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A Comparative Investigation of Firms' Innovative behaviors During Different Stages of the Cluster Life-Cycle (Cover study for PhD dissertation)

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A Comparative Investigation of Firms' Innovative Behaviors during Different Stages of the Cluster Life-Cycle

Cover Study for PhD Dissertation

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1. Introduction

While in many recent studies there have been overloaded heroic stories about innovativeness of clustered firms (see Baptista and Swann, 1998; Porter, 1998; Roelandt and Hertog, 1999; Steinle and Schiele, 2002), this dissertation intends to scrutinize such epics more specifically along one of cluster's describing characteristics, i.e. cluster life cycle (Swann, 2002; Sölvell, 2008). The arguable point is that such attractive picture may change in long-run of cluster life cycle, especially when target group is shifted from cherished 'innovative firms' to ignored 'innovation-active firms'¹. Whereas only few researchers stand against such mainstream, however, by being either aggressively critical (see Martin and Sunley, 2003, p. 22) or partly cautious (see Pouder and John, 1996)² about usage of such symbolic stories, yet, they are not only too few but also merely theoretical. Consequently, lack of the empirical and in-depth study is still sensible.

Prevalently discussing nowadays, clustering leads to regional economic growth (Porter, 1998; Lundequist and Power, 2002; Sölvell, 2008, p. 26; McCann, 2008, p. 24-25; Tsagdis, 2009). Contemplating in endogenous cluster dynamics (Belussi and Sedita, 2009), 'innovation' is vital for cluster growth (Sainsbury, 1999; Ecotec, 2001; Sölvell et al., 2003; Belussi and Sedita, 2009, p. 510). However, various behaviors of clustered firms, e.g. innovativeness of firms, are inherently dynamic rather than static, i.e. they may change over passing the life cycle of cluster (Pouder and John, 1996, p. 1192; Bergman, 2008, p. 128). As Karlsson (2008, p. 13) pointed out;

"It is important to observe that the factors that once enabled a cluster to form and grow may not necessarily be as important in sustaining it".

Even furtherer, Menzel and Fornahl (2009) declared that, for example, technological heterogeneity of firms in a cluster, which is a significant firm's behavior for emergence and

¹ For the distinctive definitions for 'innovative firms' and 'innovation-active firms', see Oslo Manual, 2005, P.47 and p. 59 respectively.

² Pouder and John (1996) argued that innovativeness of firms inside cluster may grow but it is, unquestionably, limited to early stages of cluster development. However, while this study offers cause and effect relation for growth/ decline of innovation along cluster life cycle, it does not measure innovation explicitly. In addition, it captures only 'output approach' in innovation of firms and 'input approach' seems to be ignored, which means this study only focused in *innovative firms* and *innovation-active firms* has been overlooked (input/output approach and innovative/innovation-active firms will be discussed in 'theoretical framework' part of this study).

growth of a cluster, will be a fatal poison for a cluster later, i.e. in its maturity stage³. Accordingly, such changing behavior requires adaptive responses from policymakers as well as firms side. In other words, as Hertog et al., (2001, p. 407) noted; “*Facilitating an emerging cluster requires different actions from policy makers than revitalizing an existing mature cluster.*”

2. Overall problem discussion

2.1.What is the problem?

The overall problem is that there are some gaps in knowledge frontier⁴ of research area concerning firm’s innovation in the context of cluster, i.e. there is not explicit and sufficient amount of theoretical/empirical studies to monitor and analysis the innovative behaviors of clustered firms along cluster life cycle, while the necessity of this issue has been noted briefly in previous section (and will be discussed in part 2.2 and 2.3, too).

In fact, such overall problem is constituted by several sub-problem/gap issues, which are vital to be addressed, as follows. **First**, there is not a consensus among few existing researches about dynamic of firm’s innovation in life cycle stage. For example, Pouder and John (1996) sturdily stated that degree of firm’s innovation will be decreased in mature stage of cluster life cycle, while Menzel and Fornahl (2009, p. 23) noted that there is *not* any guarantee that clusters in declining stage are less innovative. **Second**, while there have been some empirical studies to analysis the interrelation between elements of firm’s innovation process (see footnote 12 for the list of studies), yet, they dealt with cluster context quite rarely. **Third**, measuring innovation-related issues, e.g. firms’ innovative behaviors, has always been difficult for economists and other social scientists (for general problems of innovation measurement see Smith, 2006, p. 149); “*It is a typical case of discrete units: a real innovation is different from any other*” (Archibugi and Sirilli, 2001, p. 38). **Forth**, whereas there are varieties of approaches in innovation measurement, there is not still a standard way which could satisfy all types of studies. **Fifth**, innovation data are *not* normally available in longitudinal manner over long time period (at least in recent dominant method of

³ In addition, there were also the similar argument by Maskell and Malmberg (2007, p. 11) about the *entrepreneurs’ myopic behavior* leading to decline of a cluster, while such behavior was the driving force for emergence of that cluster once upon a time.

⁴ Knowledge frontier will be discussed in a separate part later.

output/subjective approach deployed by Oslo Manual and CIS⁵) to make it feasible to measure innovation over long-run of life cycle for one specific cluster. **Sixth**, it seems everybody is talking about ‘innovative firms’, but nobody cares about ‘innovation-active firms’. **Seventh**, while there have been considerable efforts in describing the evolutionary pattern of cluster⁶, yet, there is not only the lack of any clear attempt to specify indicators of each phase, i.e. what are the (generic) signals of cluster at the beginning of each phase, but also even there is not a consensus way to identify a cluster. **Eighth**, different scholars have mentioned the dynamic behavior of firms over the time-axis, particularly along industry/product life cycle (Audretsch and Feldman, 1996; Klimenko, 2004, p. 178; Dornberger and Utama, 2006, p. 17; Menzel and Fornahl, 2007, p. 4). Regard to the fact that ‘cluster life cycle’ differs from ‘industry life cycle’ (Pouder and John, 1996, p. 1194; Menzel and Fornahl, 2009, p. 10), however, it seems such dynamic behavior has been ignored over cluster life cycle context yet⁷. **Ninth**, when it comes to recommendations related to cluster performance area, e.g. for escaping from decline phase and jump to renaissance in cluster life cycle context, most of the previous literatures has their focal arrow toward government/policy makers (Klink and Langen, 2001, p. 461). Surprisingly, it seems nobody triggered other actors, especially firms.

