Disentangling Clusters

Agglomeration and Proximity Effects

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To my parents

PREFACE

This report is the result of a research project that was initiated at the Institute of International Business and concluded at the Center for Strategy and Competitiveness at the Economic Research Institute at the Stockholm School of Economics.

This volume is submitted as a doctor's thesis at the Stockholm School of Economics. In keeping with the policies of the Economic Research Institute, the author has been entirely free to conduct and present his research in the manner of his choosing as an expression of his own ideas.

The Center is grateful for the financial support provided by NUTEK (now Tillväxtverket, Swedish Agency for Economic and Regional Growth), VINNOVA (Swedish Governmental Agency for Innovation Systems), the European Commission's Directorate General for Enterprise and Industry, and the Torsten and Ragnar Söderberg Foundations.

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Acknowledgements

When I joined SSE many years ago to study clusters, I was not aware of the destination of the journey upon which I had just embarked. What started as a cluster mapping exercise turned into a global survey of cluster organisations, and somehow—several years and one European Cluster Observatory later—this dissertation materialised.

None of this would have been possible without the marvellous support I received from my dissertation committee. Örjan Sölvell has been my main tutor throughout the entire process, and no one deserves more appreciation than he does for making these years fun, exciting, and educational. I cannot imagine what the process would have been like without his unfailing enthusiasm and ever-helpful generosity. Thanks to him, I could avoid many of the pitfalls and problems that can so easily cloud the work with a dissertation, and instead enjoy what is truly fun and exciting about research. To Stefan Johnsson, I owe many thanks for his encouraging support and helpful pointers at critical junctions of this project, and I am grateful to Henrik Glimsted for providing alternative perspectives and many corridor discussions that always stimulated new thoughts.

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Until a few months before the completion of this dissertation, my academic home was at the Institute of International Business (IIB), which was recently dissolved. For all the great seminars, the countless fun lunches, and for providing a stimulating and exciting research environment in general, I would like to thank fellow IIBers Anna D., Anna K.-K., Bow, Carl, Christian, Christina, Ciara, Claes, Dominik, Elena, Emre, Henrik, Ivo, Jesper, Kerstin, Kjell, Lars, Laurence, Lena W., Lena Z., Lin, Malin, Patrick, Peter, Robin, Sergey, Sergiy, Stefan, Udo, Vanja, and Örjan. In particular, I would like to thank Claes, Jesper, and Sergiy for the fun work and Ciara, Laurence, and Lin for the work fun.

During an early phase of the project, I was grateful to be part of the Centre for Research on Innovation and Industrial Dynamis (CIND) at Uppsala University, where Prof. Anders Malmberg and the CIND faculty lent a friendly hand in introducing me to the wondrous world of economic geography and cartography. Later, I had the good fortune to visit the Institute for Strategy and Competitiveness (ISC) at Harvard Business School, where I was given the opportunity to more fully develop some of the thoughts that I now present in this dissertation. ISC has also generously provided data and methodological support essential for parts of the analysis. I am grateful to Prof. Michael Porter, Mercedes Delgado, and Richard Bryden for their help in making this possible.

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When writing a dissertation, one might go through a phase when one relies heavily on the encouragement and hospitality of others to maintain some measure of social life outside research. For me, that period lasted roughly five years, and I cannot thank my family and friends enough for their care and friendship.

Stockholm
May 4th, 2009

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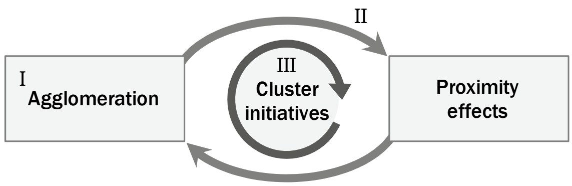
Introduction

Agglomeration is one of the most strikingly obvious features of economy. Even casual observation reveals that economic activity does not have an even geographical distribution. It shows a staggering condensation in some areas and remarkable scarcity in others.

This dissertation deals with a particular kind of agglomeration, namely, that of related industries, or clusters. I will argue that the study of clusters can benefit from a clear distinction between two different concepts. The first is *agglomeration*, by which I mean high spatial densities of economic activity. The second is *proximity effects*, which I define as phenomena that affect economic activity in a way that depends on spatial distance. Agglomeration and proximity effects are different things, but they are closely related to each other in a circle of mutual reinforcement: agglomeration strengthens proximity effects, and proximity effects increase agglomeration.

In recent decades, clusters have become a prominent framework for economic policy. Numerous cluster initiatives all over the world aim at supporting and enhancing the dynamics of clusters. Together with agglomeration and proximity effects, cluster initiatives form the components of the basic model on which this dissertation is struc-

Figure 1. The basic model of this dissertation



tured. Based on this model, I pose three fundamental questions about clusters (see Figure 1):

I. How should cluster agglomeration be measured?

II. What are the economic benefits of cluster agglomeration?

III. How are cluster agglomerations and cluster effects organised through cluster initiatives?

The three research questions are addressed in seven studies. Two of these have been published in academic journals, and two have been published in the present or similar forms as reports from Uppsala University and Stockholm School of Economics (see Table 1).

Table 1. List of dissertation studies

	Research question	*Issue*	*Publications*
Study 1	I	New measures of concentration and localisation	
Study 2	I	Cluster mapping of Sweden	Published by CIND (2003, in Swedish) and CSC (2008, in English)
Study 3	I	Industry concentration in Europe and USA	
Study 4	II	Clusters and entrepreneurship	Accepted for publication in Small Business Economics (2008)
Study 5	II	Clusters, innovation and regional prosperity	
Study 6	III	Activities of cluster organisations	Based on a report published by CSC (2006)
Study 7	III	Cognitive perceptions in cluster organisations	Published by European Planning Studies (2007)

In the remainder of this introduction, I will expand further on the model and develop the research questions.

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Agglomerations and proximity effects

For well over a century, scholars have studied the phenomenon of agglomeration of economic activity and the mechanisms behind it. Agglomeration occurs across different *geographic* scales: from areas within cities, such as the dense shopping streets of Stockholm, to across continents, like the vast urban corridor that stretches from Liverpool to Milan. Agglomeration also occurs across different *industry* scales. On the one hand, groups of highly specialised activities are concentrated in some locations, like the map and antique print dealers in London's West End, or the TFT-LCD manufacturers of southern Taiwan. On the other hand, economic activity in general is also concentrated in some locations, such as in vast cities like Shanghai or Los Angeles. In fact, there is ever-increasing concentration of economic activity in cities, and it is now estimated that more than half of the world's population lives in cities (NCSU, 2007).

The phenomenon of agglomeration is by no means new. In 1890, Alfred Marshall (1920/1890) noted the concentration of chair makers in Buckinghamshire and the predominance of the cutlery trade in Sheffield. Even long before then, some industries were known to be particularly strong in certain places, such as the watchmakers of Geneva and the shipbuilders of Venice.

History also shows that agglomerations can be remarkably persistent. An industry can remain strong in a particular location for centuries, and cities can remain dominant within their countries or continents for several centuries or even millennia. Amsterdam's history as a centre for publishing dates back to the mid-17th century. In China, Luoyang was a major city for more than a millennium, and Xi'an (formerly Chang'an) has a history dating back more than 3000 years, during which the city served as a capital across ten different dynasties. Certainly, cities as well as industry centres rise and decline, but those processes can often be slow and drawn out.

Although agglomeration is widespread, it does not affect all types of economic activity in the same way. Some industries are strongly condensed, while other are much more dispersed. Banks gather in the financial districts of large cities, while hairdressers spread out proportionally with population and wheat farmers tend to locate far away from city agglomerations.

Along with the observation that agglomeration exists comes questions about why it exists. What factors and forces bring these condensations about and, more importantly, what sustains them? A range of theories has been proposed to account for agglomeration, and because it is a spatial phenomenon, these theories all rely on *effects of proximity* in one way or another. Things that affect all places equally could not account for agglomeration, but effects that are stronger at shorter distances could.

Alfred Marshall is usually credited with presenting the first theory of the mechanisms behind *industry agglomeration*, i.e., the agglomeration of a particular industry. He suggested that the co-location of business resources could produce proximity effects that he termed "external economies" (Marshall, 1920, p. 221). Marshall proposed four such external economies that induce agglomeration: transfer of skills and inventions between colleagues, competitors and generations; the growth of subsidiary industries supplying the core industry with specialised inputs and services; scale advantages in the shared use of specialised machinery; and a local labour market for specialised skills. [1,2] For *general agglomeration*, i.e., agglomeration of economic activity in general, Jane Jacobs (1969), proposed that proximity of several businesses in different activity fields gives rise to new types of businesses, and that this in turn accounts for economic growth in cities. We shall return to these theories—and others that have been proposed—later in the discussion. For now, let us con-

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[1] Although this section by Marshall is referenced frequently, interpretations of it vary considerably. While Marshall lists *four* sources of external economies, they are usually summarised as *three*. For example, Duranton and Puga classify them as "arising from labour-market interactions, from linkages between intermediate- and final-goods suppliers, and from knowledge spillovers, loosely following the three main examples provided by Marshall" (Duranton & Puga, 2004, p. 2066). And what Marshall describes as reduced costs for specialised machinery and increased supply of subsidiary goods and services, Krugman (1991, p. 37) categorises as "provision of non-traded inputs".

[2] It is important to note that the argument Marshall makes is for *industrial concentration*, that is, the advantage of having several related firms in one location. He does not argue that *regional specialisation* would be beneficial, that is, that a location would benefit from being dominated by only a few industries. On the contrary, he claims that it is important to have industries that can mitigate each other's periods of depression, and that are supplementary and do not compete for the same type of labour.

clude that the fundamental assumption has been that if agglomerations exist there must be some set of proximity-dependent effects, which serve to make them grow and sustain them.[3] Different types of agglomeration can be accounted for by different types of proximity effects.

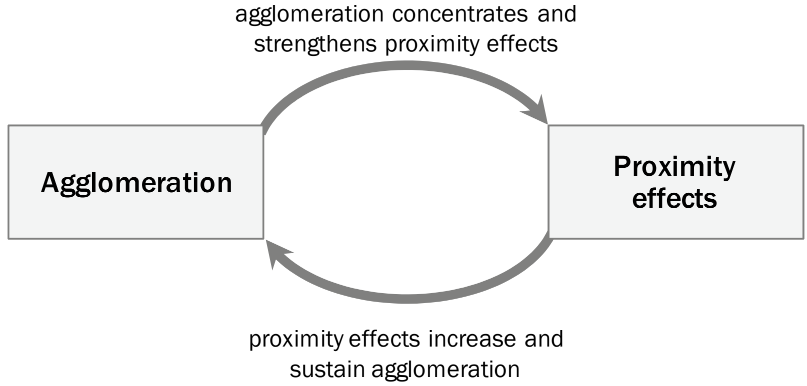
We therefore have two different concepts with which to contend. First, there is *agglomeration*, which we can define as *high spatial densities of economic activity*. The spatial range of these high densities and the delimitation of the type of economic activity are left out of the definition, and can be changed from case to case: they merely represent different types of agglomeration. Second, there are *proximity effects*, which we can define as *phenomena that affect economic activity in a way that depends on spatial distance*. The nature of these effects is something we leave open, as is the question of whether the effects are beneficial or adverse for economic activity: they represent different types of proximity effects.

Agglomeration and proximity effects are two separate entities, but the fundamental assumption is that they can mutually reinforce each other in what one could call "circular and cumulative causation", to use the term of Myrdal, Wicksell and others before them (O'Hara, 2008). This concept is illustrated in Figure 2.

Agglomeration enhances proximity effects through a very straightforward—one could even argue trivial—mechanism. Consider for example the labour-pooling effect. If supply and demand of labour with some specialised skill increases in a particular location, matching between employers and employees will likely improve. The larger the pool of employees, the more likely is it that an employer can find someone with the particular subset of skills that is needed for a particular job. Conversely, an employee will find it easier to find a role in which to make use of a more specialised competence in an area populated by a greater number of potential employers. Therefore, the employee has greater incentives to develop her skills and is less likely to hold on to a job below her level of competence. If one firm is reduc-

[3] The mechanisms that initially *bring about* the agglomeration need not necessarily be the same set of mechanisms that *sustain* agglomeration. For instance, Marshall suggests that the "seeds" of agglomeration could be historically accidental, such as the location of a court, or based on the location of some natural resource, such as a mine. Once an initial agglomeration is in place, proximity effects can kick in and increase it. Distinguishing further between these two agglomeration processes is a task that falls outside the scope of this dissertation

Figure 2. The mutually reinforcing relationship between agglomeration and proximity effects



ing staff, the surplus labour force is more likely to be able to find employment where their skills are appreciated if a greater number of firms are nearby to approach.[4] Increased numbers of firms in one location therefore enhances labour mobility, promotes skill development, and improves the use of available skills. The same applies to other proximity effects, such as close access to subsidiary industries and local knowledge spillovers. Any effect that depends on geographical proximity of two firms will multiply as more firms agglomerate in one location.[5]

Conversely, proximity effects also produce agglomeration, but in a somewhat more indirect manner. If proximity provides economic benefits, this can produce agglomeration through one of several mechanisms. One mechanism involves *growth and survival.* Positive

[4] Among empirical studies, Power and Lundmark (2004) found that for Stockholm's highly concentrated ICT cluster, labour mobility was significantly higher within a cluster than within the rest of the urban economy. The authors suggest that this workplace mobility could be a main channel for knowledge spillovers, as opposed to spontaneous meetings and accidental face-to-face encounters of a more social nature, as suggested for instance by Marshall's notion of knowledge being ”in the air”. (Marshall, 1920, p. 225)

[5] This applies to positive proximity effects as well as negative, so that when we observe low or decreasing degrees of agglomeration, we can consider this an effect of negative or decreasing proximity effects. For instance, Norcliffe and Zweerman Bartschat (1994) suggest that ”locational avoidance” lies behind the urban-rural shift, in a process geared to avoid high labour costs in metropolitan areas and, at a later stage, reduce the risk of losing skilled labour.

proximity effects could translate to increased growth or increased survival of agglomerated firms, which would in the long run lead to increased agglomeration. The other mechanism involves *attraction*. External economies that enhance the performance or survival of a firm would provide incentives for new firms to locate (or for established firms to re-locate) to agglomerated areas where these economies are strongest, an outcome that would, again, lead to increased agglomeration. Either of these mechanisms connects some form of economic benefit (enhanced performance or survival) with agglomeration.

There is, however, a third type of mechanism that has been proposed by Sorensen and Audia (2000), which would not necessarily be based on economic benefits. If *entrepreneurial entry rates* are enhanced through proximity effects, this could result in agglomeration even without any corresponding economic benefits. It is possible to imagine a scenario in which some form of proximity effect leads to increased entrepreneurship, which in turn produces ever-increasing numbers of new firms, but that these firms are not particularly profitable or survive very long. The agglomeration, despite its poor performance and low survival rates, would be maintained solely by the influx of new entrepreneurs. Sorensen and Audia propose that this combination of high entry rates and poor performance could be a mechanism behind industry agglomeration. If so, the link between agglomeration and economic benefits, which has been assumed since the days of Marshall, would not necessarily hold true, and industry agglomerations would not necessarily represent something socially desirable. We shall return to this interesting hypothesis below.

Agglomeration and proximity effects are so intimately interconnected that it can be tempting to view them as one and the same, or as two sides of the same phenomenon. However, I believe this is a problematic view, and possibly one that has played a role in causing much of the confusion that surrounds the study of clusters. Proximity effects, such as external economies of scale or scope, are independent of agglomeration, and should be treated as such. Proximity effects occur whenever more than one firm (or more than one establishment, or more than one employee, depending on the organisational level at which the effect operates) is present in one location. They operate in densely populated locations as well as in sparsely populated ones. The difference is that by their very nature, they become *stronger* the higher the degree of agglomeration exists, but a high level of agglomeration is not a *prerequisite* for them. Conversely, an agglomeration is an agglomeration regardless of the effects that sustain it. A clump of firms co-located by pure chance is an agglomeration, as is a group of firms struggling to survive in an environment with severe external diseconomies. Proximity effects are not a precondition for agglomeration.

Industrial districts, regional innovation systems, and urban innovation [6]

We will now return to the wealth of theories that have developed relating to agglomeration, which in turn will lead us to the concept of clusters.

From the 1940s to the 1970s, economic geography was conspicuously absent in mainstream economic theory. Krugman (1995) attributes this neglect to the shift in economics toward mathematically rigorous modelling. Until the arrival of the Dixit-Stiglitz model of monopolistic competition, it was impossible to incorporate scale economies, and so external economies simply had to be ignored.

However, in the 1980s and 1990s, agglomeration once again attracted considerable scholarly attention. In economics, "new economic geography" and "new trade theory" evolved new models for conceptualising the ways in which economies of scale could give rise to international and interregional trade. In economic geography, agglomeration became a subject of study with a particular focus on knowledge transfer. New theories addressing this topic were developed, and empirical studies were subsequently carried out to validate them.[7]

One group of theories focused on the agglomeration of individual industries or vertically integrated buyer-supplier networks. For scholars working on this question, the agglomerations in northern Italy were of particular interest (Pyke, Becattini, & Sengenberger, 1990). This type of agglomeration, termed *industrial districting*, is characterised by a high concentration of firms in a geographically minute area that often fit a narrow specialisation profile. Industrial

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[6] Not covered in this section, but of great importance, are the location theories proposed by von Thünen (1826) and further developed by Weber (1909/1929). This group of theories explains the location of industries by using transportation costs rather than external economies, and one might say that they are theories of location rather than co-location. Study 1 suggests that von Thünen-type effects are highly relevant for the degree of urbanisation of industries.
[7] For an overview see Malmberg, Sölvell and Zander (1996).

districts are dominated by small and medium-sized enterprises that tend to be strongly embedded in their local environment, and Becattini defines the industrial district as "a socio-territorial entity which is characterised by the active presence of both a community of people and a population of firms in one naturally and historically bounded area." (Becattini, 1990, p. 38) The flexible specialisations and small-batch production capabilities of these small firms have been seen as a post-Fordist alternative to the large-scale, vertically integrated corporations that came to dominate Western economies after WWII. (Piore & Sabel, 1984)

Another group of theories consider the agglomeration of industrial activity in general, rather than specific industries. Jacobs (1969) proposes that all innovation occurs in cities, where there are great numbers of people and firms representing different types of knowledge.[8] Cities allow division of labour, and when work is combined in novel ways, innovation occurs. Innovation is therefore enhanced by the co-location of a multitude of activities in different sectors. Florida has a similar perspective, but emphasises the importance of what he terms the creative class, which is comprised of people who "engage in work whose function is to create meaningful new forms" (Florida, 2005, p. 34). Florida estimates that the creative class constitutes about 30% of the US workforce. They gradually migrate to *creative centres*, attracted by living conditions that include high-quality experiences and openness to diversity.

The concept of *regional innovation systems* (Asheim & Gertler, 2003) focuses particularly on the processes that generate innovation. Like national innovation systems (Lundvall, Johnson, Andersen, & Dalum, 2002), regional innovation systems have a systemic approach to innovation and are based on the ways in which different types of actors (such as firms, research organisations, and public agencies)

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[8] Jacobs suggests that while an innovation occurs and is initially exploited in cities, use of that innovation can then be transplanted to non-city locations. She gives a radical example of this, as she proposes that agriculture and animal husbandry originally evolved in cities as subsidiary activities to trade, and only later became rural activities. A contemporary example is Hamra Gård, a large farm that happens to be located in what is an exceptionally urban location on the outskirts of Stockholm. It is, however, not only a commercial dairy and crops farm, but has since 1894 served as a test and demonstration plant owned and operated by DeLaval, the world's leading supplier of milking equipment. This case suggests that the development of agricultural machinery, even if used in a highly rural industry, is an urban matter.

interact to develop new knowledge and new competences. In addition, the regional innovation system concept focuses on what happens in a regional milieu that can be referred to as a learning region. In particular, tacit knowledge (Polanyi, 1958), which can be challenging to articulate and codify, is difficult to transfer over long distances because of its context-specific nature. It therefore plays a key part in determining how users and producers of innovations engage in two-way interaction. The regional innovation system is "the institutional infrastructure supporting innovation within the production structure of a region" (Asheim & Gertler, 2003, p. 299).

