2011
	VC Investment	Brenner, 2000 | Braunerhjelm, 2000 | Chatterji, Glaeser and Kerr, 2014 |
	Start-up birth rate	Fornahl and Menzel, 2003 | Mario A Maggioni, 2004 | Menzel and Fornahl, 2009 | Brenner and Schlump, 2011| Suire and Vicente, 2014
Cooperation	**Intensity of network activities**	Brenner, 2000 | Bergman, 2008 | Brenner and Schlump, 2011
Variety	**Heterogeneity of available knowledge**	Menzel and Fornahl, 2006 | Menzel and Fornahl, 2009 | D. H. Shin and Hassink, 2011| Biggiero et al., 2016
Spatial significance	**Specialization**	Maggioni, 2002 | Brenner and Schlump, 2011 | Handayani et al., 2012
	Agglomeration	Maggioni, 2002 | Maggioni, 2004

These indicators are deployed to build a conceptual model presenting the potential input of CLC in the way of operationalizing S3 and specifically EDP. Such research objective is pursued by:

1. scoring qualitatively the strength of each indicator at each stage of the CLC (Table 2). The scores are assigned by the authors on the base of deductions and insights drawn from the literature and previous works [13]. For the scoring, the authors used a scale based on five degrees of intensity: low, medium/low, medium, medium/high, and high.
2. framing the indicators within a conceptual model (Fig. 1) towards comprehending the potential input that stage-specific features of clusters (in term of innovative dynamism, cooperation among firms, diversity of knowledge and actors, and spatial significance) can provide towards the operationalization of S3, and in particular EDP.

According to Table 2, indicators belonging to the same dimension vary in equal manner during the evolution of clusters. Consistently the conceptual model which follows (Fig. 1) presents directly the four families of indicators, rather than the single indicators, and opens to a discussion.

Table 2. Indicators score.

	Dynamism			Cooperation	Variety	Spatial significance	
	R&D	VC	Start-ups birth rate	Intensity of network activities	Heterogeneity of available knowledge	Specialization	Agglomeration
Emergence	high	high	high	medium	high	low	low
Development	mid/high	mid/high	mid/high	mid/high	mid/high	mid	mid/high
Maturity	low	low	low	mid/high	low	high	high

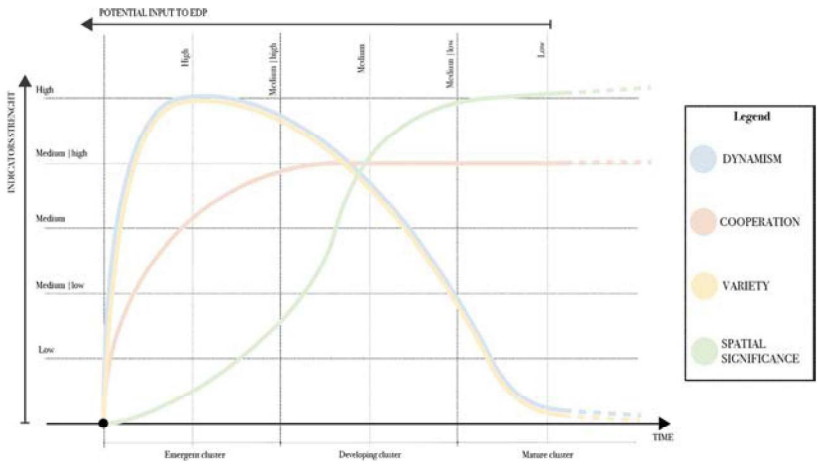

Fig. 1. Conceptual model of CLC analysis potential input to EDP.

The discussion firstly, provides an interpretation of the indicators and their variation in strength over the CLC stages, and secondly, highlights the relevance of clusters stage-specific features in terms of dynamism, cooperation, variety, and spatial significance towards inputting EDP.