2.2. Why addressing the problem is interesting and important?

In order to investigate above mentioned problem (and sub-problems), this dissertation needs to establish the theoretical platform addressing its multi-disciplinary and also multi-level focal problem⁸. Such theoretical platform, in one hand, tries to map the innovative behavior of firms regard to firm-level innovation process (within knowledge economy context), and on the other hand, introduce the method not only to detect a qualified cluster, but also to define the indicators of each stages of cluster life cycle.

⁵ Community Innovation Survey (CIS) is a pan-European survey carried out every four years (recently every two years) by each EU member state and is designed to gather information on the extent of innovation in European firms across a range of industries and business enterprises. The sixth round (CIS 2008) is carrying on currently.

⁶ The example for such kinds of effort is developing triggering (driving) factors for cluster evolution even in phase-wise manner (see Sölvell, 2008, p. 40, 42; Belussi and Sedita, 2009).

⁷ Although there have been some studies in describing the dynamic behavior of clustered firms (Pouder and John, 1996; Van Klink and De Langen, 2001; Martin and Sunley, 2003), they are not fully comprehensive and they will be criticized in detail in ‘papers’ related part.

⁸ It is multidisciplinary since, from one hand, it deals with cluster concept and notably its life cycle, on the other hand it copes with measurement of (clustered) firms’ innovation, in particular innovative behavior. It is also multi-level, as it deals with cluster life cycle in cluster-level, while on the other hand it attempts to measure innovation in firm-level. Further discussion about how to deal with such multi-level study will be in ‘Theoretical Framework’ part (see also *Appendix 1*).

Empirically speaking, this dissertation intends to analysis a vast range of innovative behaviors of clustered firms (along various stages of cluster life cycle) and compares it to non-clustered one. Such analysis contributes to better understanding of relation between various elements of innovative behavior of firms, e.g. firm's input and output to their innovation processes. In particular, by applying econometric approach, functional relationships between innovative behavior variables can be estimated in the industrial cluster context. Such analysis seems much more important, if one bears in mind that various types of innovation *differ* from each others, not only in terms of features, but also (perhaps most importantly) in terms of their micro/macro impact on firms' behavior/society⁹.

2.3. For whom the problem can be important?

Above mentioned problem analysis can shed light for both firms' innovation strategy as well as (innovation) policy makers in regional and national context. Undoubtedly, the clustered firms need to be aware of the dynamic of spatial dimension in which they are located, whereas, however, firms normally lack such meso/macro insight, i.e. cluster-level perspective. So, analyzing firm's innovative behavior investigation within cluster context can provide the guideline for the firms to define their innovation strategy contingently in line with cluster evolutionary path and not with blind eyes of macro dynamic.

In accordance with policy making context, for example, the hot topic of 'Swedish paradox' (Edquist and McKelvey, 1998) can be corresponded¹⁰, which has not ever been sufficiently analyzed within the industrial cluster context. Analyzing the innovative behavior of firms, e.g. examining the elements of firms' innovation input/output, along various cluster life cycle stages may open up new insights for solving such a widely speaking problem.

3. Overall Purpose, objectives, and research questions

The overall purpose of this dissertation is to fill some existing gaps, discussed in previous part, within current knowledge frontier, i.e. analysis the innovative behaviors of clustered

⁹ In terms of *features*, Ornaghi (2006) showed that product innovations have a larger technological diffusion than process innovations, both in magnitude and pervasiveness. In terms of *impact*, Becker and Egger (2009), arguing that while both product/process innovation is important to stimulate firm's *export*, product innovation is more influential in firm's propensity to export rather than product innovation (micro impact). Also, Ornaghi (2006) indicated that social rates of return are higher for product innovation than for process innovation (macro impact).

¹⁰ Initially proposed by means of *R&D intensity* (Edquist and McKelvey, 1998), Swedish paradox has been confirmed again recently by wider indicator of *innovation intensity*, based on CIS data (Bitard et al., 2008).

firms along cluster life cycle (and compare it to non-clustered ones) and coming up to recommendations for firms as well as policy makers to improve their contingency approach toward innovativeness of firms in different stages of cluster evolutionary path. Such overall purpose is to be pursued in terms of the following four objectives seeking to answer respective key research questions:

- ❖ Undertake Critical literature review on cluster and innovation notions, cluster life-cycle stage, innovative behavior (measurement). (*paper 1*)
 1. What is the suitable range of firm's innovative behaviors? How are firms' innovative behaviors to be measured?
 2. How a cluster can be identified? How is cluster life-cycle stage to be established? (maybe *paper 2*, too)
- ❖ Establish the relation between elements of firm innovative behaviors in each stages of cluster life cycle, separately and empirically (*paper 3-5*)
 3. What is the fluctuation (raise and fall) map of each innovative behavior in each stages of life cycle?
 4. What can be the correlation (or sensitivity analysis) between various components of 'innovation activities' and 'innovation introduction' and 'sales' (i.e. causal relation between three elements of innovative behavior in each life cycle stage)?
- ❖ Establish the relation between cluster life-cycle stage and cluster-firm innovative behaviors, holistically (*paper 6*)
 5. How clustered firms' innovative behaviors vary along cluster life-cycle stages?
 6. Addressing hypothesis: e.g. clustered firms show product innovation, non-clustered firms show process innovation.
- ❖ Recommend respective firm and policy improvements. (*paper 3-6*)
 7. What kind of firm approaches and policy instruments *have been used* to increase amount of innovative behaviors during a cluster's life cycle stages?
 8. What *may be* the most cost-effective and contingent firm approaches and policy instruments to improve innovative behaviors at different cluster life-cycle stages?

Each objective (and subsequent research questions) will be addressed in assigned paper(s), as indicated in brackets above, and will be elaborated more in 'papers' part of this cover study. Nonetheless, interrelation of research questions with each other is inevitable, which requires

working with several of those papers simultaneously. Moreover, following scheme illustrates the overall layout of this dissertation, starting with creating the theoretical ground, dealing with cluster life cycle and innovative behavior notions, leading to subsequent empirical studies.

Figure 1- Dissertation layout; 1st paper as theoretical platform for empirical studies in the subsequent papers

<u>(Paper 2)¹¹</u>	<u>Paper 3</u>	<u>Paper 4</u>	<u>Paper 5</u>	<u>Paper 6</u>
(Simulation of cluster life cycle)	Comparative investigation of firms innovative behavior in <i>early stage</i>	Comparative investigation of firms innovative behavior in <i>growth stage</i>	Comparative investigation of firms innovative behavior in <i>maturity stage</i>	Comparative investigation of firms innovative behavior in various stages (<i>whole body perspective</i>)
<u>Paper 1</u> : Theoretical platform				

4. Knowledge frontier

Attempting to **relate spatial clustering to process of innovation** has been made explicitly in the notion of ‘innovative milieu’ (Aydalot, 1986), which has its route in more sociological literatures (among others Granovetter, 1985), rather than economics or business/management ones. Furthermore, looking at **variation of firm’s innovation in an aggregated level**, e.g. by means of technology/industry life cycle, has been cherished in empirical studies lately (Adner and Levinthal, 2001; Audretsch and Feldman, 1996; Klimenko, 2004, p. 178; Dornberger and Utama, 2006, p. 17; Menzel and Fornahl, 2007, p. 4), while it can be traced back to influential work of Utterback and Abernathy (1975).