The cluster concept

In 1990, Michael Porter published *The Competitive Advantage of Nations*. In this book, he suggested that there was a need for a new paradigm for international trade. Comparative advantages in factor endowments, as proposed by the Heckscher-Ohlin model of trade, could not explain why such a large share of trade occurs between countries that are similar in factor endowments.[9] The explanation, he suggested, is that the competitiveness of firms in a country depends on four determinants in their environment, as summarised in the so-called diamond model.

In summary, the diamond model comprises the following four components. *Factor conditions* represent the position in factors of production, such as skilled labour or infrastructure. The model stresses the importance of upgrading existing resources, rather than resource endowments. It also points to the possibility that selective factor disadvantages can contribute to long-term competitiveness, because they force firms to compensate for the disadvantage. *Demand conditions* build competitive advantage when the "home" market offers particularly sophisticated or demanding customers, or when local demand anticipates demand trends in other locations. *Firm strategy, structure, and rivalry* reflect how firms can enter and exit an industry, how individual firms choose to compete with each other, and how the industry as a whole is structured. Management styles tend to vary from one location to another, and this can give rise to advantages for

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[9] Staffan Burenstam Linder in his SSE dissertation (1961) proposed that similar demand structures combined with demand for differentiated goods would lead to national specialisation and could therefore account for trade between countries with identical factor endowments.

specific industry sectors. Local rivalry is particularly important for promoting, upgrading, and enhancing competitiveness. *Related and supporting industries*, finally, emphasises the fact that industries gain competitive advantage partly through the presence and strength of other industries that not only supply them with goods and services, but also serve as a source of innovation.

These four determinants interact and often reinforce one another. For example, if a nation has a strong position in related industries, there may be a larger supply of qualified engineers in the relevant field, which translates to stronger factor conditions. In addition, government intervention and chance events can also influence the determinants.

The main purpose of *The Competitive Advantage of Nations* was to explain differences on a *national* level, and trade was used as the main indicator of competitiveness. However, Porter also noted that clusters of competitive industries often tend to be agglomerated on a *sub-national* level.

> The systemic nature of the "diamond" promotes the *clustering* of a nation's competitive industries. A nation's successful industries are usually linked through vertical (buyer/supplier) and horizontal (common customers, technology, channels, etc.) relationships. (Porter, 1990, p. 149, emphasis in original)

> Competitors in many internationally successful industries, and often entire clusters of industries, are often located in a single town or region within a nation. (*ibid.*, p. 154)

> Geographic concentration of firms in internationally successful industries often occurs, because the influence of the individual determinants in the "diamond" and their mutual reinforcement are heightened by close geographic proximity within a nation. (*ibid.*, p. 157)

So Porter's initial definition of the term "cluster" was a group of competitive industries within a nation, and agglomeration on a sub-national level was viewed as an additional factor that could further strengthen competitiveness. In Porter's later writing, however, the sub-national agglomeration aspect of clusters is more prominent. Also, the definition is extended to include not only companies, but also other types of organisations and institutions, such as universities, government agencies, etc. It is clear, however, that companies still constitute the core of the cluster, and that other types of organisations are ancillary.

> A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by communalities and complementarities. (Porter, 1998, p. 199)

The key aspect that sets Porter's clusters apart from other types of agglomerations, such as Marshall's industrial districts or Jacob's cities, is the fact that they are constituted by groups of industries. Porter stresses repeatedly the fact that clusters are something broader and more far-reaching than individual industries.

> More than single industries, clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, as well as providers of specialized infrastructure. Clusters also often extend downstream to channels or customers and laterally to manufacturers of complementary products or companies related by skills, technologies, or common inputs. (Porter, 2000a, p.16-17)

While Marshall notes the presence of subsidiary industries (primarily providers of machinery and specialised inputs), he sees them as a potential driving force behind industry concentration, i.e., an external economy, rather than a defining part of the industry agglomeration itself. Marshall's subsidiary industries surround the agglomeration; they do not constitute it. Jacobs, as well, notices how industries promote innovation and growth between and amongst each other. However, Jacobs does not stress the relatedness of industries (which she refers to as "work"). On the contrary, she points to the ways in which new industries evolve from unrelated industries.

> The point is that when new work is added to older work, the addition often cuts ruthlessly across categories of work, no matter how one may analyze the categories. Only in stagnant economies does work stay docilely within given categories. (Jacobs, 1969, p. 62)

Thus, Porter's view on agglomeration takes an intermediate position between those offered by Marshall and Jacobs. While Marshall considers the agglomeration of a core industry, supported by some vertically integrated subsidiary industries, and Jacobs considers the variety of any industries colocated in a city, Porter focuses on groups of related industries. Despite the shifts over time in Porter's exact definition of clusters, the multi-industry dimension has remained unchanged. Indeed, this constitutes more than an important trait of clusters; I would argue that it is in fact the single defining characteristic that sets clusters apart from other agglomeration concepts.

Porter proposes several proximity effects that enhance the performance of cluster agglomerations. To a large extent, these proposals are similar to those presented by Marshall and Jacobs. He argues for Marshallian labour pooling, local access to specialised suppliers, and knowledge spillovers. He also highlights, similarly to Jacobs, the ways in which a mix of collocated industries can give rise to innovation. In making this argument, Porter does not introduce an idea that is essentially new. What is new, however, is his continuing focus on competition. The cluster concept was originally defined in terms of groups of competitive industries, and rivalry and competition comprise one of the four parts of the diamond model. Porter repeatedly stresses the importance of rivalry in creating cluster dynamics and, conversely, emphasises that our understanding of how firms build and sustain competitive advantage becomes clearer when geography and agglomeration are taken into account (Porter & Sölvell, 1998).

Like Marshall and Jacobs, Porter does not postulate *a priori* a geographical scope for agglomeration. The relevant range, he argues, depends on the reach of the proximity effects that he proposes are involved in the process.

> The geographic scope of clusters ranges from a region, a state, or even a single city to span nearby or neighbouring countries (e.g., southern Germany and German-speaking Switzerland). The geographic scope of a cluster relates to the distance over which informational, transactional, incentive, and other efficiencies occur. (Porter, 2000a, p. 16)

So, to summarise the argument up to this point, there are different forms of agglomerations, spanning different spatial ranges and different industry ranges. Among these, cluster agglomeration is unique in that it spans multiple related industries. There are also a large number of proximity effects, which influence economic activity in a way that depends on spatial distance. These proximity effects take several different forms, and they operate across different spatial and industry ranges. (See Table 2.) Agglomerations and proximity effects mutually reinforce one another, giving rise to the persistent agglomerations we can observe empirically.

Table 2. Agglomerations and proximity effects: dimensions and examples

Agglomerations	*Proximity effects*
Spatial ranges:	Types of effects:
trans-national	Externalities
national	e.g., congestion (negative)
regional	External economies of scale
metropolitan	e.g., infrastructure utilisation
etc.	External economies of scope
Industry ranges:	e.g., knowledge spillovers
general (all economic activity)	Distance-dependent costs
clusters (related industries)	e.g., transportation costs
industry (single industries)	Spatial ranges
	Industry ranges

Thus far, we have seen how agglomeration and proximity effects relate to each other, and how the cluster concept fits into this model. We will not turn to how the cluster concept has been applied as a framework for economic policy and regional economic development.

Clusters and policy and cluster organisations

While the policy implications of economic geography have remained largely ignored by policymakers, the contributions of geographic economists have had a considerable impact (Martin & Sunley, 2003). Porter argues that the multi-industry range of the cluster concept makes it particularly suitable as a framework for economic policy.

> Why view economies using the lens of clusters instead of, or in addition to, more traditional groupings such as companies, industries, SIC codes, and sectors (e.g., manufacturing, services)? The most important reason is that the cluster as a unit of analysis is better aligned with the nature of competition and appropriate roles of government. Clusters, broader than traditional industry categorization, capture important linkages, complementarities, and spillovers in terms of technology, skills, information, marketing, and customer needs that cut across firms and industries. These externalities create a possible rationale for collective action and a role for government. (Porter, 2000a, p. 18)

In particular, the cluster concept has been influential in a recent wave of regional economic development policies. Clusters have emerged as a core concept in an array of recently enacted initiatives and measures.

> The globalisation-localisation nexus described above indicates that as economic activity globalises, the nature of local economies has become more important to the development process. As a result, there has been increased interest in policies to support clusters. In the last decade, dozens of regions, states, provinces, cities, and local communities have instituted development plans based on clusters. [...] In addition, multilateral organisations, such as the OECD, UNIDO, the World Bank, UNCTAD, the European Commission, and others are assessing and using cluster strategies as tools for regional and local development. (OECD, 2000, p. 13)

So influential has the cluster concept become that critics have labelled it "a world-wide fad":

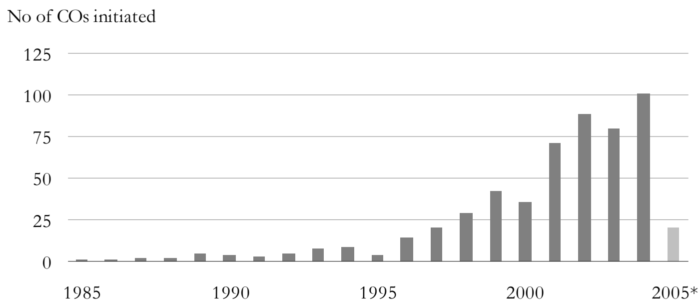
> From the OECD and the World Bank, to national governments [...], to regional development agencies [...], to local and city governments [...], policy-makers at all levels have become eager to promote local business clusters. Nor has this policy interest been confined to the advanced economies: cluster policies are also being adopted enthusiastically in an expanding array of developing countries [...]. Clusters, it seems, have become a world-wide fad, a sort of academic and policy fashion item. (Martin & Sunley, 2003, p. 6)

All of these cluster policy initiatives have in turn resulted in the formation of a large number of local or regional public-private partnerships aimed at developing and supporting clusters.

> Active clustering may require a new form of cluster-wide, dynamic self-help organisation. It is often easiest to start afresh with a new form of governance, a more concentrated spatial focus and a "cluster" rather than "industry" reach. Once operational, a new organisation can be folded into established structures. Such organisations require committed leadership, active participation from the relevant members of the public and private sectors, and a dedicated secretariat to take care of ongoing activities. (OECD, 2000, p. 26)

An inventory of cluster organisations worldwide was conducted as preparations for the Global Cluster Initiative Survey 2005 (Ketels, Lindqvist, & Sölvell, 2006). 1400 cluster organisations were identified, and the initiation year of 545 of these are shown in Figure 3. The data suggest there has been a surge in the formation of cluster organisations from 1996 on.

Figure 3. Initiation year of cluster organisations



* Numbers for 2005 are incomplete, since the survey was carried out in spring 2005.

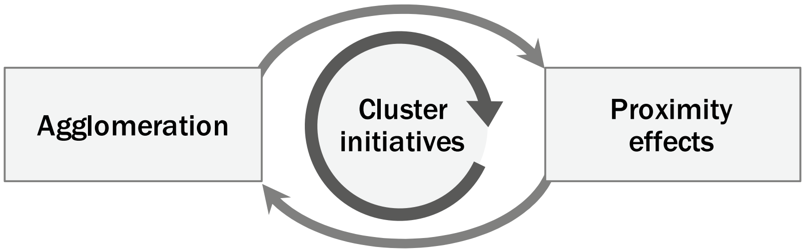
The common aim of cluster initiatives[10] is to enhance the economic benefits of clusters. Through organised efforts, they attempt to improve the growth or the competitiveness of a cluster, by reinforcing the feedback circle of agglomeration and proximity effects. Some focus on the link *agglomeration → proximity effects*, and try to improve economic performance by supporting the most agglomerated sectors of the economy. Some focus on the link *proximity effects → agglomeration*, and try to increase the number of firms and jobs by improving the external conditions for them. In both cases, cluster initiatives are about reinforcing the links between agglomeration and proximity effects. With the advent of cluster initiatives, we can therefore add a third component to our model, as shown in Figure 4.

Research questions

This dissertation deals with three main questions. The first has to do with the nature of agglomeration and, more specifically, how best to measure it.

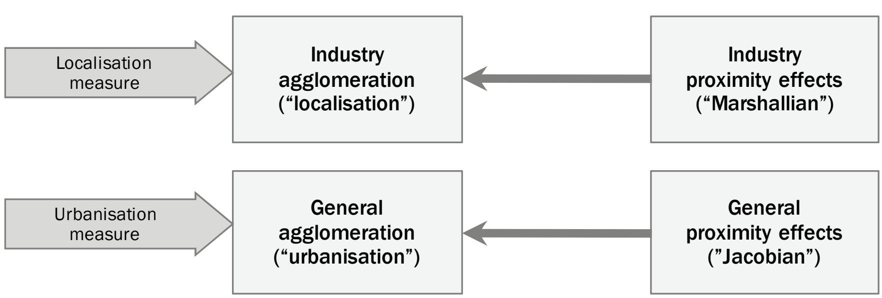
[10] The terms "cluster initiative" and "cluster organisation" are closely related, and in my previous research I have often used them interchangeably. More recently, I have made a more clear distinction between the two. Cluster initiative refers to the process of cluster-related actions, while cluster organisation refers to the organisational entities that these processes can give rise to. In a typical case, a cluster initiative includes the establishment of one or several cluster organisations. High-level cluster actions, such as a national policy for innovation promotion through cluster support, can be referred to as "cluster programmes".

Figure 4. Cluster initiatives as enhancers of agglomeration and proximity effects



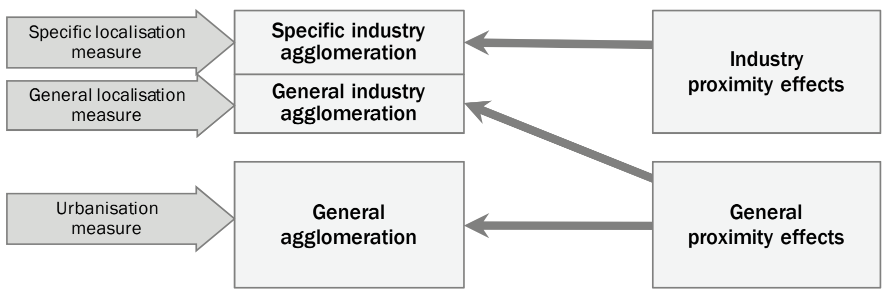
Industry agglomeration and general agglomeration have long been considered fundamentally separate phenomena (Hoover, 1936). Industry agglomeration is usually referred to as *localisation*, and is typically measured as, and in some cases even defined as, the degree of disproportionality in the distribution of an industry compared to a reference distribution, which is usually the manufacturing sector or the total population. General agglomeration usually goes under the name *urbanisation*, and can also be measured as population density. Underlying these two types of agglomeration are industry proximity effects and general proximity effects. The former, often referred to as *Marshallian*, occur when firms in the same industry are in close proximity to each other. The latter, termed Jacobian, tend to occur when firms in different industries are proximate. The assumption has been that the relationship between agglomerations and proximity effects is uncomplicated: one type of proximity effect has been assumed to be associated with one type of agglomeration. Hence, by measuring one, we get an indicator of the other. (See Figure 5.)

Figure 5. Pairwise relationships between proximity effects and agglomerations



However, although general proximity effects are *driven by* the proximity to economic activity in general, that does not imply that they *affect* all industries equally. If they affect some industries more than others, they can actually give rise to industry agglomeration. If, for example, an industry is particularly strongly affected by generally proximity effects, so that it benefits strongly from localising in urban locations, it will not only become urban, but it will also become localised. (This may seem surprising, but is a simple effect explained in Study 1.) This means that the relationships between proximity effects and agglomeration are more complicated. Industry agglomeration (localisation) can be the result of industry proximity effects, which we can label *specific industry agglomeration*, as well as general proximity effects, which we can label *general industry agglomeration*. Usual localisation measures will not distinguish between these. We need agglomeration measures that can discriminate between the two sources of industry agglomeration. (See Figure 6.)

Figure 6. How general proximity effects produce industry agglomeration



To illustrate, let us a consider universities (or "tertiary education" as they are called in industry statistics.) Universities are highly agglomerated, and they are also highly urban. In fact, half of their agglomeration with other universities derives from their tendency to colocate with *anyone*. So their *total* industry agglomeration is constituted by a strong *general* industry agglomeration and an equally strong *specific* industry agglomeration. Were we to measure only total industry agglomeration, it would considerably overestimate the tendency of universities to localise specifically with other universities: universities agglomerate partly simply because they are urban.

This measurement problem impacts what has been the subject of a vigorous debate over the last decade, namely, the relative strengths of Marshallian and Jacobian effects (Beaudry & Schiffauerova, 2009). **Study 1** deals with this particular problem, proposes a method for measuring urbanisation and localisation separately, and presents results from Swedish data.

The industry dimension of agglomeration is equally problematic. Central to the cluster concept is the fact that it involves groups of related industries. Martin and Sunley point to the methodological problems of such relatedness:

> At what level of industrial aggregation should a cluster be defined, and what range of related or associated industries and activities should be included? How strong do the linkages between firms have to be? (Martin & Sunley, 2003, p. 10)

The typical approach to this problem is to use the structure of industry classification systems. Such systems group industries in a hierarchical way, so that each category is divided into sub-categories, which in turn are divided into further sub-categories, and so on. Top-level categories are denoted with a single-digit number or letter, second-level categories with a two-digit number, and so on.

The majority of studies that have tested Marshallian effects group industries on the 1-digit or 2-digit level, in such a way that generates groups with a fairly broad variety of activities. However, the fact that two industries fall into the same category in a classification system does not necessarily mean that they are related in the Marshallian sense. For instance, in the NACE rev. 1.1 system, class 35 manufacture of other transport equipment includes manufacturing of boats (35.1), locomotives (35.2), aircraft and spacecraft (35.3), motorbikes and bicycles (35.4), and invalid carriages (35.5). Apart from the fact that they are all vehicles, these groups may not be particularly related to each other technically or otherwise. Building and repair of boats and ships (35.1) may be more related to sea and coastal water transport (61.1) and cargo handling and storage (63.1) than with other vehicles. Using an existing and often arbitrary classification system as a basis for determining relatedness is therefore problematic.

A more precise way to establish relatedness is to use actual observed co-location patterns. Industries that display a tendency to co-locate with each other are then assumed to be related. This method produces industry groupings irrespective of industry classification and sector categories, allowing for a less restrictive method of constructing cluster groups. Cluster mappings that have applied this method have been conducted in the US (Porter, 2003) and Canada (Institute for Competitiveness and Prosperity, 2002) but prior to **Study 2** of this dissertation, the model had not yet been applied in Europe. From a methodological perspective, as a test of co-location based analysis of agglomeration, it would therefore be of interest to replicate the study in order to determine whether agglomeration patterns could be identified in Swedish data using groupings of related industries that were developed with US data.[11]

Beyond its methodological interest, the prospect of comparing agglomeration patterns in the US with Europe also has bearing on a more fundamental issue, namely, whether the degree of industry agglomeration is higher in the US than in Europe. Krugman (1991) found, using a rather crude analytical method, that US regions were more specialised than European nations. The reason, he suggested, was that trade barriers had long been higher within Europe than within the US. As transportation costs fell, economies of scale and externalities produced increased localisation in the US. In Europe, this trend was hampered by tariffs, differences in regulation, and other policies that discriminate in favour of local production. As an indicator of what Europe would look like if trade barriers continue to come down, data from the US can be used to help indicate whether we should expect increasing or decreasing industry concentration in Europe.