R&D investment is considered both as an indicator of clusters innovativeness [14], and a determinant of entrepreneurship [15]. Indeed, R&D propels the generation and diffusion of knowledge, which in turn furthers the vibrancy of entrepreneurial environment and favors inventions. The benefits of R&D seem to be particularly important during the early life course of firms [16], as new-born firms (such as start-ups) tend to exploit investment on R&D more efficiently than the old ones. Consequently, clusters featuring high number of start-ups, attract and call for R&D investment, which in turn generate remarkable innovative outputs. Given these considerations, it seems logically more convenient to operate R&D investments during the initial phases of the CLC, namely emergence and development. These two initial stages appear to be more suitable for entrepreneurial discoveries, because of their high start-ups' birth rate, and flourishing innovative environment. Conversely, clusters in their maturity rely on aged firms, which operate according to consolidated, if not stagnating, industrial practices. Henceforth, envisioning that EDP is meant to "(…) logically identify (…) the domains where new R&D and innovation projects will (…) create future domestic capability" [17], it is reasonable to conclude that emergent and developing clusters offer optimal context conditions for EDP implementation. The same conclusion is also in the case of Venture Capital (VC) investments. VC investments refer to "a form of equity financing particularly important for young companies with innovation and growth potential but untested business models and no track record" [18]. This funding system is seen both as a marker of clusters' innovative potential, as well as an essential factor nourishing clusters' entrepreneurial environment [19]. Indeed, VC is especially advocated in, and appealed by, highly pioneering territorial contexts [20]. Such setting coincides with those of emerging and developing clusters. Therefore, VC investments, by focusing especially on the explorative stages of the CLC, trigger potential innovations which could be intercepted in the way of EDP. Along with R&D and VC, start-ups birth rate is the third indicator accounting for dynamism and goodness of the entrepreneurial environment within clusters. Start-ups include all newly born firms that are up to two years old [18]. Such "young" and usually small-sized businesses, because of their very explorative, and potentially innovative nature, are crucial endogenous drivers of territorial development. High values of the indicator start-ups birth rate also mean that entrepreneurial actors (the bearers of entrepreneurial knowledge) are particularly active. To sum up, there is a positive correlation at the territorial level between high values of the indicator start-ups birth rate (which usually attributes emerging and developing clusters), high density of entrepreneurs and high availability of entrepreneurial knowledge. Given that EDP has a "(…)special focus on the regional entrepreneurial environment, assessing whether it is lively and can generate a significant flow of experiments, innovation ideas (…)" [20], it is reasonable to deduce that emerging and developing clusters could provide valuable inputs in the way of entrepreneurial discoveries. As already stressed, high values of the indicator start-ups birth rate are a marked feature of clusters' emergence and development stage. Instead, the entry of start-ups, and their importance in the functioning of the cluster, drastically decreases

during maturity. This theoretical evidence suggests that EDP can be effectively supported by the bold entrepreneurial, innovation-oriented, cross-sectoral environment manifested at the two initial stages of clusters' evolution.

Networks activities refer to actions generating or nourishing organisational forms of economic activities [21]. The intensity of network activities provides a measure of knowledge exchange and firms connectedness, within certain geographic boundaries (which are mutable and permeable). Empirical studies demonstrate that increases in network activities are positively correlated with the rise of firms' innovativeness [21]. The same studies also prove that the willingness to engage in knowledge-based networks has a negative correlation with firms' size. These evidences, suggest that network activities are more intense in the presence of new-born, small-sized firms (such as start-ups). The latter orientate towards more flexible, sometimes informal, forms of networks. On the contrary, big firms rely on routine-based, formally-regulated networks. These differences in the structure of, and willingness to engage in networks make small firms' more innovative, more adaptable and less sector-specific than big ones. However, networks and spillovers co-evolve with clusters. As previously highlighted, networks are mostly informal, and spillovers often happen involuntarily during clusters' emergence. This is due both to the scattered configuration of the spatial agglomeration of firms and to the explorative nature of the businesses entering the market (mainly start-ups). When clusters move on to the development stage, networks get gradually more structured and spillovers more formal. This condition evolves further on during the maturity stage, when networks become rigid and spillovers significantly decrease. Given these considerations, it is reasonable to affirm that EDP should focus on emergent and eventually developing clusters, which are featured by the *"relational density"* postulated by Foray. Indeed, the significant density of start-ups and entrepreneurs, the marked attitude of firms towards innovative activities and knowledge sharing, make emergent and developing clusters an exceptional source of various entrepreneurial and economic knowledge.

The heterogeneity of knowledge [11], indicates the variety of the available knowledge-stock inside clusters. Considering that entrepreneurs are the knowledge bearers, the variety of accessible knowledge also indicate, to some extent, the assortment of entrepreneurial actors. The more such assortment is various, the more clusters manifest a marked attitude towards adjusting to changing conditions [11]. It has been said that the heterogeneity of knowledge and actors evolve over the CLC. Specifically, while the initial phases of the CLC feature high and medium heterogeneity of accessible knowledge, during maturity, this variety tends to attenuate toward homogenization. This shift, from heterogeneous to homogeneous knowledge, is due both to a decrease in the number of diverse entrepreneurial actors entering the clusters and to an increase in specialisation. Considering that EDP calls for a diversity of economic actors and knowledge, the best match in the way of EDP operationalization seems to be manifested by the features of emerging and developing clusters.