Stimulated by Oslo Manual and subsequent CIS data, recently there have been some **empirical studies to analysis the interrelation between elements of firm’s innovation**

¹¹ It is not certain, yet, that this paper, which is devoted to simulate the cluster life cycle, is going to be created at all, since it can be substitute by an alternative method, e.g. qualitative/descriptive method for mapping the various stages of cluster life cycle.

process, i.e. input, output and ultimate outcomes such as labor productivity, in several European countries, e.g. France, Germany, Sweden, Netherland, Norway, Finland, and UK¹². Most of those studies have been based on econometric techniques relying on CDM model¹³ (Crapon, Duguet, and Mairesse, 1998), although there have been even earlier work by Griliches (1979), focusing on the relationship between R&D activity and productivity growth within production function framework, however, including only patents and R&D activity as input. Whilst CDM model improved the basic model by incorporating the new indicators, still there are problems associated with this model (see Knell and Nås, 2006), which must be addressed while employing¹⁴.

An **evolutionary approach** will supplement analyses of localization economies (Hoover, 1937, 1948; Gordon and McCann, 2000) by placing the argument in a sequence that emphasizes how clusters originate, develop and decline, i.e. cluster life cycle (Maskell and Malmberg, 2007, p. 9). Regard to the life cycle of cluster, a popular approach among researchers has been *stylized stage-wise* manner of life cycle segmentation, i.e. birth, development, maturity, and ultimate stage (renaissance or lock-in), as it is reviewed in *Appendix 2*. Further, applying agent-based models (Fioretti, 2006) and **simulation techniques** (Merlone et al., 2008) is the other approach dealing with the evolutionary path of cluster life cycle, which is still quite infant.

While **Swedish paradox** has been addressed widely in national level, i.e. innovation system literatures (see Bitard et al., 2008), inquiring such phenomenon in regional level, i.e. industrial cluster context, yet, may contribute to better understanding of it.

5. Theoretical Framework

In order to shed light into the multi-disciplinary/level focal point of this dissertation, appropriate theoretical framework must be built. However, prior to discussions of theoretical framework, it is crucial to note that although cluster life cycle is going to be described and established theoretically/empirically in an aggregate level (i.e. cluster-level which can be recognized somewhere between meso and macro-level), the investigation of innovation will

¹² For the list of those empirical studies in various European (and also non-European) countries, see Hall and Mairesse (2006, p. 290) and Knell and Nås (2006, p. 2).

¹³ The CDM model combined a production function of knowledge relating R&D activity to patenting or innovative activities with economic performance as measured by labor productivity (Knell and Nås, 2006).

¹⁴ CDM model is based on knowledge production function models, which, however, argued by Iammarino and McCann (2006, p. 1021) not giving a full account of the diversity of possible industrial cluster types, nor do they tackle issues such as the evolution of clusters.

be in firm-level, which means there will be a shift in the analytical focus from aggregate level to firm-level (Manzel and Fornahl, 2009)¹⁵ in this dissertation, which has been merited in literature (see Maskell and Malmberg, 2007)¹⁶.

6.1.Firm's innovative behaviors

It is decided that the focal point of this dissertation would be measuring 'innovative behavior of firms'. It composes of (1) generic 'innovation activities'¹⁷, as *input* to innovation process, (2) introductions of (any) four types of innovation (i.e. product, process, marketing, and organizational innovation), as (intermediate *output*), (3) and the most tangible/measurable output of such introductions which is 'sales of innovative products', as (ultimate) *output* of innovation process (see Figure 2). Starting from output part and in particular *sales*, it looks plausible to refer back to popular Schumpeterian definition of innovation, who enumerated innovation as the **commercialization** of invention (Schumpeter, 1934). In line with this definition, the innovation can be measured by (commercially) 'innovation output indicators', such as sales for new, incrementally changed, and radically changed products (Calvert et al., 2002; Steward, 2008, p. 6). Furthermore, such output approach is also known as *object approach* (Archibugi and Sirilli, 2001; Smith, 2006) or *direct* measure of innovation (Steward, 2008), which is a new trend of innovation measurement method and can be seen as a performance variable (Löf and Heshmati, 2006; Lundvall and Borrás, 2006, p. 617). This fresh method seems to substitute traditional measures, i.e. patent data and R&D data, in practical studies, e.g. periodical CIS surveys, quickly. In fact, those measurement methods based on patent and R&D data, e.g. number of R&D employees, have shown some biases (Jensen and Webster, 2004) and also they are actually input/intermediate measurement of innovation, rather than direct method (Baptista and Swann, 1998, p. 530; Archibugi and Sirilli, 2001; Steward, 2008, p. 2)¹⁸.

¹⁵ As assured by OECD (2008, p. 221, 239), micro-level data in CIS, as primary empirical data of this dissertation, can be aggregated in higher analytical level, i.e. country level or cluster level.

¹⁶ Maskell and Malmberg (2007) asserted that recognition of the individual *entrepreneur's behavior* (which is even lesser-order process than *firm's behavior*) could improve the understanding of aggregate processes.

¹⁷ Innovation activities are defined as: "all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations." (Oslo Manual, 2005, p. 47)

¹⁸ Further on pitfall of patent data as measure of innovation, Smith (2006, p. 160) noted that firstly, this method are more indicator of invention rather than innovation, since there is not any guarantee that patented product can reach to commercialization stage, and secondly, some types of technology are not patentable at all. Regard to the R&D data measurement method, this dissertation aims to apply 'innovation activities' approach (will be discussed soon) which *include* R&D activities.