Since 1991, a handful of studies have addressed this particular issue, but they have all suffered from the same methodological problems that Krugman encountered in 1991, namely, the challenges of 1) finding detailed European data below the national level and US data below the state level, 2) disaggregating data into relevant and comparable industry groups, and 3) devising a method for making a consolidated comparison between the two continents. In general, the studies have confirmed Krugman's conclusion, but the methodological shortcomings are nevertheless unsatisfactory. New and improved

[11] The method developed in Study 2, which was first published in Swedish in 2003 (Lindqvist, Malmberg, & Sölvell, 2003), was then applied to a study of the ten new EU member countries (Ketels et al., 2006), and then to 32 European countries for the European Cluster Observatory.

data and measures allow us to revisit the issue once again and to undertake analyses with greater distinctness and discernment. **Study 3** performs such an analysis.

The second main research question of this dissertation concerns the link from agglomerations to proximity effects. As I mentioned earlier, proximity effects are conceived as a mechanism to drive agglomeration. It is therefore in the nature of proximity effects that they are enhanced by agglomeration or, put differently, that they are space-dependent and stronger in proximity than across distance. Much research has been devoted to examine these hypothesised effects (see Rosenthal & Strange, 2004 for an overview).

Of particular interest are the strategy implications of agglomeration. Agglomeration is an outcome, a symptom one might say, of the economic benefits that arise from co-location. As I mentioned earlier, for agglomeration to arise from proximity effects, we need an adaptation mechanism through which decision-makers perceive some benefit from establishing and expanding a firm in a dense location and act upon it, or an evolutionary mechanism through which firms in dense locations multiply and grow more quickly than those in other locations, or a combination of both.

If adaptation is the main cause of agglomeration, this means that locational factors *do* play a significant role in this process for managers. If, conversely, evolution is the main cause of agglomeration, this does not preclude that location factors *could* play a significant role in managerial decision-making. Either way, if we have reason to believe that agglomeration influences the performance of firms, then agglomeration has an important role to play in strategy research. Surprisingly, this topic has not been afforded a great deal of focus in the strategy literature. After two decades of research primarily among economic geographers and geographic economists, there is hardly any trace of the concept of clusters in mainstream strategy research.

Is agglomeration justifiably overlooked in strategy? If the assumed connection between agglomeration and economic benefits that I have discussed above does not exist, then strategy does not need to concern itself with clusters or other forms of agglomeration. Interestingly, a suggestion for a mechanism that could produce agglomeration even in the absence of economic benefits has been proposed by Sorensen and Audia (2000). They suggest that cognitive and social effects in a location with a high concentration of an industry can cause *hyper-entrepreneurship*[12], that is, increased rates of entrepreneurial entry can be caused by increased access to resources that are needed to start a firm combined with exaggerated expectations of success. These expectations are fuelled by asymmetrical distribution of information: a few successful ventures get more attention than many failures, building up to something resembling a permanent gold rush without the gold. Sorensen and Audia find support for this effect in a study of the US shoe industry in the period 1940-1989. They note that failure rates were higher in more concentrated regions, as were founding rates.

> "[W]e conclude that variation in the structure of entrepreneurial opportunities, rather than variation in the economics of production and distribution, maintains geographic concentration in the shoe industry. This finding suggests that geographic concentration can continue to characterize industries even when the underlying economic equilibrium no longer justifies such a spatial distribution." (Sorenson & Audia, 2000, p. 427)

However, Sorensen and Audia note that the study covers only the shoe industry, where both the rate of innovation and the importance of human capital are low. They call for further research, particularly "to investigate whether a high-technology industry, such as computer hardware or biotechnology, operates according to the same principles." This plea in turn forms the basis for our next research question. From a strategy perspective, the higher founding rates in clusters are not problematic. Higher firm mortality and diminished performance, however, are. If new firms experience worse rates of survival and performance the higher the surrounding agglomeration is, the presumed connection between agglomeration and economic benefits does not necessarily hold. **Study 4** examines this issue in greater detail.

If research on firm-level effects of clusters is somewhat scarce, region-level studies are relatively plentiful. This is undoubtedly in no

[12] I define hyper-entrepreneurship as increased entry rates combined with decreased survival rates. Sorensen and Audia do not use the term hyper-entrepreneurship. Florida and Kenney (1991) uses the term to denote the "continuing proliferation of small high-technology firms which lack the resources and the scale to be globally competitive", but since then it has, according to Google Scholar, only been used once in Journal of Law-Medicine.

small part due to the greater accessibility of region-level statistics, which can be used for agglomeration studies.

As mentioned earlier, the question of whether Marshallian or Jacobian effects are strongest has sparked a long series of studies (Boshuizen, Geurts, & van der Veen, 2009; Paci & Usai, 1999; van der Panne & van Beers, 2006, and many others) aimed at disentangling the two effects. The results, however, have been largely inconclusive (Beaudry & Schiffauerova, 2009).

While Marshall primarily describes mechanisms that promote economic performance of firms and Jacobs focuses on the mechanisms behind the growth of new industries, the two theories have a common ground in that they both make predictions regarding innovation. Marshall suggests that a high concentration of an industry in a particular location promotes innovation,[13] while Jacobs suggests that it is the presence of varied industries that generate "new work", i.e., produce innovation that leads to new divisions of labour and new occurrences of industries.

> [E]ach kind of new work … [is] added logically and "naturally" to a specific bit of older work. This is how innovations are made in our own time. … This process is of the essence in understanding cities, because cities are places where adding new work to older work proceeds vigorously. (Jacobs, 1969, p. 50)

However, innovation has an input side and an output side. It does not only come about spontaneously (or "naturally" as Jacobs put it) but it is also the result of dedicated investments in research and development. Public and private R&D activities have become an important driver of innovation, which means that R&D has become an important intermediate factor in innovation.

Research on innovation in clusters has often tried to disentangle Marshallian and Jacobian effects, but the intermediate effect of R&D has not been included in such studies. For a better understanding of how agglomeration (Marshallian concentration as well as Jacobian urbanisation) affects innovation, it would be useful to include R&D in the analysis and determine how it is affected by agglomeration. This is what we will do in **Study 5**.

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[13] Marshallian effects are commonly referred to as regional specialisation effects, although industry concentration and regional specialisation are not necessarily connected. (Aiginger & Davies, 2004)

The third main research question of this dissertation is how cluster initiatives operate in order to "organise" cluster agglomerations and cluster effects. Most research on cluster organisations has been based on either single cases or a small number of cases. To allow an analysis across varying industries and political settings, large-scale surveys can provide valuable insights. **Study 6** represents a preliminary attempt in this direction. It reports results from a global survey aimed at several hundred cluster organisations around the globe. It attempts to determine which activities cluster organisations perform in practice, and how these activities relate to performance. It also tests empirically some hypotheses about factors that have been claimed to be important for the performance of cluster organisations.

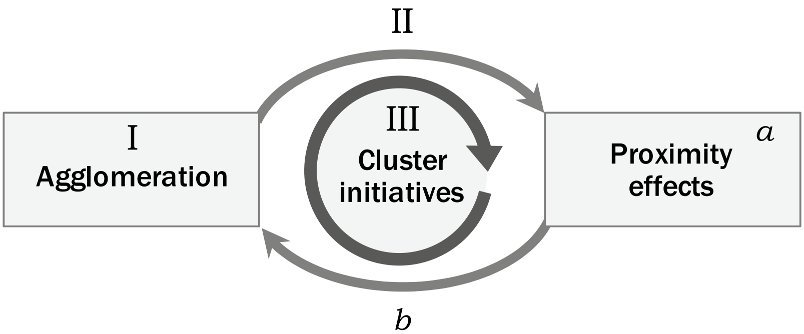
Finally, when the cluster concept is used as a framework for policy initiatives, a *cognitive* aspect becomes important. For cluster organisations, it matters how people involved in the organisation perceive the cluster. The cluster organisation involves individuals with widely varying backgrounds who represent different stakeholders in the cluster, and this introduces the possibility that they have systematically differing views about what the organisation should do and why. Organisation literature on decision-making groups comprising diverse members (e.g., Maznevski, 1994) suggest that diversity can present obstacles to smoothly functioning interaction processes.

Cluster organisations are public-private partnerships, which means that they will involve people from both the private and the public sector. With their differing backgrounds, it is possible that they perceive the cluster with which they are working in different ways and therefore prefer different objectives for the cluster organisation. This social aspect of clusters has received little attention in the existing cluster literature, but it comprises the focus of **Study 7**.

The three main research questions and corresponding papers are illustrated in Figure 7.

Two research areas fall outside the focus of this dissertation. The extensive literature on proximity effects (marked *a* in Figure 7) are reviewed in Study 4 and Study 5. The issue of the mechanisms connecting proximity effects to agglomeration (marked *b* in Figure 7) is a matter of distinguishing between two different types of processes through which firms react to their environment. According to Hannan and Freeman (1977), there are two main views of how organisations relate to their environment, and external economies can produce agglomeration according to either view. The *adaptation perspective* pre-

Figure 7. The dissertation's main research questions



Research question	*Study 1*	*Study 2*	*Study 3*	*Study 4*	*Study 5*	*Study 6*	*Study 7*
I. How should cluster agglomeration be measured?	×	×	×				
II. What are the economic benefits of cluster agglomeration?				×	×		
III. How are cluster agglomerations and cluster effects organised through cluster initiatives?						×	×

sumes that organisations scan the environment, formulate strategies depending on the threats and opportunities they observe, and adjust their organizational structure according to this strategy. From this perspective, external economies can cause agglomeration if organisations are able to recognise the mechanisms directly, such as concluding that locating in close proximity to larger numbers of suppliers should be beneficial, or if they are able to observe the effects of the externalities, such as noting that firms in a particular region are particularly successful and that locating in that region might be a wise decision. Alternatively, the strategic response could be to entice other firms to relocate to the same location as oneself.

Another view is the *population ecology* perspective. According to this, patterns evolve over time in populations of organisations. Organisations are to some degree structurally inert and thus can find it difficult to adapt to changes in the environment. Those that cannot adapt face a larger risk of failing. Birth rates and mortality rates for different types of organisations in the population will therefore determine, through competition and selection, which organisational characteristics will grow to dominate the population. If we apply this perspective to localisation, it means that the number of firms in locations where external economies provide beneficial conditions with time will outgrow the number of firms in locations were external economies are weaker. Populations will gradually agglomerate in locations with strong external economies. Even a marginal advantage in one location – brought about by random co-location of a few firms, or the presence of some natural resource, or for whatever other reason – can generate a dramatic agglomeration if given enough time.

Although the question of which of these two mechanisms, management decisions or population effects, is at work under what conditions is a fascinating one, it falls outside of the scope of this dissertation.

◊ ◊ ◊

We will now turn to the discussion section of this summary chapter. The first part of the discussion concerns agglomeration and how to measure it. I will address a prominent theme in the literature, which is the debate on how clusters are defined. From there I turn to the drawbacks of disproportionality measures, and in particular their limitations in distinguishing between agglomeration driven by different types of proximity effect. As an alternative, I suggest new ways of using Ripley's K function, in the form of the proposed Q function, and I will highlight some useful interpretations of it.

Measures of cluster agglomeration

The range controversy

The cluster concept has frequently been critiqued for being definitionally vague (Asheim, Cooke, & Martin, 2006; Martin & Sunley, 2003). In particular, a major point of contention has been the fact that Porter's initial definition of clusters only mentioned regional agglomeration as an additional enhancer of cluster dynamics. The critics therefore assume that agglomeration is a late addition to the concept, suggesting that Porter initially overlooked it but somewhat disingenuously snuck it into the 1998 definition.

> Hence, what originally started out as a way of decomposing a national economy, the competitive diamond as a group of interlinked industries and associated activities has *become a spatial entity*, the clusters as a *geographically localized* grouping of interlinked firms. (Asheim, Cooke, & Martin, 2006, p. 10, emphasis added)

I believe this critique is unfounded. It ignores a simple fact that should not be unfamiliar to any economic geographer, namely, that nations (in the economics sense of the word) are spatial entities. They may be as small as Luxemburg or as large as Russia, but they *are* spatial. Therefore, when Porter in 1990 sets out to find competitive firms, he identifies agglomerations on a national level. With exports as his main indicator of competitiveness, it is not surprising that sub-national regions (for which trade statistics are rarely available) play a secondary role. Nevertheless, from the very beginning, Porter's definition is one of spatial agglomeration, be it national or other.[14]

It is true, however, that the spatial range of clusters is wide, both in Porter's definitions of the concept, as well in the definitions set forth by other researchers. However, unlike Porter's critics, I cannot see that this absence of scale is a "comfort blanket of universality" that "stretches the definition to the limits of credulity" (ibid., p. 12).

First, the lack of exact distance limitations is not specific for Porterian clusters. There is no accepted definition of the appropriate size of a Marshallian industrial district, nor of a Jacobian city. Nevertheless, in the case of clusters, this lack has been presented as a serious flaw.

> The obvious problem raised by these cluster definitions is the lack of clear boundaries, both industrial and geographical. … Although throughout his work on clusters Porter emphasizes the critical role of 'geographical proximity' in the formation, performance and identification of clusters, the term is never defined with any precision. Indeed, it appears to be highly and ridiculously elastic, for he suggests in fact that clusters can be found at almost any level of spatial aggregation … To make matters worse, 'the appropriate definition of a cluster can differ in different locations, depending on the segments in which the member companies compete and the strategies they employ'. … [T]o use the term to refer to any spatial scale is stretching the concept to the limits of credulity, and assumes that 'cluster-

[14] It should also be noted that many of the cases that Porter present are highly local.

> ing processes' are scale-independent. If the same externalities and networks that typify clusters do indeed operate at a whole variety of spatial scales, this surely weakens the empirical and analytical significance of the cluster concept. (Martin & Sunley, 2003, p. 10-12)

Second, the assumption that the lack of a range definition implies that the proximity effects would be "scale independent" and that the same set of effects would operate at "a whole variety of spatial scales" seems unnecessarily restrictive. Rather, what we should expect (and subject to empirical testing) is that clusters are affected by several different proximity effects with different ranges, and that for different clusters different proximity effects are the most influential. It is reasonable to assume that labour-pooling effects can operate over different ranges than vertical buyer-supplier linkages. In addition, it is reasonable to assume that buyer-supplier linkages for automotive manufacturing operate over different ranges for automotive manufacturers than for oil companies or violinmakers.

Keeping geographical range out of the definition of cluster agglomerations is, I would argue, critical for the phenomenon to be possible to research in a meaningful manner. I base that conclusion on the premise that agglomeration and proximity effects are separate entities, and that the connection between them is a matter of theoretical conjecture to be empirically tested. If we were, for example, to define clusters as groups of related industries that are agglomerated within a distance of 5 kilometres, this would preclude, by definition, any effect that would bring about agglomeration of related industries over distances of 25 kilometres. Such proximity effects (and such agglomerations) would have to be classified as a non-cluster type. In addition, the same effect, when active over short distances, would give rise to clusters, but when active over longer ranges, it would not. These artificial delimitations would serve only to make an integrated study of cluster agglomeration impossible. Instead, it is the task for empirical research to establish which types of proximity effects drive cluster agglomeration over which ranges, and these are likely to vary considerably from case to case.

The problem of mixed definitions

Critics of the cluster concept have been barking up the wrong tree, so to speak. The problem with cluster definitions is not their lack of geographical range limitations; rather, the problem lies in the fact that

Table 3. Different interpretations of the cluster concept

1 Co-location	Shallow ↓	Easy to measure ↑
2 Co-location and technological proximity		
3 Input/output table complementarities		
4 Co-location and superior performance		
5 Marshallian externalities		
6 Network firms		
7 Labour mobility		
8 Explicit collaboration		
9 Informal knowledge spillovers	Rich	Hard to measure

Source: (Swann, 2006, p. 257). Numbering added.

they combine agglomeration and proximity effects. Swann (2006) provides a good illustration of this mix. He illustrates different interpretations of the cluster concept as a spectrum ranging from easy to measure but "shallow" interpretations, to "rich" but hard to measure interpretations (see Table 3).

What Swann perceives as a spectrum of definition is actually a combination of two different dimensions. Interpretations 1–3 are definitions of agglomeration, with varying restrictions for industry relatedness. 4 is a mix of agglomeration and a proximity effect, or rather, the economic outcome of proximity effects in the form of superior performance, while 6–9 are proximity effects. What Swann notices but fails quite to pin down is that problems arise when the phenomena of agglomeration and proximity effects are combined.

This problem has been present in the cluster literature from the very beginning, when Porter defined clusters as nationally agglomerated groups of related industries *that are particularly competitive*. He did not merely suggest that agglomeration of related industries could give rise to particularly competitive firms; he *defined* clusters as competitive. If we apply Porter's 1990 definition strictly, uncompetitive clusters cannot exist, because if they are not competitive, they are not clusters. In this way, Porter thus, unintentionally I would believe, made the phenomenon for which he was arguing tautologically true, creating a circular argument: competitiveness is promoted by clusters; clusters are defined as competitive. [15,16] This mistake is rectified in the 1998 definition, which is an agglomeration-based definition. However, others have continued to produce a long list of similar mixed definitions, several examples of which follow.

Rosenfeld presents several definitions that include different types of proximity effects:

> A business cluster, we agreed, is a "geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue, that share specialized infrastructure, labour markets and services, and that are faced with common opportunities and threats". (Rosenfeld, 1995b, p. 15)

> A cluster is a loose, geographically bounded agglomeration of similar, related firms that together are able to achieve synergy. (Rosenfeld, 1995a, p.12)

Brenner has a definition that specifies a causal relationship. With this definition, we cannot identify a cluster unless the causes behind it are known:

> A local industrial cluster is an industrial agglomeration that is caused by local self-augmenting processes. (Brenner, 2005, p. 14)

An example of a definition where agglomeration is absent, or possibly implicit, comes from Roelandt and den Hertog. Here, the types of proximity effects at play are restricted to production chain linkages, while other effects are excluded:

> networks of production of strongly interdependent firms (including specialised suppliers) linked to each other in a value-adding production chain. (Roelandt & den Hertog, 1999, p. 9)

Bergman and Feser similarly leave the agglomeration aspect implicit, but focus on the ways in which competitiveness depends on the cluster:

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[15] Compare the circular definitions in the resource-based view of the firm, where competitive advantage is proposed to stem from firm resources, and firm resources are defined as anything that contributes to competitive strategies. (Barney, 1991)

[16] One could also argue that Jacobs offers a circular argument about cities. A "city", which she argues is the main source of economic growth, is defined as a "settlement that consistently generates its economic growth from its own local economy". (Jacobs, 1969, p. 262)

> An industry cluster may be defined very generally as a group of business enterprises and non-business organisations for whom membership within the group is an important element of each member firm's individual competitiveness. (Bergman & Feser, 1999, section 2.1)

I have no objection to any of these *descriptions* of clusters. They capture many of the intricate effects that connect cluster agglomeration with the proximity effects that are associated with enhanced performance and competitiveness. My objection is that these relationships are postulated in the *definition* of clusters. Instead of a coherent phenomenon to formulate theories about and explore empirically, they create a quagmire of partially overlapping but mutually excluding definitions, each focusing of one particular set of hypothesised proximity effects. Proponents of knowledge spillover effects will insist that no true cluster can exist unless there is evidence of knowledge spillovers. Value-chain proponents will claim that any genuine cluster must be connected through input-output relations. Labour market specialists will explain that real clusters are delimited by the flow of labour, and so on and so on.