Specialisation refers to the share of regional employment in a sector, relative to the national context. This indicator is widely endorsed in literature as a marker of spatial concentration of industries [9]. The discourse on specialisation presents a split-screen view. On the one hand, low specialization: (i) prevents clustered firms from exploiting the full potential of competitive advantages and (ii) allows clustered firms to benefit a

vibrant, cross-sectoral and diversified entrepreneurial environment (typical attribute of emergent and developing clusters). On the other hand, high specialisation leads clustered firms to exploit competitive advantages fully, while eventually leading to stagnation and lock-in (a common attribute of mature clusters). Tersely, high specialisation can lead towards flattening clusters' economic vibrancy and innovativeness as well as losing the positive effects of the variety externalities theorised by Jacob. Once again, the best fitting ecosystem for EDP is expectedly the one provided by emergent and developing clusters. Indeed, considering that EDP pertains to the detection of potential domains for future regional specialisation, targeting already specialised clusters would mean pointing out traditional industrial sectors instead of S3-type domains. Another indicator accounting for the spatial configuration of clusters is the agglomeration. The latter indicates the number of firms concentrating in some geographical regions [9]. This indicator's value increases as clusters get holder, till reaching its peak during the maturity stage. At this point, the mass of economic activities located in a specific geographic area reaches its maximum. As a consequence, the attractiveness of such areas starts decreasing due to a scarce availability of locational benefits [9]. Conversely, in cases when spatial agglomeration presents a configuration not saturated yet, businesses from outside are encouraged to locate inside clusters because of potentially high locational benefits. These considerations reveal that the locational attractiveness should be found in clusters that have not reached the spatial agglomeration peak yet, namely: emerging and developing clusters.

3 Conclusion

This article presented a theoretical discussion on the role of clusters and cluster policies to support S3, and specifically EDP implementation. Although a significant body of scientific literature confirms that EU experience with clusters and cluster policies is a crucial element towards supporting the implementation of S3, nonetheless many operational gaps keep standing out. One of the most problematic factors pertains to the operationalization of the EDP. Consistently the authors intended to test whether the CLC analysis could eventually guide the discovery of regional economic potentials.

Considering the discussion presented in the previous section of this work it is reasonable to claim that the EDP implementation could significantly benefit the framework conditions for innovation, relational density, and diversity of knowledge and actors provided by some specific stages of the CLC. In detail, the authors find that emerging and developing clusters can provide a number of significant inputs towards implementing EDP (Fig. 1): (i) the significant strength (medium and high) of innovative dynamism (in terms of R&D and VC investment, and start-ups' birth rate) signal high quality framework conditions for innovation; (ii) the medium and high strength in intensity of network activities indicates a significant relational density among clusters insiders and a tendency towards innovative, cross-sectoral cooperation; (iii) the medium and high heterogeneity of available knowledge, which also indicate the variety in the assortment of economic actors, enables the opportunity to enlarge the regional knowledge-base, gathering economic and entrepreneurial knowledge; finally, (iv) the

low/medium levels of firms' agglomeration and specialization suggest the existence of a territorially localized economic potential, which has not been fully exploited yet.

These findings call for consideration of policy-makers, to reflect more consciously on CLC analysis to overcome EDP implementation issues, and consequently get to a fully effective operationalization of S3.

By drawing on these findings it is possible to derive a couple of recommendations. First, the innovative potentials of regions need to be analysed under an evolutionary perspective by considering the study of the CLC. Disregarding the investigation of the CLC would produce an underestimation of regional economy's dynamics, and consequently a misinterpretation of the context. Given that S3 aims at enhancing the untapped potentials of regional economies, hence it cannot ignore the insights provided by such evolutionary-based, CLC-oriented context analysis. Second, different policies must be adopted in different regions on the base of the analysis of the CLC. As already stated in previous paragraphs, emerging, and developing clusters display suitable context conditions for the implementation of EDP, and S3, while mature clusters do not. Consistently, the exercise of S3 is more likely to produce a desirable restructuring of the economic systems in regional contexts dominated by emerging and developing clusters. Conversely, the application of S3 in regional contexts dominated by mature clusters can hardly produce the expected restoration of regional economies, which would benefit much more traditional industrial policies for cluster support. This differentiation, implies to the need for aligning public intervention with respect to the different phases of clusters' evolution.

However, the study presents some limitations pertaining to the conceptual model. Firstly, the lack of established conventions on indicators for the study of clusters makes the selection of the variables for the model, a relatively arbitrary process. Secondly, the CLC cannot be satisfyingly explicated through a single model. Given these considerations, some potentially influential factors are ignored, while the variables that are most frequently endorsed in the literature are included. Moreover, given that industries are not alike, and that different variables have different importance in the industries, it might be that the model does not represent the mechanism of some industrial sector. The same limit also applies when considering diverse territorial contexts. However, the theoretical literature provides evidence that a detailed modelling of all relevant processes might not be of crucial importance. From this, it is reasonable to conclude that while the model is not fully explanatory, it still reflects appropriately the potential contribution of the CLC and spatial analysis in the way of S3 and EDP.

Further studies are needed to empirically validate the model presented in this paper.

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