However, by utilizing mere output measure of innovation, i.e. measuring introduction of four types of innovation or innovative product sales, this dissertation may not succeed to capture all aspects of innovative behaviors of firms, since many of innovative behaviors of firm may never end up to any salable product (Oslo Manual, 2005)¹⁹. Perhaps one could, yet, query why it is important to consider innovative behaviors, if they may not result in sales. The answer is implanted in the notion of firm's 'innovation capabilities'²⁰, which is noted by Mone et al. (1998) and Cooper and Kleinschmidt (2000) as the most important determinant of firm performance (Calantonea et al., 2002), however quite difficult to measure directly (Oslo Manual, 2005, p. 141), since it requires measurement of embedded knowledge within individual/organization (see definition in footnote **Error! Bookmark not defined.**). Nevertheless, the fact is that 'innovation activities' are vital to increase the 'innovation capabilities' of firms, even if they never end up to a recognizable innovative product (Oslo Manual, 2005, p. 36). This approach roots back to efforts of Rosenberg who develop so-called chain-link model of innovation (see Kline and Rosenberg, 1986). This model revealed that innovation is not a linear process, rather it is a learning process with multiple *inputs* and feedback mechanism (Smith, 2006, p. 150)²¹.

In fact, 'innovation activities' approach not only captures *succeeded* innovation activities, which normally lead to implementation of four types of innovation, but also includes *ongoing* and *abandoned* innovation activities, which lead to increase in firm's innovation capabilities while they are not observable in output approach (see Figure 2). In addition, innovation activities encompasses both R&D and non-R&D activities, so that the coverage on innovative behavior of firms will be even more. Therefore, this dissertation adopts 'innovation activities' approach proposed by Oslo Manual (2005) (which can be called an improved version of input approach for innovation measurement method) in parallel with 'output approach', which discussed earlier, in order to maximize the analytical coverage of innovative behavior of firms. The schematic summary of above discussed theoretical framework regard to measure *what* and *by which* approach is presented in Figure 2.²²

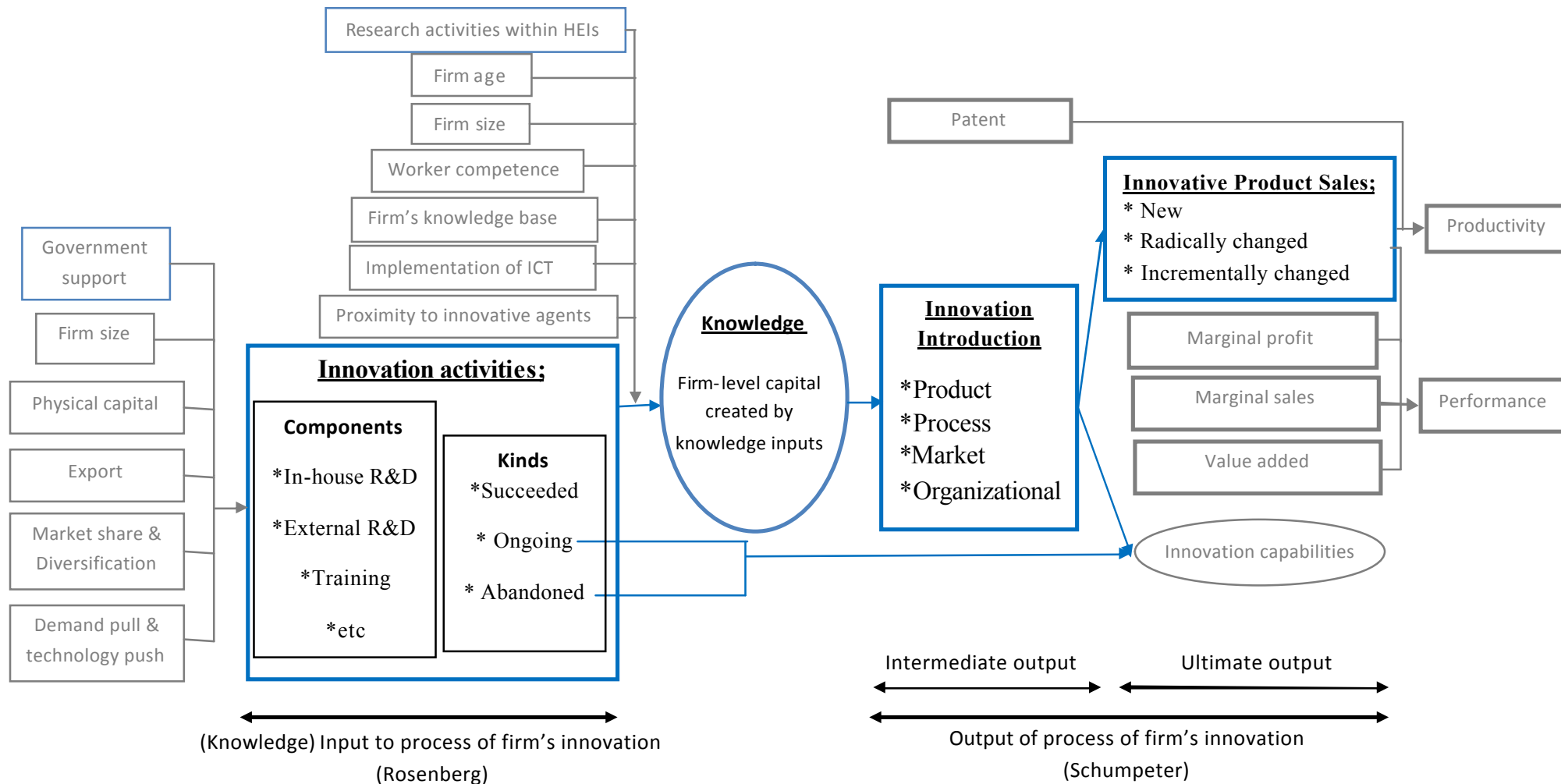
¹⁹ An example of those innovative behaviors of firm that may never end up to any salable product is a rejected NPD project (e.g. by top management) which, however, has been contributing to increase the stock of knowledge for developing the next similar project.

²⁰ Innovation capabilities has been defined as "the skills and knowledge a firm needs to effectively absorb, master, and improve existing as well as new technologies, processes, and business models" (Lall, 1992; Romijn and Albaladejo, 2002)

²¹ Furthermore, Pavitt (1984) already dug into various sources of innovation, i.e. innovation inputs, and classified them based on sectors (Malerba, 2006, p. 384).

²² Blue boxes and arrows in Figure 2- are the scope of analysis of this dissertation, while the greys are out of scope. Blue boxes are suggested by Oslo Manual (2005), while greys are suggested by various

Figure 2- Components of 'innovative behaviors of firm' (thick blue boxes) and other influential factors



Note: Blue boxes are components of firm's innovative behavior, while grey boxes are the other influential factors in innovation process, which are not to be addressed in this dissertation. Square boxes denote measurable quantities, while oval one is unmeasurable concepts (for which proxy mostly used).