This, I believe, is the root of much of the confusion that permeates cluster research. It is as if the phenomenon of global warming were to be defined in terms of *specific causes* (e.g. "shifts in temperature caused by human CO_2 emissions") instead of as a type of *temperature measure* (e.g. "a global, rapid increase of temperature").

Geographical and industry ranges – empirical approaches

The best way to handle clusters, then, is to focus on the concept's key contribution, which lies in addressing agglomeration on an industrial scale that is wider than industries, but more narrow than all economic activity or broad sectors like "manufacturing". The exact industrial range is a matter of choice depending on the purpose of the particular study, just as cities are sometimes best viewed as city centres and in other cases as metropolitan areas.

There are two ways of determining which industries should be considered to be related. One way is to determine which industries are related to each other in terms of some selected proximity effect, and then test empirically whether those industries tend to form cluster agglomerations. For example, one can choose shared technology as the key driver behind relatedness. Neffke and Svensson Henning (2008) measure it by calculating the frequency of products from different industries being produced in the same plants. This way of determining relatedness works well if one wants to examine a particular proximity effect and how it is related to agglomeration.

Another approach is to begin on the agglomeration side and determine which industries tend to co-locate with each other. Then, one can test empirically whether these agglomerations give rise to proximity effects. This is the approach selected by Porter (2003), and it has the benefit of not assuming which proximity effect is the relevant one. Rather, it treats agglomeration of multiple industries as revealed relatedness, an indicator of unspecified proximity effects.

For geographic scope, similar empirical approaches can be applied. For example, it is possible to measure the distance over which pairs of industries are most strongly co-located (Marcon & Puech, 2003). This gives an indicator of the distance where aggregated proximity effects are the strongest.

The approach of using agglomeration patterns as indicators of revealed relatedness between industries has been applied in Papers 2–5 of this dissertation. The results suggest that the method is viable outside of the North American context where it was initially developed. However, further insights can be gained from studies applying revealed relatedness based on European co-location patterns. This is a promising area for future research.

Distinguishing between different sources of industry agglomeration

In a study of Nordic manufacturing, Malmberg and Maskell (1997) notice a puzzling fact. Although manufacturing in Nordic countries (as in other places) has become more dispersed in the post-war period, individual manufacturing industries have become more concentrated. They argue that the dispersion of manufacturing as a whole reflects diseconomies of urbanisation, while concentration of individual industries is the result of economies of concentration. While there is no reason to doubt their conclusions, there is reason to consider more closely whether the measures they apply can correctly capture the effects they discuss. Their study, and many like it, makes some assumptions about the connections between measured agglomeration and the underlying external economies that do not hold up under scrutiny.

The first problem concerns the relationship between urbanisation and concentration. Malmberg and Maskell, as many others, use a

Table 4. Two different scenarios of dispersion

	Total population	Scenario 1		Scenario 2	
		$manuf_{before}$	$manuf_{after}$	$manuf_{before}$	$manuf_{after}$
Region 1	50	15	5		10
Region 2	25	10	10	15	10
Region 3	15		10	10	5
Region 4	10				
Region 5	10				
$Gini_{abs}$		0.64	0.48	0.64	0.48
$Gini_{rel}$		0.63	0.59	0.61	0.49

Gini measure to assess how dispersed the manufacturing sector is as a whole. This method is appropriate; Gini is indeed a measure of dispersion. However, they then draw the conclusion that an increase in dispersion is an indication of a shift from metropolitan to non-metropolitan areas. This could certainly be the case, but it is not necessarily so. A simple example, shown in Table 4, will illustrate this point.

Let us imagine a country with five regions. Region 1 is the most urban, and regions 4 and 5 are the least urban. In each region, some share of the population is engaged in manufacturing. In scenario 1, manufacturing relocates from a single metropolitan region to two regions that are more rural. Both an absolute and a relative Gini would pick this up as dispersion, causing Gini values to decrease. Consider now instead scenario 2, where manufacturing is initially concentrated within non-metropolitan regions but later disperses to a more metropolitan region. This scenario, too, will produce both absolute and relative decreasing Gini values. In other words, decreasing Gini values can be associated with dispersion into metropolitan as well as non-metropolitan regions.

Obviously, the problem here is that Gini only reflects dispersion, and cannot make any distinction that indicates whether dispersion occurs towards more urban or more rural regions. Even relative Gini cannot make this distinction. The same goes for other disproportionality measures, such as Krugman, Theil, and Generalised Entropy: they only measure *deviations from a proportional distribution.* The conclusion is that disproportionality measures cannot capture accurately processes of urbanisation or ruralisation of industries.

The second problem is more insidious. Malmberg and Maskell (1997) note that relative Gini values for individual industries have increased and draw the conclusion that this could be an indication of intra-industry agglomeration forces. They point out that industry concentration—as opposed to spatial concentration—can confound results and as such, the relative size of plants must be taken into consideration (Ellison & Glaeser, 1997). However, the fact that ruralisation of an industry can in and of itself bring about increased localisation is not acknowledged. As we see in the five-island example at the beginning of Study 1, the degree of urbanisation can influence the degree of concentration. In other words, if an industry becomes more localised, it might be a result solely of it becoming more rural (or more urban).

Again, the problem is that proportionality measures cannot distinguish effects in urban regions from effects in rural regions. They can tell whether an industry becomes more localised, but the question of whether this trend is due to intra-industry externalities or urbanisation externalities is not clear. This is not a minor methodological problem; rather, it goes to the very root of our ability to separate two fundamental phenomena.

The solution to the problem is to substitute proportionality measures with measures that can account for urbanisation and concentration separately. Such a measure, termed the *Q*-function (which is derived from Ripley's *K*-function), is presented in Study 1.

Separating localisation and urbanisation depends upon two important insights. The first is that both effects exert different impacts on different industries. That localisation varies by industry is generally accepted, but the possibility that urbanisation varies from industry to industry is rarely taken into account, although it has been considered in the past. For example, Hoover (1936) shows how the Gini measure (or Lorenz curve) can be used to measure urbanisation as well as localisation. The idea of a joint measure that captures both effects is therefore nothing new.[17]

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[17] Hoover points out that Ohlin (1933, p. 209) distinguishes between ”active” industries, which localise due to some local resource and thus drive population size, and ”passive” industries, which localise close to markets, and thus adjust themselves to the population distribution. However, this dichotomy fails to capture the difference between urban agglomeration (such as for commercial banks) and proportional distribution (such as hairdressers).

Table 5. Absolute and relative Gini values of four hypothetical industry distributions

	Total population	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*
Region 1	50	5			
Region 2	25	5	5		
Region 3	15		5	5	
Region 4	10			5	5
Region 5	10				5
$Gini_{abs}$		0.60	0.60	0.60	0.60
$Gini_{rel}$		0.67	0.65	0.64	0.60

Note: Four scenarios with the same agglomeration (two regions with 5 each) shifted gradually from more urban (scenario 1) to more rural regions (scenario 4). Note how, counter-intuitively, the relative Gini value decreases.

The second insight is that urbanisation confounds localisation. Duranton and Overman (2005) note that localisation should be considered as industry concentration over and above the general tendency to agglomerate. However, their suggestion to deal with this problem is to use relative concentration measures (using total manufacturing as the baseline) instead of absolute ones.

> "This measure must also control for the general tendency of manufacturing to agglomerate. For instance in the United States (U.S.), even in the absence of any tendency towards localization, we would expect any typical industry to have more employment in California than in Montana. This is simply because the former has a population more than 30 times as large as the latter." (ibid., p. 1078)

On an intuitive level, this approach would seem valid. What Duranton and Overman suggest is that a relative measure will discount urban agglomeration and afford more weight to agglomeration that occurs in rural regions. However, because the Gini measure is designed to measure not agglomeration but disproportionality, this outcome is not certain. In fact, as Table 5 illustrates, the relative Gini can give exactly the opposite result: in this case, the same agglomeration gives *higher* Gini values when it occurs in urban regions, not lower.

Because Gini has no logical connection to agglomeration—it has a graphical interpretation, but no agglomeration interpretation—it can behave in unpredictable ways. There is no way to know *a priori* how the Gini value will react to changes in the upper part of the Lorenz curve compared to changes in the lower parts. The same problem applies to all disproportionality measures.

Feser and Sweeney (2000) make a major advance toward a solution. They identify Ripley's *K*-function as a way to determine whether a group of related firms have a greater tendency to co-locate than the average manufacturing plant. Up to this point, their approach is excellent (apart from the issue of whether manufacturing or total employment should be used as the baseline). The *D*-function they propose, however, is the *difference* between the concentration of the focus industry and that of the baseline:

$$D(s) = K_{11}(s) - K_{22}(s)$$

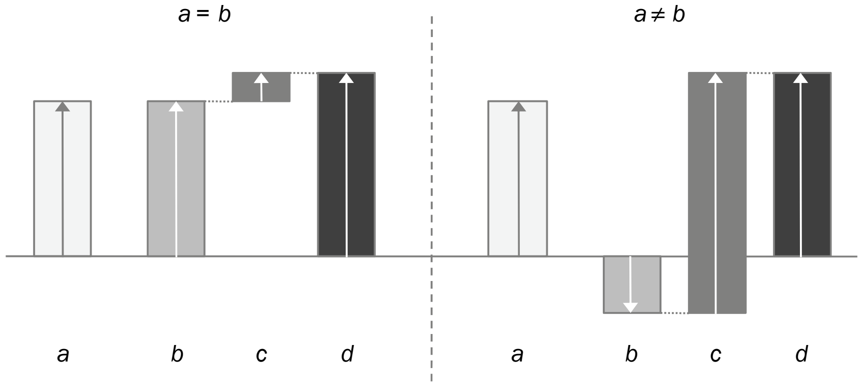
where s is the agglomeration range, K_{11} is the K value for the focal industry, and K_{22} is the K value for the baseline. Feser and Sweeney assume that localisation is an additive effect, i.e., that total localisation is the sum of inter-industry localisation and general localisation:

$$K_{11}(s) = D(s) + K_{22}(s)$$

For example, if an industry shows the same level of localisation as the baseline, then there is no inter-industry localisation effect; all of the localisation can be explained by baseline localisation. However, as we saw in Study 1, we need to take into account that urbanisation can vary from one industry to another. What matters is not only how urban the baseline distribution is, but also how urban the focal industry is. Figure 8 illustrates this problem schematically.

If we assume that the focal industry's level of urbanisation is equal to general urbanisation ($b = a$), then industry concentration (c) is the difference between general urbanisation and the industry's localisation, as Feser and Sweeney suggest. This is illustrated in the left hand of Figure 8. To measure industry concentration, we just sub tract general urbanisation ($b = a$) from the industry's localisation ($d - b$), and what remains is the industry's tendency to co-locate (c) over and above urbanisation in general. However, if we instead assume that our focal industry can have a different urbanisation than the general urbanisation ($b \neq a$), then c can be very different from $d - b$, as the right side of Figure 8 shows.

Figure 8. Industry agglomeration under different assumptions of industry ruralisation



a general urbanisation, *b* industry urbanisation, *c* industry concentration, *d* industry localisation

Interpretation and decomposition of the *Q* function

When two firms are co-located, proximity effects come into play. Many proximity effects are such that they occur betweens co-located pairs of actors (e.g., pairs of firms, pairs of employees). For these effects, the value of co-location increases with the number of co-located actors. For example, if a firm requires a local supplier with an unusual competence, it is twice as likely to find one if there are twice as many local suppliers to choose from. Similarly, if a worker is looking for an employer that requires the particular combination of skills that she possesses, then the likelihood of finding a perfect match is twice as high if there are twice as many firms. In network theory, the value of these kinds of networks are described by Metcalfe's law (Swann, 2002). It states that in a network with n members where the individual member's utility is proportional to n, the aggregated value of the network is proportional to $n \cdot (n-1)$, or, for large n, proportional to n^2.

It is this type of network effect that the *Q* function captures. For proximity effects that can be approximated with Metcalfe's law, the *Q* function provides a direct measure of how well such effects are facilitated by agglomeration.

In Study 1, I demonstrated how the *Q* function could be used to decompose localisation into concentration and urbanisation. If we have an industry i and a baseline of general economic activity x, the total localisation of i is the product of its concentration and its urbanisation:

$$\text{localisation of } i\ (r) = \frac{Q_i(r)}{Q_x(r)} = \underbrace{\frac{Q_i(r)}{Q_{ix}(r)}}_{concentration} \cdot \underbrace{\frac{Q_{ix}(r)}{Q_x(r)}}_{urbanisation}$$

To illustrate with a numerical example, consider an economy where (for some given r):

- an i firm is within range of 10% of other i firms: $Q_i(r)$ = 10%,
- an i firm is within range of 1% of all firms: $Q_{ix}(r)$ = 1%,
- and any firm is within range of 2% of all firms: $Q_x(r)$ = 2% .

$$\frac{Q_i(r)}{Q_x(r)} = \frac{Q_i(r)}{Q_{ix}(r)} \cdot \frac{Q_{ix}(r)}{Q_x(r)}$$

$$\frac{10\%}{2\%} = \frac{10\%}{1\%} \cdot \frac{1\%}{2\%} = 10 \cdot 0.5 = 5$$

The interpretation is that industry i is five times as localised as firms in general, and that this depends on i being ten times as concentrated as firms in general, but also half as rural.

However, it is possible to use the Q function to decompose localisation further. Let us add a group of industries labelled c. To determine whether c can be considered to be related to i, we want to measure the tendency of i to co-locate with those industries. Expressed in probabilistic terms: if i tends to co-locate with c more than with x, this suggests that i and r form a cluster. This tendency is calculated with the following quotient:

$$\frac{Q_{ic}(r)}{Q_{ix}(r)} = \frac{i \text{ tendency to colocate with } c \text{ firms}}{i \text{ tendency to colocate with all firms}}$$

If this quotient is >1, then this suggests that i is related to c, because they are agglomerated. By decomposing the total concentration of i into its tendency to localise with the cluster—which we can call *cluster concentration*—and its tendency to localise particularly with itself within the cluster—which we can call *industry concentration*—we get the following expression for localisation:

$$\text{concentration of } i\ (r) = \frac{Q_i(r)}{Q_{ix}(r)} = \underbrace{\frac{Q_i(r)}{Q_{ic}(r)}}_{\substack{industry\\ concentration}} \cdot \underbrace{\frac{Q_{ic}(r)}{Q_{ix}(r)}}_{\substack{cluster\\ concentration}}$$

For our numerical example, let us assume that:

- an *i* firm is within range of 5% of *c* firms: $Q_{ic}(r)$ = 5%

Our calculation now becomes:

$$\frac{Q_i(r)}{Q_x(r)} = \frac{Q_i(r)}{Q_{ic}(r)} \cdot \frac{Q_{ic}(r)}{Q_{ix}(r)} \cdot \frac{Q_{ix}(r)}{Q_x(r)}$$

$$\frac{10\%}{2\%} = \frac{10\%}{5\%} \cdot \frac{5\%}{1\%} \cdot \frac{1\%}{2\%} = 2 \cdot 5 \cdot 0.5 = 5$$

The interpretation is that industry *i* is five times as localised as firms in general, and that this depends on *i* being five times as likely to localise with *c* firms, in addition to being twice as concentrated within the *c* cluster as other *c* firms, and being half as urban as firms in general.

Similarly, we can decompose the total urbanisation of *i* into the *clusters urbanisation* of *c*, and the *industry urbanisation* if *i* within the cluster:

$$\text{urbanisation of } i\ (r) = \frac{Q_{ix}(r)}{Q_x(r)} = \underbrace{\frac{Q_{ix}(r)}{Q_{cx}(r)}}_{\substack{industry\\ urbanisation}} \cdot \underbrace{\frac{Q_{cx}(r)}{Q_x(r)}}_{\substack{cluster\\ urbanisation}}$$

For the numeric example, we assume that

- a *c* firm is within range of 1% of all firms: $Q_{cx}(r)$ = 1%

The decomposed localisation, then, is

$$\frac{Q_i(r)}{Q_x(r)} = \frac{Q_i(r)}{Q_{ic}(r)} \cdot \frac{Q_{ic}(r)}{Q_{ix}(r)} \cdot \frac{Q_{ix}(r)}{Q_{cx}(r)} \cdot \frac{Q_{cx}(r)}{Q_x(r)}$$

$$\frac{10\%}{2\%} = \frac{10\%}{5\%} \cdot \frac{5\%}{1\%} \cdot \frac{1\%}{1\%} \cdot \frac{1\%}{2\%} = 2 \cdot 5 \cdot 1 \cdot 0.5 = 5$$

In the numeric example, we see *i*'s urbanisation derives only from the urbanisation of the cluster *c*. Beyond the urbanisation of *c*, which is 0.5, *i* is neither more nor less urban.

This example illustrates how the *Q* function can be used to test different types of hypotheses about proximity effects and how they affect an industry or a group of industries. We can test a hypothesised proximity effect by expressing it in probabilistic terms and calculating the associated *Q* values.

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We will now leave the agglomeration aspect, and come to the next part of the discussion section. I have chosen to comment on three important fields where clusters have a key role to play. First, I will argue that the cluster concept is under-explored in the strategy management literature, considering the impact clusters have on firm performance. Second, referring to the interesting debate regarding the benefits or disadvantages of clusters for entrepreneurship, I will support the argument for clusters as benign environments for new firms. Third, I will discuss clusters as a framework for policy, and highlight some important sources of variation between cluster initiatives.

Clusters and strategy

The impact of clusters in mainstream strategy literature

Two publications can be said to have played a particular role in sparking the renewed academic interest in agglomeration and external economies. In 1990, Michael Porter published "The Competitive Advantage of Nations", in which he introduced the term "clusters." The book took Porter's research into a new direction, adding a geographical component to his previous work on corporate strategy and industry competition. He suggested that there is tremendous geographical variation in the competitiveness of individual firms, and that the sources of a firm's competitiveness should be sought partly in the firm's geographical environment. Soon thereafter, in 1991, Paul Krugman published his Gaston Eyskens lectures in "Geography and Trade", in which he argued that because of the demand for analytical rigor and the earlier inability to model market structures with increasing returns to scale, economists had come to neglect geography as a factor in economics. With improved models, this could now be remedied “by demonstrating that models of economic geography can be cute and fun, I hope to attract other people into tilling this nearly virgin soil.” (Krugman, 1991, p. 99)

Krugman was successful in his endeavour. Within a decade, economic geography was firmly established as an important part of economics. “New trade theory” or “new economic geography” had become a research field producing vast amounts of publications and eventually, a Nobel Prize for Paul Krugman.

A concomitant development did not occur within the field of strategy. Despite Porter’s eminent standing as one of the most central figures in strategy, the concept of clusters had next to no impact on the strategy field. In 2000, Porter noted “the central but largely unexplored role that location plays in the agenda for companies.” (Porter, 2000b, p. 254). Certainly, many studies were conducted assessing the importance of clusters on firm performance, but with only a handful of exceptions, these studies occurred outside the strategy literature. Instead, they were typically conducted by and discussed among economic geographers. Indeed, it was in economic geography that Porter himself found an outlet for his work on clusters.[18]

A review of the three leading strategy journals gives an idea of the extent of the absence of clusters in strategy research. An article search of Strategic Management Journal (SMJ), Academy of Management Review, and Academy of Management Journal (AMJ) for the word “cluster” in keywords or abstracts from January 1990 to September 2008 produced 30 hits. 15 of these refer to the statistical method of “cluster analysis” and are unrelated to industry clusters. Seven articles use the word “cluster” in the generic meaning of “grouping”, e.g., firms as “clusters of firm resources”, “clusters of companies” as strategic groups, and “clusters of distinct technical systems”. The remaining eight articles make some reference to clusters in the Porterian sense. These we will review briefly.