Figure 2 not only outlines the conceptual relations of some related aspects of innovation in firm-level, but also (more importantly) is a framework to specify what/how is going to be measured in firm's innovative behavior in this dissertation, i.e. innovation activities in input side and introduction of four types of innovation together with product sales in output side. Since both input and output to innovation process can be called innovative behavior, this dissertation intends to grasp both of them, which allows for comprehensive monitoring and analysis of innovative behavior of firms along different cluster life cycle stages. Moreover, by adapting such dual input-output approach, this dissertation plans to shift the target group from cherished 'innovative firm' to ignored 'innovation-active firms'. With slight modifications, above discussed approach of this dissertation has been called '*subject approach*' in literature (Smith, 2006).

6.2. What is industrial cluster?

6.2.1. How to identify a cluster?

In fact, there is no consensus method for cluster identification, yet, either in terms of key variables to be measured or the procedure by which geographical boundaries of a cluster should be determined (Martin and Sunley, 2003, p. 19). Nevertheless, this dissertation needs to have clear criteria to pick up some industrial agglomeration as a case study cluster for its intended investigation.

In order for any industrial sector to qualify as a cluster in any given functional region²³, the sector must be over-represented in some dimensions (criteria). Such criteria, which can be called necessary conditions for cluster existence, are as follows;

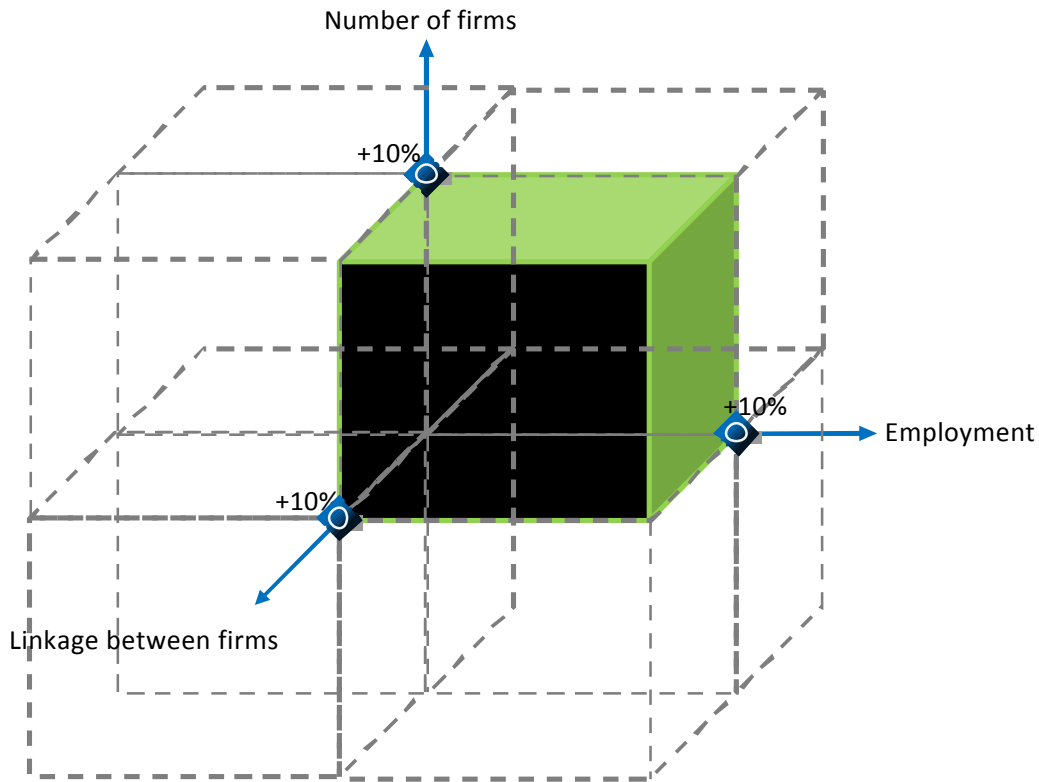
- ❖ **Number of firms** in the region within under-study sector. Identified cluster merely with this criterion can be said to have 'pure agglomeration' as its theoretical podium (Gordon and McCann, 2000).
- ❖ Relative **employment** (or production concentration) of region in comparison with nation. It is measured by 'Location Quotients' (Miller et al., 2001), however, without consideration of linkage between firms (Martin and Sunley, 2003, p. 20) and other (counties) neighbors (Carroll et al., 2008). Identified cluster merely with this criterion can be said to have 'pure agglomeration' as its theoretical podium, too (Gordon and McCann, 2000) [check Miller et al., 2001, Ch.3]
- ❖ The **linkages between firms** (Athiyaman and Parkan, 2008, p. 212) which can be expressed by both industrial dynamic perspective (?), i.e. supplier-buyer relations (Johansson and

²³ Functional region means local labor market, which has been identified up to 81 in Sweden (NUTEK, 1998)

Forslund, 2008, p. 49)²⁴, and sociological (or socio-economic?) perspective, i.e. social interaction, which has been noted by ‘innovative milieu’ literatures as the provider of trust among firms (Aydalot, 1986). Identified cluster with the former, which can be labeled hard relation, has ‘industrial complex’, while the latter one, which can be labeled soft relation, possesses ‘social network’ as the theoretical podium (Gordon and McCann, 2000).

While the first and second conditions have been already applied simultaneously in order to detect cluster (see Karlsson et al., 2006) in a more *demographic* sense, by adding up last condition, this dissertation wishes to enrich cluster identification discussions with *industrial dynamic* approach. The schematic of three necessary conditions for a functional region to be called a regional cluster (in a specific sector) is shown in the following figure:

Figure 3- Three necessary criteria for a functional region to be identified as a cluster



Note: If a functional region shows positive 10 percent residual for all three dimensions (regard to equation 1 to 3), then it is located in green area, i.e. it is qualified to be cluster.

Such three criteria for cluster identification must be measured in order to be applicable in empirical cluster detection. They will be measured by following three regression equations:

$$\ln Emp_r^i = a_1 + b_1 \ln Pop_r + \varepsilon_1 \quad (1)$$

$$\ln Pla_r^i = a_2 + b_2 \ln Pop_r + \varepsilon_2 \quad (2)$$

²⁴ They uttered such linkage as vertical and horizontal ‘knowledge spillover’.

$$\ln Lin^i_r = a_3 + b_3 \ln Pop_r + \varepsilon_3 \quad (3)$$

Where Emp^i_r is employment in sector i in region r , Pla^i_r is number of plants in sector i in region r , Pop_r is population in region r , Lin^i_r is overall linkage between firms in sector i in region r , \ln is the natural logarithm and ε is the error term. The residual are saved and for those cases where the residual is positive and above 10 percent for all three criteria, i.e. employment, plants, and linkage, for any given sector, then a regional cluster is identified (see Figure 3).

While number of firms and employment are obvious to measure, the proxy will be used for ‘linkage between firms’: Proxy for soft linkage is ‘the extent to which individual within different firms meet each’ other (Staber, 2010, p. 162)²⁵, while number of formal contract between supplier-buyer (vertical relation) as well as joint ventures (horizontal relation) are the proxy for hard relation.

6.2.2. What is cluster life cycle? (How to identify the development stage of a cluster)

It is crucial to track the life cycle of cluster, since not only *various behaviors of clustered firms*, e.g. innovativeness, are inherently varying along different stages of life cycle, therefore can be explained truly (in line with micro level) (Pouder and John, 1996, p. 1192; Bergman, 2008, p. 128), but also nature of *agglomeration effects* are highly to cluster life cycle (in line with macro level) (Iammarino and McCann, 2006, p. 1026).

Regard to the life cycle of cluster, this dissertation is in favor of stylized stage-wise manner of life cycle segmentation, i.e. birth, development, maturity, and ultimate stage (renaissance or lock-in). Such approach has been popular, undoubtedly, among researchers of field, as it is reviewed in *Appendix 2*. However, stylized stage-wise segmentation of life cycle does not mean that all clusters follow the unique and predetermined evolutionary path, rather various possible scenarios may happen even for a single cluster. Inspired by Menzel and Fornahl (2009), a cluster starting from left may follow one of the possible five paths illustrate in Figure 4. It may decline in early phase or reaches to ‘critical mass’ (Borras et al., 2005; Belussi et al., 2008) and consequently grows. Subsequent to maturity, it may either declines (lock-in) completely or experience renaissance by incrementally adapting to a changing environment, radically renewal by integrating new technology, or even totally transforms and

²⁵ This proxy can be measured by information, advice, and friendship (Staber, 2010, p. 162; Ibarra, 1995, p. 683-684)

moves into completely new fields²⁶. In fact, the development of the cluster is not a deterministic move from the left to the right, rather a steady oscillation between the left and right sides of the Figure 4, specifically regard to second, third, and forth scenarios.

Figure 4- Five possible scenarios addressing cluster evolutionary path over time

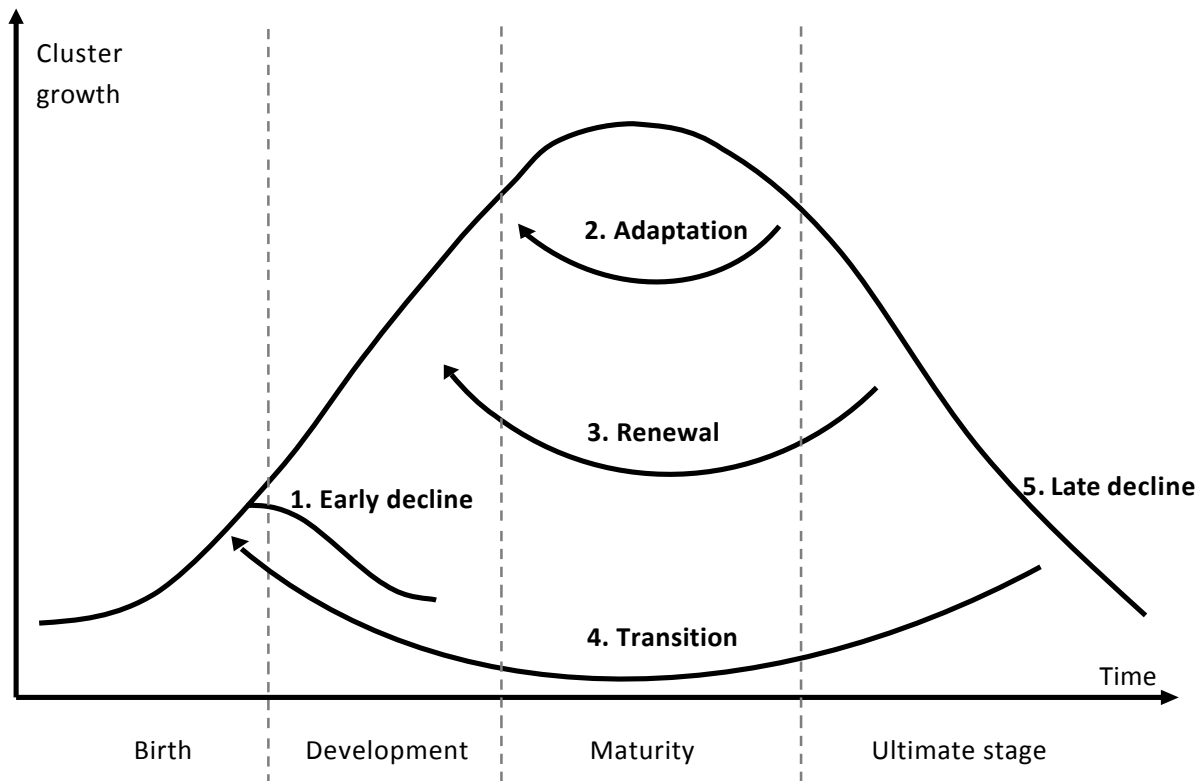


Illustration of such various paths for a cluster evolutionary, in fact, roots in path-dependency logic (Van Klink and De Langen, 2001), which is driven by several endogenous/exogenous factors (Klepper, 1996; Belussi and Sedita, 2009). A number of those factors, particularly related to firm's behavior, have been addressed in previous literatures from various perspectives to describe the evolutionary path of cluster, e.g. from industrial demography perspective, i.e. firm's entry/exit, (Van Klink and De Langen, 2001; Swann, 2002; Maggioni, 2005), value chain perspective, i.e. linkage between firms, (Van Klink and De Langen, 2001; Manzel and Fornahl, 2009), Locational cost/benefit (Swann, 2002; Maggioni, 2005; Belussi and Sedita, 2009), social capital perspective (Maskell and Kebir, 2005; Sölvell, 2008), demand (Bergman, 2008), and technological heterogeneity (Manzel and Fornahl, 2009). Moreover, it seems most of those aspects have roots to specific theories, as indicated in Table 1.