Pouder and St. John (AMR, 1996) put forward the proposition that agglomeration economies erode over time. Fast-growing geographic

[18] The most cited articles and book chapters on clusters by Porter have been published in *Harvard Business Review*, *Economic Development Quarterly*, *The Oxford Handbook of Economic Geography*, *Research Policy*, and *Regional Studies*. Notably, the only one of these channels that has a strategy profile is HBR, which is aimed more at practitioners than academics.

clusters of competing firms, termed "hot spots", initially derive great benefit from economies of agglomeration, which create an innovative environment. With time, however, the same forces create homogenous and stagnant environments that actually serve to impede innovation. In particular, firms in hot spots will find it difficult to identify and react to an industry-wide environmental jolt, and they will suffer proportionally greater losses from the consequences of such a jolt. The argument is theoretically founded on the tenets of economic geography as well as on the punctuated equilibrium model, organisation ecology, resource-based theory, institutional theory, and management cognition theory.

McEvily and Zaheer (SMJ, 1999) apply social network theories and ideas from the embeddedness literature to trace the sources of competitive capabilities in the network of advisors (outside the firm) from which managers elicit advice on business management matters. For a sample of metalworking job shops, they investigate the propensity to participate in regional institutions which were part of a national programme for enhancing productivity by providing support services such as training courses and equipment demonstrations. They find some support for a positive relationship between having a regionally dispersed advice network and acquiring competitive capabilities. They also find that participating in regional institutions is associated with acquiring capabilities, but discover no support for the hypothesis that having a dispersed advice network would be associated with participation in regional institutions.

Shaver and Flyer (SMJ, 2000) examine the hypothesis that firms with the best technologies, human capital, training programs, suppliers, or distributors have the least to gain from locating in clusters, and that clusters will therefore suffer from adverse selection. They test this hypothesis empirically by measuring the survival of (and the degree of retained control over) greenfield entries through foreign direct investment in the US. They find that states with a high proportion of the respective industry are more likely to attract foreign greenfield entries. They also find that agglomeration reduces the likelihood of survival, particularly in strongly agglomerated states, which they interpret as indirect evidence of adverse selection.

Zaheer and Zaheer (SMJ, 2001) analyse the microstructure of markets (i.e., the competition occurring between a subset of firms in an industry) using Porter's cluster concept as an explicit point of departure. In an analysis of the interbank currency market, a global electronic exchange, they analyse the role of a firm's location. They hypothesise that being located in the same cluster (London, New York, Tokyo), in the same country, and in the same time zone respectively will make banks more likely to compete on-line for the same customers. Although they found some support for the cluster effect, they uncovered stronger support for nation and time-zone effects.

Tallman et al. (AMR, 2004) address the question of why firms in clusters may as a group outperform firms based in other locations, even while there is performance variation within the cluster. They propose a hierarchy of knowledge stocks and flows, where some types of knowledge flows easily between cluster firms, enhancing their joint competitiveness, while other types remain firm-specific and preserve intra-cluster performance differentials. Similarly, factors that act to impede the flow of knowledge between one cluster and another can provide a sustained joint competitive advantage for the firms of that cluster.

Canina, Enz and Harrison (AMJ, 2005) study how demand-based performance of firms is affected by the strategy choice of neighbouring firms in their cluster. Using the US lodging industry as the empirical example, they divide hotels into strategic segments based on whether they apply a differentiation strategy or a low-cost strategy (in a range from luxury hotels to economy hotels). They find that low-cost firms benefit from co-locating with differentiation firms, but that differentiation firms suffer from co-locating with low-cost firms.

Using Canadian mutual fund companies, Bell (SMJ, 2005) investigates the ways in which innovativeness (as estimated by an expert panel) is influenced separately by network effects (managerial and institutional centrality of firms) and by other cluster effects (location within or outside the Toronto financial cluster). He finds that firm innovativeness is enhanced by locating in the cluster, even after separately accounting for network structure effects.[19]

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[19] This approach is interesting and has parallels in economic geography. The notion is that "cluster effects" are those that remain when other local effects are eliminated. In this case, the author considers manager centrality as a "network effect" as opposed to a "cluster effect", although the two are significantly correlated. One might argue that one of the advantages of locating in the Toronto cluster is that it is easier to maintain a central network position there due to the ease of face-to-face interaction. Boschma (2005) takes a similar position by disentangling different forms of proximity: cognitive, organisational, social and institutional proximity can act as substitutes for geographic proximity. However, one could also argue that although cognitive, etc., proximity can indeed occur without geographical prox-

Finally, Mesquita (AMR, 2007) focuses on the role of trust in clusters and suggests that trust does not necessarily arise spontaneously, but may require deliberate efforts to build and rebuild. The author proposes a model for the ways in which trust can be reconstructed in environments where relationships have been shattered and are too complex to be disentangled in a self-managed way. Trust facilitators (individuals, government agencies, independent organizations) can leverage their reputation to help firms manoeuvre out of non-collaborative positions. The theoretical model proposed contributes significantly to the cluster development literature.

That these eight articles, out of a total of approximately 2000 articles published over the span of 18 years in three leading strategy journals, are the only ones that mention clusters explicitly in their abstracts, gives an indication of the limited impact the concept has had on strategy research. It is also interesting to note the particular aspects of the cluster concept that have found some resonance in strategy. Three articles are theoretical in nature, two of which (Pouder & John, 1996; Tallman, Jenkins, Henry, & Pinch, 2004) focus on knowledge creation and knowledge flows, and the third (Mesquita, 2007) focuses on trust. Two empirical papers focus on choice of customers (Zaheer & Zaheer, 2001) and capabilities building (McEvily & Zaheer, 1999). Only three articles study performance measures in terms of innovativeness (Bell, 2005), plant survival (Shaver & Flyers, 2000), and revenues (Canina, Enz, & Harrison, 2005).[20]

The impression is that – in strategy – clusters have been studied mostly in the light of established strategy paradigms for which the cluster perspective is ill suited and difficult to incorporate. Throughout the 1990s, the attention of strategy scholars was shifting from the external perspective of industry organisation to the internal perspective of the resource-based views and dynamic capabilities. In that sense, the cluster concept arrived when the strategy tide had turned

imity, the great value of geographical proximity is its ability to foster the other types of proximity. Geographic proximity, we find, is an excellent proxy for, and apparently a key driver of, other forms of proximity.

[20] One might question whether Canina et al. (2005) actually apply the cluster concept. Despite the explicit reference to clusters, the study in fact examines variation of strategies within a single industry in geographically small regions (tracts). The degree of agglomeration is not part of the model, and agglomeration economies play no role in the study. Since the lodging market is extremely local, there is negligible competition between firms in different regions. The only aspect of clusters that is actually under scrutiny is local market competition.

in the opposite direction, so to speak. The authors of one of these articles express the situation thusly:

> Existing strategy research employing the resource-based view of the firm tends to explain firm heterogeneity and profitability differences as arising primarily from internally generated capabilities. Moreover, this, and other economics-based perspectives explaining firm heterogeneity, implicitly suggest that firms are *autonomous and atomistic in their pursuit of competitive advantage*. Our research challenges both assertions by pointing to the role of network resources, and the externally embedded nature of capabilities acquisition, and highlighting the central role of firms' ties with other economic and noneconomic actors. (McEvily & Zaheer, 1999, p. 1152, emphasis mine)

However, towards the end of the 1990s, a new stream of research in strategy again shifted the focus outwards again. The relational view of the firm suggested that critical resources may reside outside the firm and be embedded in interfirm resources and routines (Dyer & Singh, 1998). Social networks promote trust and reduce transaction costs, and as such a firm's history of prior relationships impacts the competitive position of a firm (Gulati, Nohira, & Zaheer, 2000). When the strategy field turned its focus outwards again, it was thus the network concept that accounted for extra-organisational dependencies. Networks are certainly one aspect of clusters, but they capture only a small share of the effects inherent in the cluster concept, even as they force the geographical component to a position of secondary importance or insignificance. (Notably, Dyer and Singh as well as Gulati et al. make prominent references to Porter's 1980 work on competitive strategy, but neither make any mention of his later work on clusters.)

The role of clusters in strategy research

Although clusters have had little impact on the strategy literature, there are several links between the study of clusters and that of firm strategy. It is possible to extend both the resource-based view and the activity-based view of the firm to include cluster conditions. (See Enright, 1998 for an extensive discussion.)

According to the resource-based view of the firm (Barney, 1986; Wernerfelt, 1984), a firm is a bundle of resources whose competitiveness depends on obtaining a mix of resources that are superior to those possessed by competitors. If the resources are *valuable*, *rare*, *difficult to substitute* and *difficult to imitate*, they can provide a sustainable competitive advantage for the firm (Barney, 1991). Resources are difficult to emulate or replicate for several reasons (Dierickx & Cool, 1989). *Time compression diseconomies* occur if assets that can easily be acquired over long periods of time are difficult to acquire in a short time. *Asset mass efficiencies* imply that already having a large stock of an asset facilitates acquiring more of it. *Interconnectedness of asset stocks* means that the acquisition of one stock will require the build-up of another. *Asset erosion* is the process by which assets decay unless deliberate investment is made to ensure their maintenance. The slower this process of decay is, the more forcefully an actor must be committed to the use of the asset, and the stronger is the deterring effect that prevents others from imitating it. *Causal ambiguity*, finally, means that it is unclear which stocks will determine the firm's probability of success.

Enright (1998) argues that the resource-based view of the firm can also be extended to clusters. In addition to resources that are internal to the firm and resources that are generally available on the market, he suggests a third category consisting of resources that are internal to a region, but external to any single firm.[21] In particular, unique historical conditions, causal ambiguity and social complexity characterise cluster conditions and make cluster resources particularly difficult to imitate. Many clusters evolve over long periods of time and retain their competitive position over the course of decades or even centuries, therefore developing region-specific resources that are difficult for other regions to match. Causal ambiguity arises particularly when tacit knowledge is involved, and tacit knowledge develops and spreads particularly well within clusters through experience and practice. (Already Marshall (1920, p. 225) points out that the "mysteries of the trade" are "in the air".) Clusters are also characterised by social complexity (Piore & Sabel, 1984; Scott, 1983) due to the wide range of ties and links that evolve between people who work and live in the same area. The embedded nature (Granovetter, 1985) of firms in clusters allows business transitions to be conducted within a clear set or rules that can reduce the risks of opportunistic behaviour. The social web of a cluster is virtually impossible to duplicate in other lo-

[21] This is similar to the notion of "club goods" in economics, i.e., goods that are non-rivalrous within the cluster but excludable outside it.

cations. The conclusion is that, from a resource-based view, clusters are important factors in shaping competitive advantage for firms.

Another less explored perspective in strategy is the activity-based view of the firm. Instead of focusing on what the firm *has*, it focuses on what it *does*; in this view, the firm is conceptualized as "a bundle of activities" (Hagström, 1990). Porter (1985) describes the firm in terms of a value chain, i.e., as a set of generic activities in which all firms engage. Inbound logistics, operations, outbound logistics, marketing and sales, and after-sales services constitute primary firm activities, while firm infrastructure, human resource management, technology development and procurement are support activities. From this perspective, sustainable competitive advantage stems from systems of interdependent activities. Trade-offs in the way activities can be combined to make it difficult for competitors to imitate a set of activities, as well as to make it possible to sustain a strategic position (Porter, 1996).

This perspective bears important geographical implications. Porter (1986) notes how the globalisation of markets has increasingly rendered competition a global matter. International corporate strategy becomes a matter of how best to distribute and coordinate activities. Hagström (1990) points out that while some activities may be located according to external cost considerations, other activities can be located according to internal agglomeration economies. The choice of location may determine which activities must be carried out internally and which can be profitably outsourced. Clusters clearly play an important role in this respect. Agglomerated firms have more opportunities to coordinate their activities. As well, they can jointly influence the environment through various collaborative efforts, such as lobbying for infrastructure investment.

Taking all of these points into consideration, clusters appear to have solid theoretical claims on relevance for strategy. Conversely, we can view strategy from the perspective of clusters. Porter argues that clusters "affect both the ability of firms to attain operational effectiveness and their ability to choose distinctive, rather than imitative, strategic positions" (2000b, p. 265). In this, he acknowledges the cost-reductions and scale economies that are often the focus of economists' treatment of clusters. Clusters promote, he notes, operational improvement through rapid dissemination of best practices, and through providing opportunities for experimentation with new activity configurations. However, Porter particularly stresses the effect of clusters on the nature of competition itself. Clusters foster strategic competition, he argues, and clustered firms tend to be similar in operational effectiveness, which in turn forces them to compete through strategic rather than operational differentiation. Proximity to rivals discourages plain imitation, promotes differentiation, and facilitates the search for niche opportunities.

The conclusion is that there are indeed compelling theoretical arguments to be made for why the cluster concept could play an important role in the study of strategy. Our understanding of a firm's strategic position and the opportunities and limits on its strategic manoeuvring can be improved if we take into account the regional context in which the firm operates. Depending on the purpose of a particular study, there are different methodological approaches that can be used to account for clusters.

First, regardless of the purpose of a study, cluster effects can be included as control variables. Even when the focus of the study falls well outside the scope of firm properties, behaviours or performance factors that are arguably affected by clusters, it could be important to eliminate the confounding effects of a cluster by performing a sample selection that is invariant from a cluster perspective, or alternately, by including cluster effects as a control variable. This would be no different from controlling for firm age or industry.

Second, the choice of location is a strategic decision. New firms have a choice of initial location, and established firms are not locked into a single location, but can distribute their activities across regions according to strategic considerations. Even single-establishment firms have the option to move from one location to another, and do so, albeit not frequently. Firm migration and relocation were studied extensively studied in the 1970s (see Hallenberg, Wissen, & Dijk, 2002 for an overview). More recent studies have indicated that migration rates increased during the 1990s (Kemper & Pallenberg, 1997). In a study of large firms, which are known to relocate less frequently, only about 3% of firms were shown to relocate each year (Brouwer, Mariotti, & Ommeren, 2003).[22]

[22] On a wider sector scale, it was noted that manufacturing activities in general moved from central urban regions to more peripheral rural regions in several European countries from 1955 to 1975 (Keeble, Owens, & Thompson, 1983). This trend is known as the urban-rural manufacturing shift, but later studies confirmed that it continued during the 1980s and that it involved service industries as well as manufacturing industries (Keeble & Tyler, 1995). However, it is important to note

Third, even without relocating, the firm has the potential to influence the environment. Clusters are not only the results of evolutionary processes, but are also subjected to constructive forces, i.e., efforts to change and improve conditions for firms in the cluster (Sölvell, 2009). Such efforts, known as cluster initiatives and cluster organisations, have become a frequent feature of regional economic development and typically include considerable active involvement from member firms (Ketels, Lindqvist, & Sölvell, 2006; Sölvell, Lindqvist, & Ketels, 2003).

Clusters and entrepreneurship

Several economic and social proximity effects could link cluster agglomeration to increased rates of new business formation. From an economic perspective, locally available assets, skills, inputs and staff reduce entry barriers and increase the likelihood that an opportunity is perceived (Porter, 2000a). Local financial institutions may offer capital at a lower risk premium due to their greater degree of familiarity with the industry. A significant local market can also lower entry barriers. Porter argues that these factors benefit local entrepreneurs, but also serve to attract entrepreneurs based elsewhere.

From a social perspective, however, it has been argued that these same factors can be perceived as less attractive from the outside. A prospective entrepreneur will not only be exposed to fewer distant opportunities than to local, but proximity can also heighten the perceived desirability and feasibility of a recognised entrepreneurial opportunity (Zander, 2004). In other words, the same set of opportunities is not only more likely to be recognised by local entrants, but will also appear to be more desirable and feasible to pursue. This can be construed to mean that distant entrepreneurs often miss opportunities, but it could also mean that local entrepreneurs overrate local opportunities. This means that the *perceived* economic benefits may in fact not lead to improved performance. And this, in turn, opens up the possibility that agglomeration can be sustained in the absence of economic benefits and improved performance, which is

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that the urban-rural shift is the result not only of relocations, but also of the effects of the births and deaths of firms.

what Sorenson and Audia (2000) suggest. In their study of the American shoe industry, they find that plants in regions with high concentrations of shoe manufacturing failed at higher rates than isolated plants, a difference that was most pronounced for new plants. This trend should lead to the industry spreading out over time, but since the data did not bear that out, the only explanation is increased entry rates into the industry.

> From an evolutionary perspective, two processes could sustain these agglomerations. On the one hand, organizations in concentrated regions might perform better – and hence survive longer – than those located in sparse areas. On the other hand, new production facilities might simply open more frequently in the vicinity of industrial agglomerations. In other words, both lower failure rates and higher founding rates can sustain geographic concentration, though different forces might drive each of these processes. (Sorenson & Audia, 2000, p.425)

Sorenson and Audia propose that one implication of the findings for managers in multi-plant companies is that it is seems advantageous to locate in relatively isolated locations, unless this is prohibited by high coordination costs. For regional planners, the implication is that recruiting "seed" companies to locate in an area could initiate the self-reinforcing entrepreneurial process. They also point out that "although this process might benefit the community, these benefits probably come at the expense of any given firm that gets caught in these waves of creative destruction" (ibid., p. 457). These conclusions cast doubt upon the fundamental assumption that firms benefit economically from agglomeration.

Sorensen and Audia's study was based on one industry, footwear manufacturing, and note that "it seems particularly useful to investigate whether a high technology industry, such as computer hardware or biotechnology, operates according to the same principles." Study 4, which focuses on five knowledge-intensive sectors in Sweden, suggests clearly that this is not the case. There is no support for the conclusion that performance and survival are reduced by agglomeration; on the contrary, the results suggest that both are enhanced. Consequently, this would reverse the implications for managers and regional planners: multi-plant firms should (ceteris paribus) avoid isolated locations, and there should be no trade-off between the community's and the company's benefit of entrepreneurship in agglomerated locations.

The purpose of Study 4 is not to determine which proximity effects drive the observed improvement in performance and survival of new firms. As a speculation, though, the economic and social benefits can be combined using the perspective of networks. When new firms go from the initial stage of emergence to the subsequent stage of early growth, the type of networks that they rely on change (Hite & Hesterley, 2001). During the emergence phase, they rely on *identity-based networks*, which are networks with a high proportion of ties where personal or social identification with the other actor motivates or influences economic actions (family, friends, and possibly fools). Preexisting and heavily embedded relationships provide the resources needed to get the enterprise going. However, over time, these networks are replaced by *calculative networks*, where the potential purposes and functions of the network are more important than the identity of the ties. Calculative networks are larger, more diverse and less path-dependent than identity-based networks, and can therefore supply the breadth of resources needed in the early growth stage of the firm.

In an agglomeration, the chances of transforming an identity-based network into a calculative one is greater than for isolated firms. Not only is the availability of new calculative ties greater, as Porter points out, but the likelihood that there are links from the identity-based network to a calculative one is greater, as well. If family, friends and fools, or even the entrepreneur herself, have ties to the potential calculative relations, the transition from one type of network to the next should be eased considerably.