²⁶ For the empirical evident of each scenarios, see Manzel and Fornahl (2009, p. 15)

Table 1- Various perspectives in cluster evolution (based on firms' behavior) along cluster life cycle stages

Theories	<div>Stages</div> <div>Aspect</div>	Birth	Development	Maturity	Ultimate phase
Population ecology	Cluster dynamics	<ul style="list-style-type: none">Entrepreneur ignition (Söl)Few firms with lasting vision for new local technology path (M&F)	<ul style="list-style-type: none">Some entrants/no exits (k&L; P&J)Spin-offs (P&J)Cluster attracts people/firms (M&K)Increasing employment (M&F)Entry rate is highest (Sw)	<ul style="list-style-type: none">Few entrants/few exits (K&L)Stabilized entry (J&P)Some shake outs (Ber)Fixed employment rate (M&F)	<ul style="list-style-type: none">Few entrants/few exits (K&L)Entry of external MNCs (Bel)
Porter's diamond	Value chain	Scarce Customer-supplier relations (M&F)	<ul style="list-style-type: none">Value chain construction with different firms(up/down stream) (K&L)Increase in customer-supplier relations and specialized labor market (M&F)	Stable role of firms in value chain (K&L)	<ul style="list-style-type: none">Reorientation of role of firms in value chain(K&L)High rate of outsourcing to low-cost regions
Marshallian Agglom. econ.	Locational cost/benefit (Resource approach)	<ul style="list-style-type: none">Natural resource (Söl;Bel)Anchor firms (Söl;Bel)Ancient craft tradition (Söl;Bel)Agglomeration net benefit start to be positive (Mag)	<ul style="list-style-type: none">Agglomeration economies (P&J)Location cost is normal, but just started to grow (Sw)	<ul style="list-style-type: none">Diseconomies of agglomeration (J&P;Sw)Both average cost and average gross benefit equal to zero (Mag)Start of raise in congestion cost (Ber)	
GREMI / Social network model	Social capital	Potential for social capital and trust building (Ber)	<ul style="list-style-type: none">Networking/emerging social capital (Söl)Social capital, trust, and collaboration (M&K)	Strength of social capital (Söl)	
	Innovation rate (together with firm size)	Industry is highly (product) innovative and the small firms have the innovative advantage (A&F)	Industry is highly (product) innovative and the large firms have the innovative advantage (A&F)	Industry is lowly (product) innovative and the large firms have the innovative advantage (A&F)	Industry is lowly (product) innovative and the small firms have the innovative advantage (A&F)
	Demand	(minimal) demand for firms within region (Ber)	Demand growth (Söl;Bel)	<ul style="list-style-type: none">Supply faster than demand (Ber)Increase in production quantity and economies of scale	
	Techn. aspects	Large technological absorptive capacity (M&F)	Optimal focus on 'cluster dominant design' (shake out of firms in thematic border) (M&F)	Excessive narrow heterogeneity (M&F)	Low technological heterogeneity (M&F)

Note: The abbreviations refer to; Söl: Sölvell (2008), M&F: Manzel and Fornahl (2009), K&L: Klink and Langen (2001), P&J: Power and John (1996), M&K: Maskell and Kebir (2005), Sw: Swann (2002), J&P: John and Pouder (2006), Ber: Bergman (2008), Bel: Belussi and Sedita (2009), Mag: Maggioni (2005), A&F: Audretsch and Feldman (1996).

The fruitfulness of above table is twofold. First, it provides firm-related factors contributing to describe the cluster life cycle, which facilitate the of firm-level analysis of innovation. Second, and perhaps more important, it reveals the indicator(s) of each cluster stage, i.e. what is the signal of beginning of each stage, from various perspectives. The later allows the podium for creating the questionnaire in order to specify the stage of under empirical investigation cluster(s).

6. Papers

As outlined in part 3, this dissertation compromises six papers each of them dealing with one or several research question(s). First paper, dealing with notions of innovation and cluster (life cycle) respectively, is basically theoretical and seek to create the theoretical platform for empirical studies in subsequent papers, except paper 2 which is dealing with simulation technique for establishing the cluster life cycle.

Paper 3 to 5 will be devoted to go deeper in relation between elements of firm innovative behaviors in each stages of cluster life cycle, while each paper dealing with a distinct cluster life cycle stage, separately and empirically.

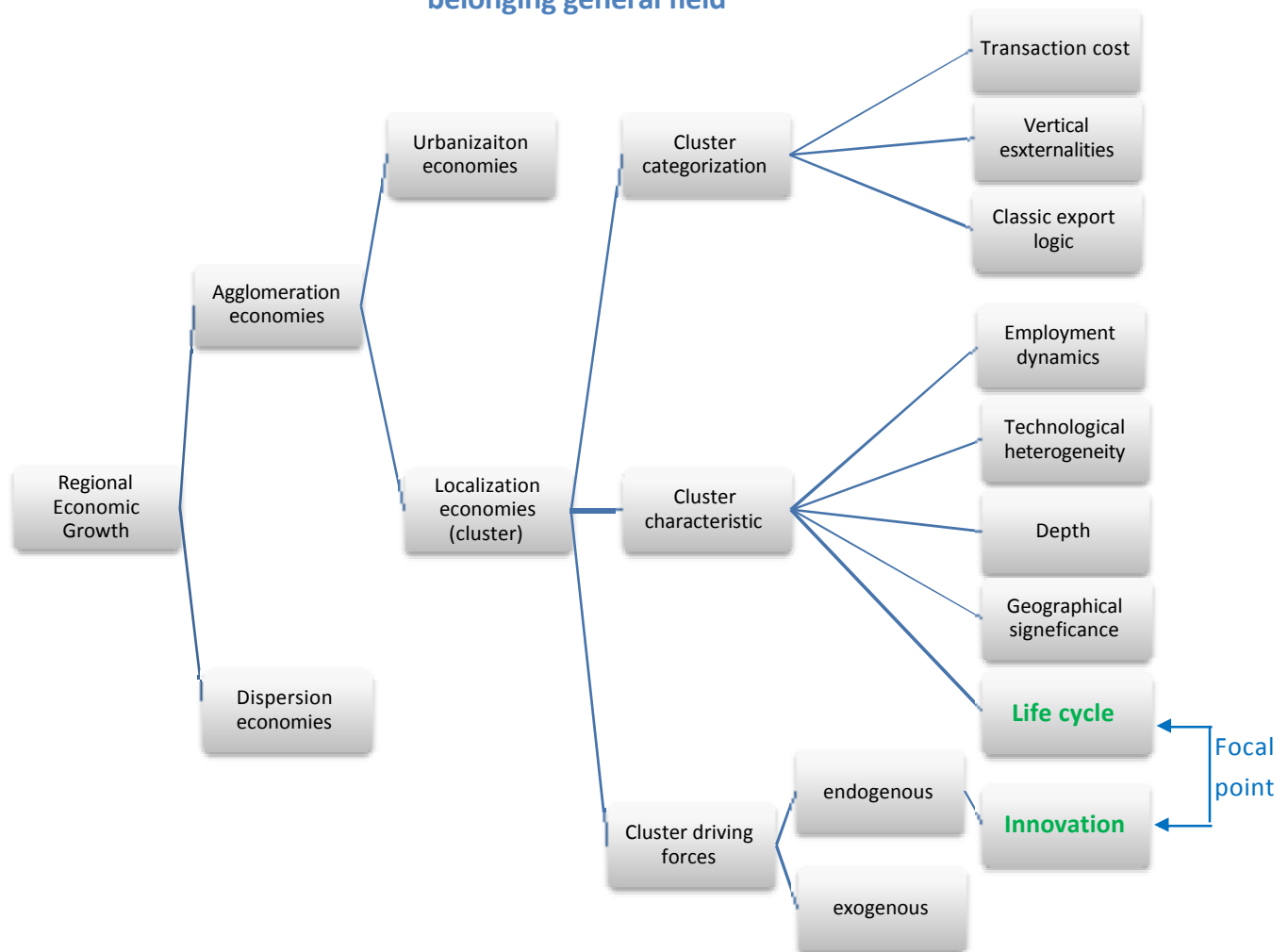
The last paper is somehow termination of all papers, in a sense that it applies outcomes of all previous paper in order to establish the relation between cluster life-cycle stage and cluster-firm innovative behaviors, in a holistic manner.

Furthermore, announcing recommendations for firms as well as policy makers to improve their contingency strategy for innovative behavior (along various stages of cluster life cycle) will be tackled in all empirical papers, i.e. paper 3 to 6.

Appendix 1- Research area of dissertation within its belonging general field

Regard to multi nature of this dissertation from analytical perspective (see part2.2), it is inconvenient to announce a single general field of research for focal point of this dissertation, nevertheless, it is possible to break down the general field of knowledge, i.e. regional economic growth, and position the focal point of this dissertation within its belonging general field, as depicted in following figure.

Figure5- Research area (focal knowledge frontier) of this dissertation positioned in its belonging general field



Starting from left, regional economic growth can be enhanced through economies of scales either by dispersion or agglomeration economies (Polenske, 2008). In addition, as Ohlin-Hoover classified originally, agglomeration economies can be addressed in two contexts of localization economies, known as clustering (Sölvell, 2008, p. 27), and urbanization economies (McCann, 2008, p.27; Eriksson et al., 2008)²⁷. Furthermore, clustering can be addressed in different aspects; ‘cluster categorization’ can be typified based on transaction cost (Iammarino and McCann, 2006), vertical

²⁷ In fact, Ohlin (1933) and Hoover (1937) mentioned also the third type of agglomeration economies, i.e. internal return to scale, which is not mentioned here because of brevity.

externalities (Johansson and Forslund, 2008), and classic export logic (Bergman, 2008), etc. ‘Cluster characteristics’ can be employment dynamics, depth, geographical significance (all mentioned by Miller et al., 2001), technological heterogeneity (Menzel and Fornahl, 2009), and cluster life cycle (Miller et al., 2001)²⁸. Finally, among endogenous or exogenous ‘driving forces’ for cluster development (see Belussi and Sedita, 2009), there have been clear emphases in endogenous factors in literature (Henry and Brown, 2006; Bergman, 2008), in which innovation of firms as a representative example²⁹ (see ‘theoretical framework’ for further elaboration).

Appendix 2- Literature review on cluster life cycle³⁰

Author	Stages	Remarks	Methodology (for life cycle segmentation)
Klink and Langen (2001)	Development, Maturation, Expansion, Transition	<ul style="list-style-type: none"> Cluster cycle that describes four different <i>stylized</i> cluster states and one <i>stylized</i> development path. The movement from one development state to another is influenced by contingent events and the ‘strategic agency’ of factors. 	Theoretical-tests case of shipbuilding cluster in northern Netherland
Pouder and John (1996)	Origination, Convergence, Reorientation /Failure	<ul style="list-style-type: none"> Various resource conditions, institutional processes, and management's mental models affect competitive behavior (and consequently) innovativeness of firms in each stage They adopted a very deterministic view that does not offer any chance of renewal and dynamic restructuring to many important high tech clusters based in the US (no renaissance) Cause and effect relation for innovation in each stage, rather than <i>measuring</i> it 	theoretical
Swann (2002)	Raise, fall, renaissance	Developing the mathematical models for firm’s entry and growth	empirical
Maggioni (2002, 2005)	Birth (take-off), golden age, maturity	<ul style="list-style-type: none"> From population ecology perspective Cluster modeling (mathematical) It is not talking about renaissance 	Theoretical/mathematical modeling of cluster growth rate (as function of time) and plotting it

²⁸ These cluster characteristics will be utilized in stratified sampling in empirical studies of paper 3 (see paper 3 in ‘papers’ part).

²⁹ Instead of talking about ‘driving forces’ to break down the field, one could argue that innovation is one of the ‘Critical Success Factors’ of a cluster (see Tavassoli and Tsagdis, forthcoming).

³⁰ As it is clear from Appendix 2, there is consensus on stylized stage-wise segmentation among researchers (despite various methodologies for segmentation).

Maskell and Kebir (2006)	Existence, expansion, exhaustion	<ul style="list-style-type: none"> Investigating each phase from 3 theoretical foundations, i.e. Marshallian local spillovers, Porterian nation's competitiveness, and GREMI's innovative milieu 	theoretical
Sölvell (2008)	Hero phase, growth, maturity, decline/ renaissance	<ul style="list-style-type: none"> Noted the concept of different evolutionary pattern for clusters, i.e. path-dependency (p.42) 	Theoretical/ describing evolutionary pattern of cluster
Belussi and Sedita (2009)	formation, development, maturity, decline/ renewal	<ul style="list-style-type: none"> They claim that instead of a standardized life cycle, Italian IDs follow a multiple growth pattern in their development. However, they still use the stylized life cycle, i.e. formation, development, etc., and path-dependency concept is related to triggering factors 	Meta-analysis of 12 Italian ID
Menzel and Fornahl (2009)	Emergence, growth, sustainment, decline	<ul style="list-style-type: none"> Perceiving the number of employee and (more importantly) degree of firm's technological heterogeneity as two driving force of cluster life cycle model 	theoretical

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