Also, we can speculate about the reason for the increased failure rates in agglomerated regions that were found by Sorensen and Audia. They suggest that increased local competition for resources would present plants located in dense areas with a higher competitive pressure than isolated plants, which would coincide with Porter's view of local rivalry (Porter, 1998). However, Porter also notes that a local cluster can lower exit barriers ”due to less need for specialized investment, deeper markets for specialized assets, and other factors” (Porter, 2000a, p. 24). It is possible that exit barriers, which were low in the US shoe manufacturing industry, were more clearly differentiated between agglomerated and isolated plants and affected exit rates to a higher degree than was the case in the studied Swedish knowledge-intensive industries. If that is indeed the case, the US shoe clusters represent dynamic systems of local rivalry, while isolated plants tend to stick it out even in spite of poor performance. Since the US study contains no information about the revenues and expenses of the plants, we cannot tell whether or not this is the case. The Swedish study in Study 4, in contrast, does contain economic performance indicators, and it suggests that agglomerated firms do indeed perform better.

Clusters and policy

The multi-faceted cluster concept has sparked a wave of economic policy initiatives on a global scale. Although they all trace at least part of their conceptual lineage back to Porter's cluster concept, it is clear that cluster policies have taken very different forms in different countries in terms of contents, actors and governance. As the following overview suggests, the variation in the contexts in which cluster organisations operate is vast.

The immediate precursor of cluster-based policies in **the US** (Rosenfeld, 1994, 2001) were the network-oriented policies resulting from the studies of the north Italian region Emilia-Romagna. In 1989-1990, the Danish Ministry of Trade and Industry formulated a model of intervention intended to stimulate inter-firm collaboration in networks identified and facilitated by publicly financed and trained personnel. Such network policies had recently been transferred and introduced in the US when *The Competitive Advantage of Nations* was published in 1990. The narrower network approach was then reshaped into more comprehensive cluster projects, which were gradually introduced in a large number of states. By 2003, 40 states had conducted cluster studies, endorsed cluster-oriented legislation, or otherwise introduced cluster-based economic development policy programmes (Akundi, 2003).

In **Europe**, Spain was an early adopter of cluster policies. By 2003, Austria, Belgium, France, Germany, Hungary, Latvia, Lithuania, Italy, Luxembourg, Slovenia, Spain, Sweden, and UK had introduced national or regional cluster policies (European Commission, 2003).

The approach varies considerably between different countries. In France, there is a national programme associated with cluster policy and programming, while Austrian cluster policies are introduced on the regional level. Some countries, like UK and Sweden have chosen hybrid models, using national frameworks to coordinate regional policies.

In Europe, the cluster concept has been more closely associated with the concept of innovation systems. Cluster policies have often been seen primarily as a tool of promoting innovation (European Commission, 2003; OECD, 1999, 2001). A reason for this, it has been suggested, is that cluster policies in the EU have grown out of innovation policies in the structural funds and the RIS/RITTS innovation programmes (Nauwelaers, 2001).

In Australia and New Zealand, cluster policies have also become an important part of economic policy. Two distinct types of approaches have been applied in **Australia**, some addressing cross-regional, well-established clusters, and some projects aimed at smaller local business networks. There have been federal policy initiatives adopting cluster development as a means of fostering economic development, but these were hampered by wavering federal support due to a change of government. However, state-level cluster projects, mainly in South Australia and Queensland, have had a significant impact (Blandy, 2001; Enright & Roberts, 2001; Roberts & Enright, 2004).

In **New Zealand**, cluster support policies first developed in the late 1990s among local-level economic development agencies. In 2002, the Ministry of Economic Development ran a pilot, and in 2003 the permanent Cluster Development Programme (CDP) was launched under the management of the newly formed agency New Zealand Trade and Enterprise. Over the next few years, a total of 82 cluster projects were financed through this programme. Funding was provided primarily to cover the cost of facilitators. For larger sums, cluster projects could also apply to NTZE's Regional Partnership Programme (RPP). After three years, the CDP's fund was disestablished in June 2006. The programme continued to support an annual cluster development conference and workshops for facilitators, while funding for cluster support activities was transferred entirely to the RPP. (Ministry of Economic Development, 2005; New Zealand Trade & Industry, 2006; Perry, 2004)

Cluster projects have also been conducted in **developing and transition economies**, for example in Latin America (Altenburg & Meyer-Stamer, 1999). Of particular importance has been the role played by multi-lateral and bi-lateral donor agencies. The United Nations Industrial Development Organisation (UNIDO) has been involved in a large number of cluster projects in Latin America

(Honduras, Nicaragua, Honduras, and Jamaica) (Ceglie & Dini, 1999), India (Samii, Wassenhove, & Bhattacharya, 2002), North Africa (Tunisia and Morocco) and Sub-Saharan Africa (Nigeria) (UNIDO, 2000) with an emphasis on network development among small and medium-sized enterprises (SMEs). The United States Agency for International Development (USAID) has conducted cluster projects in more than 20 countries (including Albania, Bosnia and Herzegovina, Bulgaria, Cambodia, Colombia, Croatia, Dominican Republic, Egypt, FYR Macedonia, Guyana, Kazakhstan, Kenya, Lebanon, Mongolia, Nicaragua, Pakistan, Romania, South Africa, Sri Lanka, Thailand, Uganda, Vietnam, and Yugoslavia). (For example Vietnam: Khuong, 2004) Similarly, the World Bank has conducted such projects in several countries.

It is clear from this overview that cluster initiatives occur in widely differing contexts, and is driven by different types of actors with different goals and ambitions. Drawing lessons that apply to cluster initiatives in general is therefore difficult.

The results of Study 6 indicate that while some factors have an impact on performance across the sample, other factors did not have such a general effect. The reasonable conclusion is not, however, that the latter factors are unimportant. Rather, considering the greatly varying contexts, it stands to reason that their impact depends on contingent factors, such as, for example, the type of economy in which the cluster organisation operates. While data limitations preclude a more detailed analysis of performance impact, a study of variation in objectives provides some support for this argument. Table 6 extends the sample to transition and developing economies, and indicate which objectives are considered to be the most important for cluster organisations in different types of economies.

Innovation support is the most frequently named main objective in advanced economies, and although ranked as number 3 in Transition and Developing economies it is only half as frequent in that context. Conversely, increasing the value added is ranked as the most important objective in Transition and Developing economies, while it rates only as number 4 with a little more than half the frequency in Advanced economies. Improving the business environment is another activity that is substantially more frequent in advanced economies. Export promotion is shown to be 2–3 times more frequent in Transition and Developing economies, where it is the second highest-ranked objective. These patterns suggest that cluster organisations objectives

Table 6. Objectives of cluster organisations in advanced, transition and developing economies

Objectives	*Advanced*		*Transition*		*Developing*	
Support innovation	56%	(1)	32%	(3)	32%	(3)
Improve the business environment	47%	(2)	20%	(7)	20%	(7)
Attract firms and investment	31%	(3)	27%	(5)	20%	(7)
Increase the value added of production	31%	(4)	52%	(1)	51%	(1)
Increase employment	22%	(5)	22%	(6)	27%	(5)
Commercialise academic research	21%	(6)	15%	(9)	4%	(12)
Create a cluster organisation	20%	(7)	28%	(4)	22%	(6)
Develop supply chains	16%	(8)	15%	(9)	30%	(4)
Increase exports	15%	(9)	35%	(2)	49%	(2)
Seek funds from government or international organisations	12%	(10)	17%	(8)	7%	(11)
Reduce production costs	4%	(11)	10%	(11)	16%	(9)
Reduce competition	3%	(12)	2%	(13)	8%	(10)
Promote import-substitution	1%	(13)	7%	(12)	0%	(13)
N	414		60		74	

Share of respondents who indicated objective as one of the three most important.
Source: Global Cluster Initiative Survey 2005 (Ketels, Lindqvist, & Sölvell, 2006)

are related to the general economic conditions in their countries.

However, systematic variations also occur between advanced economies. According to the "varieties of capitalism" perspective (Hall & Soskice, 2001), firms are the key actors in shaping the economy, and the way they coordinate their activities is the fundamental factor that shapes economic performance. Hall & Soskice draw a core distinction between *liberal market economies*, where firms coordinate activities primarily via hierarchies and competitive market arrangements, and *coordinated market economies*, where firms rely more heavily on non-market relationships. "In any national economy, firms will gravitate toward the mode of coordination for which there is institutional support." (ibid., p. 9) These institutions reinforce each other in a complimentary way, so that the economy develops in either of two directions. Cluster organisations are strongly embedded in these institutional environments, which suggest that there could be sys-

Table 7. Comparison of cluster organisations in coordinated market economies (CME) and liberal market economies (LME)

	CME countries [a]		*LME countries*
Objectives [b]			
Improve business environment	45%		52%
Increase exports	10%	**	23%
Support innovation	64%	***	44%
Commercialise academic research	27%	**	15%
Business vs. government			
Business vs. government influence [c]	−0.22	**	0.16
Initiated by business	16%	**	28%
Share of funding from business	26%		30%
Government level			
National vs. local government [d]	−0.05		−0.22
N	144–192		125–170

t-test for equality of means: ** sig.<0.01, *** sig. <0.001
[a] CMEs: AT, BE, CH, DE, FI, IC, JP, NL, NO, SE. LMEs: AU, CA, UK, IE, NZ, US
[b] Share of cluster organisations that indicate this as one of three most important objectives
[c] Construct of influence over initiation, selection of initial participants, selection of objectives, selection of activities; higher indicates government influence, lower indicates business
[d] Construct of influence (see c); higher indicates national level, lower indicates regional/local
Source: Global Cluster Initiative Survey 2005 (Ketels, Lindqvist, & Sölvell, 2006)

tematic differences between cluster organisations in the two types of economies. Table 7 confirms that this is indeed the case.

Table 7 shows that the variety of capitalism in place affects many aspects of cluster organisations. In terms of objectives, CMEs seem to favour innovation and coordination between universities and industry more than LMEs, where instead export promotion features as a more highly prioritised area. Cluster organisations in CMEs are clearly more influenced by government than those in LMEs. These differences are consistent with a “varieties of capitalism” perspective. There are also systematic sectoral and national differences (Lindqvist, 2006).

The discussion above points to the cluster organisation’s setting, or environment, as an external source of variation. However, there is also an important internal source of variation, which is built into any form of public-private partnership. As seen in Study 7, participants from the public sector will see the cluster differently from those in the private sector. Just as we cannot assume that the learnings from a cluster initiative in one setting is applicable to one in another setting, we cannot assume that the observations and conclusions of a cluster organisation participant with one background will seem reasonable to one with another background.

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We now turn to the conclusions and implications of this dissertation. First, we will revisit each of the three research questions, and summarise the key findings. And finally, the implications for researchers, practitioners and policy makers are highlighted.

Conclusions

This dissertation addresses three basic questions about clusters:

- How should cluster agglomeration be measured?
- What are the economic benefits of cluster agglomeration?
- How are cluster agglomerations and cluster effects organised through cluster initiatives?

Answering fundamental questions such as these is not a small task and it has not been the ambition to provide exhaustive answers. However, I have tried to contribute to each of them by applying an integrated perspective based on what I suggest is an essential insight, namely the need to treat agglomeration and proximity effects as separate entities, and not as two aspects or degrees of the same phenomenon.

How should cluster agglomeration be measured?

Previous research has not sufficiently taken into account how general proximity effects ("urbanisation effects") can generate industry localisation and therefore confound the results of industry proximity effects ("concentration effects"). Ripley's *K*, in the form of the *Q* function, offers a solution to many of these problems. Not only can it be used to decompose industry concentration and industry urbanisation, but it can also further separate cluster concentration and cluster urbanisation. As it uses geocoded data it can measure agglomeration on any spatial scale and can therefore avoid many of the problems associated with regional measures. In contrast, traditional measures of agglomeration, such as Gini or Herfindahl, are found to be incapable of assessing urbanisation both in their absolute and their relative forms. The empirical study of industries in Sweden applies the *Q* function and demonstrates how concentration and urbanisation can vary independently and even offset each other, as the remarkable case of reindeer husbandry illustrates.

When agglomeration is measured, this is usually done compared to a baseline distribution. Total manufacturing employment is frequently used as that baseline, possibly because many studies examine only the agglomeration of manufacturing and it is therefore convenient to use manufacturing data for the baseline as well. However, the conclusion from one of the present studies is that manufacturing cannot be assumed to be a neutral baseline for localisation patterns. Manufacturing in Sweden is found to be rural and dispersed. Making comparisons with total manufacturing instead of economic activity in general will therefore inflate concentration as well as urbanisation estimates, giving a combined effect of highly inflated localisation values.

Clusters, agglomerations of related industries, constitute an intermediary level of agglomeration between individual industries and general agglomeration. Defining which industries to consider as related is a problem that can be approached from either the proximity effect side or the agglomeration side. When starting from the proximity effect side, some proximity effect is selected (or several), and the selection of related industries is based on how this effect is found to reach across industries. It then becomes an empirical issue to test whether this relatedness also gives rise to cluster agglomeration of those industries. Conversely, when starting from the agglomeration side, co-location patterns are measured on some spatial level, and the selection of related industries is based on the degree of co-location between industries. The empirical question is then to examine which proximity effects can be shown to occur between the selected industries.

The advantage of the latter method is that it can capture cluster agglomeration regardless of which proximity effects are the drivers behind it. In other words, it allows us to identify and examine clusters from the comparatively lucid side of agglomeration, instead of the more nebulous and contested side of proximity effects. The studies of this dissertation have applied that method and define the industry borders of clusters according to co-location patterns. Cluster definitions extracted from US patterns are applied to European data, and are found to produce reasonable maps of clusters. They are also found to reveal significant relationships between cluster agglomeration and economic performance of firms and regions, which suggests that they reflect cluster proximity effects that are in operation also in Europe.

One of the studies compares industry concentration in Europe and the US. Using the co-location based method described above, and considerably more detailed data than previous studies, it confirms the established notion that industry concentration is higher in Europe than in the US.

What are the economic benefits of cluster agglomeration?

From the outset, the empirical phenomenon of industry agglomeration has been seen as an indicator of some form of economic benefits of clusters. Whether in the form of knowledge spillovers, labour pooling, local specialisation or otherwise, the drivers behind industry agglomeration have been assumed to provide some economic benefit to firms that are in spatial proximity to each other. The debate has not been over whether agglomeration is associated with economic benefits, but over what type of benefits they are.

However, an alternative explanation for the existence of clusters has been put forward, namely that of high entry rates in combination with low survival. This combination, which I term hyper-entrepreneurship, was observed in a study of the US footwear industry, where agglomeration was found to be associated with high entry levels and low survival rates of firms. The high entry rates do not in themselves present a reason to doubt the economic benefits of industry agglomeration. On the contrary, ease of entry is one of the results of labour pooling, specialisation and knowledge spillovers. The problem occurs if they are combined with poor performance and low survival. High entry rates would then explain how agglomeration could occur and be sustained in the absence of economic benefits. Could the pattern observed in the US footwear industry be generally valid? If so, our whole thinking about industry agglomerations and clusters as the products of economic benefits would have to be reconsidered.

One of the studies of this dissertation addresses this particular issue by analysing performance and survival among new firms in six knowledge intensive clusters in Sweden. The findings are contrary to those in the US shoe industry, and show that cluster agglomeration is associated with higher employment growth, higher VAT payments, higher salary payments, and higher survival rates.

The conclusion of is not that high entry rates do not contribute to maintaining cluster agglomeration. Instead, the conclusion is that it is not the only mechanism maintaining agglomeration. Clusters, it seems, are sustained by a combination of both high entry rates and increased survival. The study finds no evidence of hyper-entrepreneurship—increased entry rates despite decreased survival expectancy.

The economic benefits of cluster agglomeration for firms also translate to economic benefits for regions. Regional specialisation and urbanisation in combination affect economic performance (measured by GDP per capita, gross value added per capita, and wages per capita). When innovation is included as a intermediate variable in the model, we find that Marshallian externalities (of specialisation) are important for economic prosperity, but only indirectly through innovation. Specialised regions in Europe perform better in terms of innovation input and output, which in turn leads to improved regional performance. Apart from the innovation effect, there is no direct positive effect of regional specialisation. Urbanisation, on the other hand, does have a direct effect on regional performance, and through its effect on public R&D also has an indirect effect on private R&D and hence innovation. The findings suggest that the connection between public R&D and innovation (as measured through patenting) is not as clear as one might expect. It appears that public R&D spending that does not stimulate private R&D spending does not lead to enhanced innovation.

How are cluster agglomerations and cluster effects organised through cluster initiatives?

Cluster organisations engage in a wide variety of activities in order to support and promote clusters. These activities form seven main categories: Joint production, HR upgrading, Branding, Firm formation, Business environment, Intelligence, and Joint R&D. This suggests that the range of cluster organisation activities is wider and more complex than what is usually proposed in previous literature, which typically divides activities into three groups. These categories appear to have varying effect on various types of performance. The categories are inhomogeneous, in the sense that they combine activities of varying frequency, where some are performed often and other are rare.

Contrary to some previous research, the current study did not find any evidence that government initiated cluster organisations would perform any better or worse than non-government initiated ones. Nor is there any consistent tendency for cluster organisations that collaborate with other cluster organisations to perform better than others.

The conclusion is that factors such as collaboration and government initiation may be important for the performance of cluster organisations, but that this is contingent on other factors; the effects are not general. The findings of this dissertation show that there are consistent differences between the activities of cluster organisations in different types of economies.

Implications

The theoretical, methodological and empirical findings summarised above have implications for a wide range of academics and practitioners.

For *economic geography research*, a key implication is the advantage of separating of agglomeration from proximity effects in the treatment of clusters. The dissertation also highlights the need for better agglomerations to deal with the problems of locational equifinality (i.e. that localisation can occur from both urbanisation effects and concentration effects). The proposed *Q* function provides a way to achieve this, and also to decompose cluster concentration and cluster urbanisation from industry concentration and urbanisation. The findings also have implications for the choice of baseline with which to compare localisation patterns. The results show the risk of bias when using total manufacturing as the baseline. This dissertation advocates an empirical approach to defining and researching clusters. Too much attention has been paid to theoretically based definitions of clusters, focusing on one proximity effect or the other, while much work still remains to be done in examining empirically the phenomenon of agglomeration. We need to understand better the nature of cluster agglomerations, and for this we will need further improved methods and data.

For *strategic management research*, this dissertation points to the until now mostly overlooked possibilities that clusters offer. In this dissertation, clusters are shown to be important determinants of firm performance. In addition, the studies of cluster organisations show that firms invest considerable resources in participating in cluster-oriented efforts. Cluster organisations explicitly aspire to change the competitive position of their member firms, and their activities affect supply-chain relations, the supply of human resources, intelligence collection, sales activities, R&D efforts, and so on. Whether clusters are seen as agglomerations or as organisations, there is reason to pay more attention to the "central but largely unexplored role that location plays in the agenda of companies", in the words of Porter (2000b, p. 254).

For *cluster policy research*, *cluster policy makers* and *cluster practitioners*, the finding of this dissertation has some important implications. First, it demonstrates the applicability of quantitative approaches for exploratory and confirmatory research on cluster organisations. The results illustrate how success factors that have been found to be important in individual cases may not have an impact on performance generally. It suggests a framework for analysing cluster organisation activities, and it also points towards a configurational approach for future research. Second, the dissertation underscores the cognitive aspects of clusters. In cluster research, clusters are usually seen as objective entities, but when the cluster becomes the target of a cluster initiative subjective perceptions become important. Diverging perceptions, in particular between public and private sector participants, give rise to diverging priorities and goals for the cluster organisation. This underlines the importance of media in shaping and aligning perceptions of the clusters.

For *company managers*, especially entrepreneurs, the results emphasise the value of cluster agglomerations for company performance and, maybe more importantly, the possibility to shape the business environment by participating in cluster organisations. Business sector participants bring their particular perspective to the organisation, and their active participation affects how priorities are made.

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Summary of studies

The studies were conducted and written in roughly the following order:

- Study 2 was conducted in 2003 and was originally published the same year in Swedish by CIND at Uppsala University. The English (abbreviated) version was published by CSC at Stockholm School of Economics in 2008.
- Study 7 was conducted in 2003–2005, and was published in European Planning Studies in 2007.
- Study 4 was conducted in 2006-2008, and was accepted for publishing in Small Business Economics in 2008.
- Study 3 was conducted in 2007–2008.
- Study 5 was conducted in 2008.
- Study 1 was conducted in 2008–2009.
- Study 6 uses data from a survey conducted in 2005, where results were originally published by CSC in 2006. The current study, however, was written in 2009.

Study 1

This study examines the phenomena of industry agglomeration and general agglomeration and how they relate to industry-specific and general proximity effects. It proposes a way to measure these two types of agglomeration with a measure based on Ripley's K function, and applies it to data for 30 industries in Sweden.

The study revisits fundamental considerations in economic geography, in particular the assumptions behind Marshallian and Jacobian externalities.

The focus of the study is methodological. In particular, it discusses the shortcomings of disproportionality measures (such as Gini, Krugman, Theil, and Herfindahl) in distinguishing between industry concentration and urbanisation. Both concentration and urbanisation, it is argued, contribute to localisation.

As a solution, it is proposed to apply a probabilistic definition of concentration and urbanisation. An industry's concentration is defined as *its* tendency to co-locate with itself compared to *its* tendency to co-locate with firms in general. An industry's urbanisation is defined as *its* tendency to co-locate with firms in general compared to *firms' in general* tendency to co-locate with firms in general. Localisation is defined as the combined effect of the two, and the relationship is found to be multiplicative. The proposed *Q* function has a useful interpretation, in that it measures directly the degree of co-localisation between firms (establishments, employees) rather than the deviation from proportionality.

The proposed method is applied to 55,449 establishments in 30 industries in Sweden, whose locations are known on a postcode level. They are compared to a baseline of 1,435,165 establishments of any industry and 68,417 establishments in the manufacturing industry. The results show that localisation is not a good measure of concentration, as different combinations of concentration and urbanisation can give rise to the same level of localisation. In some cases, concentration and urbanisation offset one another, and an extreme example can be seen in the reindeer husbandry industry. The study also shows that results will vary considerably depending on whether manufacturing or all economic activity is used as the reference distribution. Manufacturing as a whole is found to be rural and dispersed.

The study contributes to the literature in economic geography by highlighting the need for better measures of localisation, as well as the need to distinguish between industry agglomeration as an indicator of concentration and as an indicator of urbanisation. The *Q* function is proposed as a measure that meets both of these criteria.

Study 2

This study applies a new method for measuring cluster agglomeration that was previously used only for studies of North American industries. Defining clusters as agglomerations of related industries, it creates industry groupings based on actual co-location patterns rather than categories in the classification system.

The study uses regional employment data covering 3.7 million employees in Sweden in 2003, which is about 90% of all employment. Roughly one third of these are employed in industries that exhibit a considerable degree of agglomeration, and these are categorised into 38 cluster categories. The data is geographically disaggregated into 81 local labour market regions.

The findings indicate that the grouped industries are distinctly agglomerated. The degree of regional concentration varies for different cluster categories, and smaller categories with few employees are generally more concentrated than large categories with many employees.

The study is descriptive in nature, and presents cluster maps for the 38 cluster categories. It also analyses growth during the period 1997–2002.

In terms of gender, it is found that in the industries included in the 38 cluster categories, women represent roughly 40% of the workforce, whereas in local industries (which display low degrees of concentration) they represent roughly 60%.

The study has implications for cluster research, in that it illustrates the applicability of measuring agglomeration of related industries using a method that is based on revealed relatedness. The study also has implications for policymakers, as it provides a method (and results for Sweden) for developing a comprehensive map of clusters based on statistical data and quantitative methods.

Study 3

This study addresses the question of whether industry concentration is higher in the US than in Europe. This has long been a stylised fact, and is assumed to be an indicator of the greater integration of US regions compared to European. Increased mobility is assumed to allow industries to agglomerate over time. However, earlier studies have suffered from methodological shortcomings in terms of finding granular data, disaggregation, and selection of industries, as well as making a consolidated comparison between two economies.

The analysis is based on employment data for 259 regions covering 31 European nations and 179 economic areas covering all US states. It includes industries in 38 cluster categories, which represent the industries with the highest degree of concentration, regardless of whether they are in manufacturing or services.

The study confirms the conclusion that industry concentration is higher in the US than in Europe. Using a battery of eight different disproportionality measures, concentration is consistently found to be higher in the USA, except for the coarsest of the measures (SLQ), where the consolidated concentration was found to be virtually identical in both economies. However, for individual cluster categories the comparison had diverging outcomes; in five of the cluster categories, there was a clear tendency towards higher concentration in Europe.

By providing more accurate data and a methodology that can be used to analyse agglomeration of related industries, the study contributes to the stream of economic research comparing the US and Europe that was triggered by Krugman's original study in 1991. It also has implications for economic policy regarding the impact of economic integration in Europe.

Study 4

This study examines how cluster agglomeration affects the performance of new firms. With their rich availability of knowledge, services, labour and financial capital, clusters provide fertile grounds for entrepreneurs. Several studies have confirmed that clusters have high entry rates, but high degrees of agglomeration could also have adverse effects due to congestion and hyper-competition for resources and labour. It has also been proposed that socio-cognitive effects could produce hyper-entrepreneurship in clusters. Exaggerated expectations of success due to skewed perceptions of entrepreneurial opportunities could generate an inflow of new firms that would maintain a cluster even if it provided economic disadvantages.

Study 4 examines this problem empirically, and assesses performance and survival among all firms founded in Sweden during a ten-year period in five different knowledge-intensive sectors. The results show that cluster agglomeration is associated with more job creation, higher tax payments and higher salaries, and that it is associated with higher survival rates, not lower. The strength of the cluster agglomeration effect varies with the level of the level of geographical aggregation, and is stronger for absolute agglomeration measures (counts) than for relative measures (location quotients).

Study 5

MAR externalities and Jacobian externalities provide two alternative but not mutually excluding explanations for innovation and economic prosperity of regions. This study approaches the issue from a new angle, in that it analyses the impact of regional specialisation and urbanisation on both innovation and economic prosperity simultaneously. In previous literature, these have been analysed separately, but in this study they are combined using a structural equation model. In addition, business and public R&D are included in the model.

Data from 211 regions in Europe is used, and regional cluster specialisation is calculated for 38 groups of co-located industries. The results indicate that specialisation does not affect regional prosperity directly but indirectly through its effect on innovation. Conversely, urbanisation has a direct effect on regional prosperity. It also has an indirect effect on innovation, by increasing public R&D which is in turn shown to be associated with private R&D, which is a driver of innovation (measured as patenting).

The study suggests that innovation plays an important role in linking cluster agglomeration to regional performance. While this relationship may vary from one cluster category to another, on the aggregate level of all cluster categories, innovation appears to drive to proximity effects that translate into region-level prosperity.

Study 6

Since the 1990, thousands of cluster initiatives have been launched. These are efforts to enhance the growth and competitiveness of clusters, and they typically result in a cluster organisation. This study uses survey data from 713 cluster organisations in 28 advanced economies as well as transition and developing economies.

Cluster organisations engage in a wide variety of activities, of which some are frequent and others rare. A factor analysis indicates that the activities form seven categories: Joint production, HR upgrading, Branding, Firm formation, Business environment, Intelligence, and Joint R&D. The relative importance of these groups tends to vary by initiator (government vs. non-government), age of the organisation, whether the organisation has organised cooperation with other cluster organisations, whether the organisation has an office or not, and the size of the organisation (number of participating firms).

The study also includes a model for four performance measures, based on the perceived performance reported by the cluster organisation managers. These models were applied to cluster organisations in advanced economies older than two years and show, as expected, that different activity categories have bearings on different indicators of performance. However, they do not show a performance effect of the initiator (government vs. non-government) or cooperation with other cluster organisations.

Study 7

While cluster agglomerations are objectively observable phenomena, clusters are also cognitive entities when they are the targets of efforts by cluster organisations. As public-private partnerships, cluster organisations engage diverse groups of participants, and this study examines if there are systematic differences in the views of participants from the public sector compared to those from the private sector. The empirical data is collected through a survey among 75 private sector and 26 public sector participants in a biotech cluster organisation in Uppsala, Sweden.

The analysis confirms that the two groups perceive the cluster differently. Public sector respondents rated the strengths competitive position of the cluster considerably higher than private sector respondents. They also had more optimistic expectations on the outcomes of the cluster initiative. The differences between the groups also extended to their views on which activities were important for the cluster initiative to pursue. Public sector respondents tended to differentiate less between the importance of different activities, while private sector respondents tended to prioritise certain activities more clearly.

Study 1

Decomposing industry localisation: concentration and urbanisation of industries in Sweden

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Study 1

Decomposing industry localisation: concentration and urbanisation of industries in Sweden

ABSTRACT The connection between intra-industry proximity effects and industry localisation has been considered unproblematic. Industry localisation has been treated as an indicator of Marshallian proximity effects. However, this paper argues that localisation is an effect also of urbanisation effects. To identify intra-industry agglomeration, localisation therefore must be separated into two components of concentration and urbanisation. The paper proposes the *Q* function, a measure based on Ripley's *K* function, as a way of achieving this. The *Q* function has an intuitive interpretation directly relevant for proximity effects. When applied to 30 industries in Sweden, the *Q* function reveals patterns of concentration and urbanisation, which with traditional localisation measures will be confounded and indistinguishable. The analysis also suggests that using the whole manufacturing sector as the reference distribution will give biased results when measuring localisation.

Introduction

The twin concepts of proximity effects and geographical agglomeration of economic activity have been the subject of a growing stream of research. External economies are economic benefits that a firm derives from the activities of other firms (or disadvantages, if the economies are negative). If these economies are local in nature, so that they affect firms in close spatial proximity more than they do firms that are located at a distance, they could over time produce patterns of localisation whereby firms tend consistently to be co-located with one another, leading eventually to agglomeration. Conversely, when firms are found empirically to agglomerate, this is considered to be an indicator of external economies or other proximity effects. Proximity effects explain such phenomena as cities and industry clusters: cities are agglomerations of economic activity in general, while clusters are agglomerations of certain industries that are related to each other.

Proximity effects generally fall into two categories. One type is effects that occur between firms in the same industry: intra-industry effects. These were first described by Marshall in 1890 (1920, 8th ed.), and referencing the further contributions of Arrow (1962) and Romer (1986), these economies are often referred to as Marshall-Arrow-Romer or MAR externalities, or alternately, as *localisation* externalities. They are driven by such phenomena as knowledge spillovers and labour pooling. The other type occurs across industries, and can be termed *urbanisation* effects. Jacobs (1969) argued that the most significant knowledge spillovers occur between industries, not within them. Cities that house many firms in a varied range of industries are therefore most likely to generate innovation and growth.

Many studies have sought to assess the strength of these two types of proximity effects, and one aim of particular interest has been to determine which of the two types exert stronger influences. Marshallian externalities are usually measured as relative concentrations using the so-called location quotients, or as absolute concentrations using the counts of establishments or employees. For urbanisation effects, the indicator is usually total employment, diversity measured as the Herfindahl index of employment across industries, or population density. (See Beaudry & Schiffauerova, 2009 for an overview.)

The generally accepted assumption is that concentration and urbanisation can be measured separately, and that measures of localisation, such as the location quotient, are valid indicators of Marshallian externalities. However, this paper will argue that the assumption that localisation follows specifically from intra-industry effects is flawed. In fact, concentration is confounded by urbanisation, as the following illustration will show.

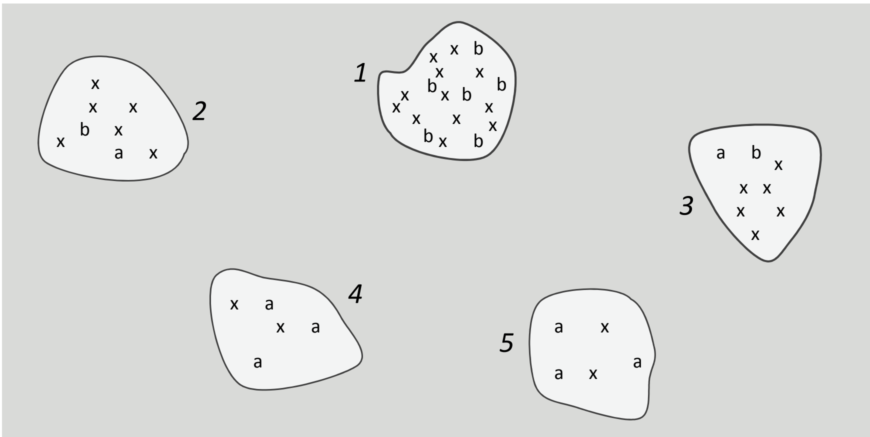
Consider a country consisting of five small islands of roughly equal size, located in an ocean far from other islands. The islands are so small that any proximity effect will have an effect between two firms on the same island, but so far apart that no proximity effects will reach between two islands. There are several firms on these islands, some in industry A, some in industry B, and the rest in various industries which we will collectively label X. The urban island 1 is densely populated, while islands 2 and 3 have medium-sized populations, and the rural islands 4 and 5 are sparsely populated.

Imagine now that industries A and B are subjected to agglomeration economies that arise *only* from co-location with *any* type of firms. For A and B, *Marshallian agglomeration effects do not exist*. In other words, although it matters how many *total* firms they are co-located with, co-location with firms of *their own* industry has no particular effect whatsoever, nor any discernible impact, whether positive or negative. Industry A is affected *negatively* by the proximity to other firms, perhaps because industry activities demand a great deal of space and therefore cannot flourish in an area with high land costs. Conversely, industry B is affected *positively* by proximity to other firms, perhaps because it benefits from having as large a local customer base as possible.

Given these conditions, how would firms most likely be distributed across the islands? Industry A would tend to locate on islands 4 and 5, where population density is lowest. Some firms may end up on islands 2 and 3, but industry A would be mostly absent from the urban island 1. Conversely, industry B will locate primarily on island B, and while a few firms may locate to islands 2 and 3, industry B will largely avoid the rural islands 4 and 5. (See Figure 1.) To this juncture, the model is very straightforward: industries that benefit from urban locations will locate in urban locations, and industries that prefer rural locations will locate in rural locations.

However, after more in-depth assessment of the concentration tendencies of these industries, an interesting twist begins to emerge. Regardless of whether we use absolute or relative measures, we find that both industry A and industry B are *concentrated:* that is, they appear to co-locate with firms of their *own* industry. Island 1 exhibits a clear disproportionality of B firms, and islands 4 and 5 are overrepresented in industry A's location choices. As evidence of this, the Gini values for both A and B would show that they have disproportionate distributions. This would seem to suggest that intra-industry agglomeration forces are at work, but that inference would be incorrect. Furthermore, if we test this supposition by calculating the correlation between performance and concentration, the false hypothesis would

Figure 1. Five hypothetical islands two industries

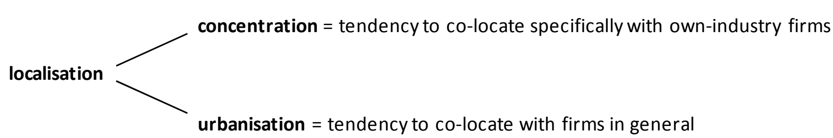


appear to be confirmed. For example, A firms on the rural islands 4 and 5 would perform better than those on the less rural islands 2 and 3. At the same time, A firms on 4 and 5 would also have higher location quotients than those on 2 and 3. So in this case, location quotients, the most commonly used measure for concentration, would correlate well with performance. Were we to use absolute measures, firm counts instead of location quotients, the result would be the same. The analysis would point clearly to the ultimately erroneous conclusion that industries A and B benefit from intra-industry co-location and therefore tend to concentrate. The conclusion is incorrect, because no intra-industry forces are operating here; in fact, the localisation of industries A and B came about through urbanisation forces alone.

This simple example shows that urbanisation effects alone can produce localisation patterns that are similar to intra-industry agglomeration effects. It demonstrates the need for a measure that more clearly distinguishes between agglomeration effects in general (urbanisation) and intra-industry agglomeration effects (concentration). This result may be surprising, since it is often assumed that using relative measures that take into account the overall population in a region would eliminate any urbanisation effect and show only the impact of the concentration effect. In practice, however, this is not the case. If an industry is urban, it will be *more than* proportionally represented in urban regions. Conversely, if an industry is rural, it will be *more than* proportionally represented in rural regions.

To keep the terminology clear, I will use three terms in this paper to distinguish between different types of agglomeration. I use *concentration* to denote the tendency to co-locate *particularly* with own-industry firms; *urbanisation* signifies the tendency to co-locate with other firms regardless of industry; and *localisation* is used to describe the two effects jointly, i.e., the tendency of firms to co-locate irrespective of whether the underlying tendency is concentration or urbanisation. (See Figure 2.) These effects can be positive or negative (or neutral): in terms of concentration, industries can be *concentrated* or *dispersed* (or neither), and in terms of urbanisation, they can be *urban* or *rural* (or neither).

Figure 2. Two types of localisation



The purpose of this paper is to present such a method for separating localisation into constituent forces of concentration and urbanisation, thus teasing apart indicators of the two types of effects. It is applied to a selection of 30 manufacturing and non-manufacturing industries in Sweden. The results show that concentration and urbanisation can indeed vary independently of one another, and that localisation of an industry can be the result of different combinations of concentration and urbanisation. It also shows that localisation functions as an important phenomenon both inside and outside the province of the manufacturing sector.

The rest of this paper is organised as follows: The next section presents an overview of methods used for measuring localisation in previous literature. The following introduces the *Q* function, a measure based on Ripley's *K* function, here proposed as a way of measuring concentration and urbanisation separately. The next section presents the dataset on the location of establishments in 30 Swedish industries, while the following presents the results of the analysis. The implications of the findings are then discussed, and the final section summarises the conclusions.

Measures of geographical concentration

In the extensive literature on industry agglomeration over the past two decades, three generations of measures have been used (Arbia, Espa, & Quah, 2008; Duranton & Overman, 2005). The first generation relied on regional data to measure the disproportionality of industry distributions across regions. Gini, Krugman, Theil, and Generalised Entropy are examples of such measures. In their absolute form (e.g. Midelfart-Knarvik, Overman, Redding, & Venables, 2002), they compare actual distributions with a distribution in which every region has the same share of an industry (with N regions, each region's reference share is $1/N$). In their relative form (e.g. Amiti, 1999; e.g. Brülhart & Torstensson, 1996), they compare some distribution against a reference distribution, most commonly the total population of the region. In the relative case, the ideal distribution is said to exist when each region has the same share of an industry as the region's share of the total population (the reference share for region n is $pop_n / \sum pop_n$). Some studies include both relative and absolute measures of concentration (e.g. Haaland, Kind, Knarvik, & Torstensson, 1999).

The second generation of measures stem from a model described by Ellison and Glaeser (1997), which measures concentrations over and above the level of concentration that could be expected to occur by chance alone (e.g. Rosenthal & Strange, 2001). The reference distribution in this model is a random one, similar to what would result if one threw darts randomly at a map. To achieve this, the number and size distribution of establishments must be taken into account. This is because high *industrial* concentration—meaning the dominance in employment of a few establishments—will in itself lead to *geographical* concentration of employment in the regions where the largest establishments are located, without reflecting the presence of any intra-industry agglomeration effects. Later studies have developed the measure through further refinements and modifications (Deverau, Griffith, & Simpson, 2004; Maurel & Sédillot, 1999).

The first two generations of measures are regional totals that assign establishments or employees to a region only. In these models, neither the distribution within those regions nor the relative location of regions to one another will affect the measure. The third generation overcomes these limitations by assessing the location of establishments irrespective of any regional borders. In the words of Duranton and Overman (2005, p. 1078), it treats establishments as "dots on a map" instead of "units in boxes". This makes it possible to study agglomeration across any distance, rather than promoting an undue focus upon a small number of aggregation levels for which regional statistics are available (such as municipalities, counties, states, etc.). However, this model does require detailed information about the location of each individual establishment. For large samples, the computations can become laborious, requiring hours or days of data processing instead of milliseconds. This class of measures is based on Ripley's *K* function (Bartlett, 1964; Ripley, 1977), which has been used previously for applications such as the ecological analysis of tree location and distribution. Introduced by Marcon and Puech (2003a), it measures the degree of co-localisation for an arbitrary range. It has been used for measuring degree of concentration, as well as the range at which concentration reaches an optimum for manufacturing industries in Paris (Marcon & Puech, 2003a, , 2003b, , 2007) and the UK (Duranton & Overman, 2005).

These three generations of measures have been used to quantify geographical industry concentration, as well as to use this measure to assess the strength of intra-industry effects of Marshallian or "new trade theory" types. Haaland et al. (1999) use the modified Hoover-Balassa index to evaluate the strength of market linkages within an industry, economies of scale, and local intra-industry demand conditions. Amiti (1999) regresses industries' use of intermediate inputs on the relative Gini in order to asses how vertical linkages influence geographical concentration. Devereux et al. (2004) use three concentration measures derived from the Ellison-Glaeser index to test the importance of knowledge spillovers as a driver of industry concentration. Rosenthal and Strange (2003) use counts of own-industry employment within concentric rings of each establishment to test the effect of localisation on the birth of new establishments. (For further examples see Beaudry & Schiffauerova, 2009.)

The common assumption that yokes together this extensive stream of research is that intra-industry effects are directly related to a measure of the degree of industry localisation (usually referred to as "concentration"). But, as the example with the five islands set forth in the introduction demonstrated, industry localisation can come about from intra-industry effects (concentration effects) as well as from trans-industry effects (urbanisation). This paper aims to resolve the persistent mismatch between the effect studied and the measure quantifying it.

Before proceeding, however, a brief note is merited on the choice of industry sectors included in the study and the choice of reference populations with which the industries are compared. Many past studies have chosen to analyse the manufacturing industry only,[1] and to use manufacturing as a whole as the reference distribution. The assumption is that manufacturing as a whole represents the "normal" or expected degree of localisation, and that an industry is concentrated only if it displays a higher degree of localisation than manufacturing as a whole. This assumption is explicit in many studies. For instance, Brülhart and Torstenson (1996, p. 14) state that where "the Gini index is (close to) zero, a sector is not localised, but spread out in line with total manufacturing employment". Duranton and Overman (2005) framed this argument slightly differently, suggesting that manufacturing may in itself be concentrated, but that this level of concentration should be discounted when one measures an industry's overall concentration:

> "This measure must also control for the *general tendency of manufacturing to agglomerate*. For instance in the United States (U.S.), even in the absence of any tendency towards localization, we would expect any typical industry to have more employment in California than in Montana. This is simply because the former has a population more than 30 times as large as the latter." (ibid., p. 1078, my emphasis)

Although this formulation sounds a bit like the core argument set forth in this paper—that urbanisation effects should be accounted for when measuring concentration—what Duranton and Overman are actually referring to in this excerpt is merely the advantage of *relative* concentration measures.

In a study of Japan, Dekle and Eaton (1999) treat manufacturing as a single industry and compare it with the finance sector. They find that agglomeration effects are lower in manufacturing than in fi-

[1] Exceptions include Combes (2000) and Marcon and Puesch (2007).

nance, and that the agglomeration effect drops much more rapidly in finance than in manufacturing. A plausible explanation for this would be that by comparing such a wide variety of activities as “manufacturing” to the more specifically defined finance sector, the agglomeration effects they study may in fact be of a wholly different character. For finance, they capture specific intra-industry effects, but for manufacturing, they measure only such proximity effects that operate across all manufacturing sectors. Presumably, such externalities must be quite diffuse and broad-based.

Decomposing localisation into concentration and urbanisation

Ripley’s K function (Ripley, 1977; , 1979) is used to compare the location of establishments with a point process, using a random process whereby the result is a point defined by its coordinates *(x, y)* in a predefined domain.[2] Consider an area of size A where there are N_i establishments belonging to industry *i*. Ripley’s K for industry i is defined as

$$K_i(r) = \lambda_i^{-1} \cdot E\{\text{number of establishments in industry } i \text{ located within distance } r \text{ from an arbitrary establishment } i\}$$

where λ_i is the density of industry *i*.

$K_i(r)$ can be estimated using a dummy variable $c_{i,j}$ to count the number of neighbours. For every pair of establishment i_a and i_b, we define $c_{i,j}(i_a, i_b, r)$ as 1 if point i_a and point i_b are within distance r from one another, and 0 otherwise.

$$\widehat{K}_i(r) = \frac{1}{\hat{\lambda}_i}\frac{1}{N_i - 1}\sum_{i_a}^{N_i}\sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r) = \frac{A}{N_i}\frac{1}{N_i - 1}\sum_{i_a}^{N_i}\sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$$

This expression has an important interpretation. The sum $\sum_{i_a}^{N_i}\sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$ is the number of (ordered) pairs of establishments that are co-located within distance *r*. The product $N_i(N_i - 1)$ is the total number of possible (ordered) pairs of establishments, since each

[2] For a full presentation of Ripley’s K function, see Marcon and Puech (2003a) or Cressie (1993).

establishment can be pared with all other establishments except with itself. This means that

$$\frac{\widehat{K}_i(r)}{A} = \frac{1}{N_i(N_i - 1)} \sum_{i_a}^{N_i} \sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$$

is the ratio of all pairs that occur within distance r of one another. If the value of this ratio is 0.25, it means that a quarter of all possible co-localisation of establishments has materialised; in other words, 25% of all possible pairs of establishments are co-located with each other.

Alternatively, we can rearrange the expression as

$$\frac{\widehat{K}_i(r)}{A} = \frac{1}{N_i} \sum_{i_a}^{N_i} \frac{1}{(N_i - 1)} \sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$$

The last sum, $\sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$, is the total *number* of establishments i_b within distance r of a particular establishment i_a. There are $N_i - 1$ possible establishments, since $i_b \neq i_a$, which means that $\frac{1}{(N_i - 1)} \sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$ is the *share* of establishments within distance r of a particular establishment i_a. If we calculate the average of this share for all N_i establishments, we get

$$\frac{\widehat{K}_i(r)}{A} = \frac{1}{N_i} \sum_{i_a}^{N_i} \frac{1}{(N_i - 1)} \sum_{i_b \neq i_a}^{N_i} c(i_a, i_b, r)$$

If, for instance, this value is 0.25, it means that, on average, a random establishment is within distance r of 25% of all other establishments.

$\widehat{K}_i(r)\,/A$, which we will define as the *Q function*, thus has two similar and intuitive interpretations:

$$\begin{aligned} Q_i(r) &= \widehat{K}_i(r)\,/A \\ &= \text{average share of establishments within distance } r \text{ from any given establishment} \\ &= \text{share of all possible establishment pairs that are within distance } r \text{ of each other} \end{aligned}$$

Ripley's *K* therefore has an advantage over Gini and similar measures, in that it has an immediate and intuitive interpretation in terms that are directly relevant for the study of economic proximity effects.[3] It gives a direct measure of the degree of co-location between establishments, which tells us much more about potential proximity effects than does a measure that captures how disproportionate a distribution may be.

Ripley's *K* can also be expressed in a bivariate form to measure the degree of co-location of establishments in two different industries (Arbia, Espa, & Quah, 2008). If N_j is the number of establishments in industry *j* with density λ_j, the bivariate $K_{ij}(r)$ can be estimated as

$$\widehat{K}_{ij}(r) = \frac{1}{A\hat{\lambda}_i\hat{\lambda}_i}\sum_{i}^{N_i}\sum_{j}^{N_j} c(i,j,r)$$

where A is the total surface of the area, $\hat{\lambda}_i = N_i/A$ and $\hat{\lambda}_j = N_j/A$. If we divide by A and rearrange the expression, we get the definition for the Q function for two different industries:

$$Q_{ij}(r) = \frac{\widehat{K}_{ij}(r)}{A} = \frac{1}{A^2\hat{\lambda}_i\hat{\lambda}_i}\sum_{i}^{N_i}\sum_{j}^{N_j} c(i,j,r) = \frac{1}{A^2}\frac{\sum_i^{N_i}\sum_j^{N_j} c(i,j,r)}{N_i/A \cdot N_j/A} = \frac{\sum_i^{N_i}\sum_j^{N_j} c(i,j,r)}{N_i \cdot N_j}$$

Again, the last expression has an intuitive interpretation. $\sum_i^{N_i}\sum_j^{N_i} c(i,j,r)$ is the number of establishment pairs *(i, j)* that are within distance *r* from each other. $N_i \cdot N_j$ is the total number of establishment pairs. If this quotient is 0.5, half of the possible co-location has materialised; half of all possible pairs of establishments are within distance *r* of each other. Expressed differently, the average establishment in industry *i* is within distance *r* of 50% the establishments in industry *j*. Please note that this measure is symmetric: $\widehat{K}_{ij}(r)$ is equal to $\widehat{K}_{ji}(r)$.

Let us now return to $\widehat{K}_i(r)/A$, which we found was a measure of industry concentration for industry *i*. Although $\widehat{K}_i(r)/A$ is an abso-

[3] The Krugman index also has an intuitive interpretation, namely the share of establishments that would need to move to another region in order to achieve a homogenous distribution. However, although this has a direct and understandable meaning, the immediate relevance for agglomeration effects is questionable.

lute measure of the concentration, this value in itself is not the focus of our interest. As Duranton and Overman (2005) point out, the relevant question is whether or not the industry is concentrated *over and above* overall economic activity. In other words, we want to relate the value of $\widehat{K}_i(r)/A$ to some measure of the overall concentration of economic activity. This comparison must be adjusted for the particular area we are studying for two reasons. First, the value will depend on the size of the area *A*, so that smaller countries will be assigned larger values than bigger countries. For example, since the whole country of Malta fits within a circle of diameter 40 km, most industries will have a very high value for $\widehat{K}_i(25\,\text{km})/A$ regardless of their concentration. For $\widehat{K}_i(40\,\text{km})/A$ the value will even be 1 for every industry. Second, the distribution of establishments depends partly on the shape and geographic conditions of the area. Lakes, coastlines, wetlands, mountains and other construction obstacles produce patterns of varying establishment density, regardless of any economic agglomeration effects.

We can, however, adjust for this effect by dividing by the $\widehat{K}(r)/A$ value for *all* economic activity. To do this, we consider all establishments as a single industry and denote it *x*. The total number of establishments is N_x, and we calculate $Q_x(r)$ in the same way as for the single industry *i*:

$$Q_x(r) = \frac{\widehat{K}_x(r)}{A} = \frac{1}{N_x(N_x - 1)} \sum_{x_a}^{N_x} \sum_{x_b \neq x_a}^{N_x} c(x_a, x_b, r)$$

We can now formulate a measure for the concentration of industry i given a distance *r*. It is the degree to which establishments in industry *i* are co-located (within distance *r*) *compared to* the degree that establishments *in general* are collocated (within distance *r*):

$$\text{localisation of } i\ (r) = \frac{Q_i(r)}{Q_x(r)} = \frac{\sum_{i_a}^{N_i} \sum_{i_b \neq ix_a}^{N_i} c(i_a, i_b, r) \Big/ N_i(N_i - 1)}{\sum_{x_a}^{N_x} \sum_{x_b \neq x_a}^{N_x} c(x_a, x_b, r) \Big/ N_x(N_x - 1)}$$

So far, what we have achieved is an adjusted value for the concentration of *i*, which takes into account the inhomogeneity of the overall establishment distribution within the area *A*. Now, we will go one step further by introducing the co-location between i and x:

$$Q_{ix}(r) = \frac{\widehat{K}_{ix}(r)}{A} = \frac{\sum_i^{N_i}\sum_x^{N_x} c(i,x,r)}{N_i \cdot N_x}$$

We multiply and divide by $Q_{ix}(r)$ and get the product of two quotients:

$$\text{localisation of } i\ (r) = \frac{Q_i(r)}{Q_x(r)} = \underbrace{\frac{Q_i(r)}{Q_{ix}(r)}}_{concentration} \cdot \underbrace{\frac{Q_{ix}(r)}{Q_x(r)}}_{urbanisation}$$

We have now arrived at the central idea of this paper, namely that *the localisation of an industry is the product of two distinct effects,* for which I will use the terms *concentration* and *urbanisation*.

The ***concentration*** quotient, $Q_i(r)/Q_{ix}(r)$, is the tendency of establishments in industry i to co-locate with other establishments of industry i compared to their tendency to co-locate with establishments of any industry. If this value is >1, the industry i has a tendency to concentrate, which suggests net positive proximity effects of concentration. If it is <1, it has a tendency to disperse, which is an indication of net negative proximity effects of concentration. If $Q_i(r)/Q_{ix}(r) = 1$, then establishments in industry i are neither more nor less likely to co-locate with their own industry than with other industries, which in turn suggests that there are neither positive nor negative proximity effects of concentration, or rather, that the net result of them is zero.

The ***urbanisation*** quotient, $Q_{ix}(r)/Q_x(r)$, is the tendency of establishments in industry i to co-locate with establishments of any industry compared to the tendency of establishments of any industry to co-locate with establishments of any industry. If this value is >1, the industry i has a tendency to locate close to establishments in general, which suggests net positive proximity effects of urbanisation. If it is <1, it has a tendency to locate away from establishments of any industry, which is an indication of net negative proximity effects of urbanisation. If $Q_i(r)/Q_{ix}(r) = 1$, then establishments in industry i are neither more nor less likely than establishments in general to co-locate with establishments in general, which suggests there are neither positive nor negative proximity effects of urbanisation, or that the net result of them is zero.

It is important to bear in mind that both concentration and urbanisation depend on *r*. In other words, the tendency to concentrate can vary by distance. An industry might benefit from concentration over short distances, but may experience a negative effect from long-range concentration. Some retail activities, for instance, may suffer from competition for customers with peers over a long distance, while simultaneously benefitting from co-locating closely with peers since a tight cluster of shops will attract customers. In this example, being located within 25 km from as few peers as possible, but within 1 km from as many peers as possible could yield optimal benefits. Similarly, urbanisation is distance-dependent. For example, an industry such as household waste treatment plants could benefit from being within 25 km of as large a population as possible, but at the same time need to avoid highly urban areas at a close distance of 1 km.

To summarise the main point: using Ripley's K in the form of the Q function, we can decompose localisation into the constituent components of concentration and urbanisation.

$$\text{localisation of } i\ (r) = \text{concentration of } i(r) \cdot \text{urbanisation of } i(r)$$
$$= \frac{Q_i(r)}{Q_{ix}(r)} \cdot \frac{Q_{ix}(r)}{Q_x(r)}$$

The key implication of this decomposition is that if we are interested in studying industry localisation as a sign of proximity effects, we must be aware that two different types of effects are at play. One type, generally associated with Marshallian effects, has to do with the benefits achieved by co-locating specifically with own-industry firms. The other type, more frequently associated with Jacobian effects, concerns the benefits of co-location with economic activity in general. Unless we separate these two effects, we cannot tell which type of benefits are at play. With the measures I have suggested above, this process of separation is indeed possible. To illustrate this point, we will now study the concentration and urbanisation of industries in Sweden.

Method

The data for this study are drawn from the most comprehensive database available on the location and industry classification of establishments in Sweden. Sweden fits several key suitability criteria as a candidate for this type of study. It constitutes an administratively homogenous area, having been an independent and unified state since 1523 and with its current borders unchanged since 1814. To the east and south lies the Baltic Sea, and the land borders with Finland and Norway are sparsely populated. Almost all of the population is found more than 100 km from neighbouring countries, and the only significant trans-national agglomeration is the Malmö-Copenhagen region. From an agglomeration perspective, this makes Sweden similar to island nations like the UK and Ireland, which considerably reduces the potential for problems associated with edge effects (Marcon & Puech, 2003a). In addition, Sweden offers significant variation in the degree of urbanisation, with several highly urban regions as well as a number of large, rural regions.

The database contains information about 1.6 million establishments (plants) in operation in Sweden as of January 2008. Because it records establishments, rather than firms, it contains the actual worksite location of employees, rather than just the location of the corporate headquarters. Excluding erroneous and missing data, a valid industry and postcode is known for 1,453,165 establishments, and these form the population for this study. Each establishment is classified into one of 806 5-digit industry categories according to the SNI 2007 classification system, which is based on NACE Rev. 2. The population includes establishments in all types of industries, including agriculture, extraction, manufacturing, and services. There are on average 1,741 establishments per industry code (range 1 to 123,260 establishments).

This study focuses on 30 of these industries. They have been selected in order to represent a wide range of activities across industry classes, with particular attention paid to non-manufacturing industries, including services and agricultural activities. Additional criteria for the selection of industries were the inclusion of industries that exhibit vertical relationships, as well as industries with at least 50 establishments with employees. The selected industries are presented in Table 1.

Table 1. Establishments counts for the selected industries

Code	*Industry*	N_{empl}	N_{tot}	*Code*	*Industry*	N_{empl}	N_{tot}
1462	Slaughter swine raising	186	570	29101	Cars	52	140
1471	Egg production	127	353	29200	Coachwork	164	275
1472	Poultry raising	103	267	29320	Vehicle parts and access.	297	580
1491	Reindeer husbandry	51	1 450	33150	Ship and boat repair	263	1 135
3111	Marine trawling	85	1 184	46320	Meat wholesale	157	490
8120	Gravel and sand pits	282	548	46610	Agricultural wholesale	450	961
10111	Livestock slaughtering	60	187	47220	Meat retail	81	332
10200	Fish processing	118	248	47230	Fish retail	200	765
10710	Bakeries	911	1 701	58110	Book publishing	418	2 323
18122	Book printing	1 100	2 691	65120	Non-life insurance	407	517
18130	Pre-press	343	1 199	66120	Sec. and comm. brokerage	361	1 571
21200	Pharmaceuticals	81	159	74102	Graphic design	775	8 397
26110	Electronic components	153	402	81222	Chimney cleaning	272	514
26200	Computers	88	265	85420	Tertiary education	1 178	1 445
26300	Communications equipment	168	329	96021	Hairdressing	2 387	24 451
					Total	11 318	55 449

Most establishments represent single-person firms without employees. Since agglomeration effects may differ between firms with and without employees, calculations have been done both for the total population of all establishments, as well as for the sub-population of establishments with employees. The latter group contains 376,245 establishments.

The main analysis has been performed using the data drawn from establishments with employees, while results for establishments without employees can be found in the Appendix. However, for reindeer husbandry, marine trawling, and hairdressing, a significant majority of establishments have no employees. Location patterns for hairdressers do not change notably if all establishments are included. For reindeer husbandry and marine trawling, however, there is a noticeable difference, and the number of establishments with employees is miniscule. For these two industries, all establishments have therefore been included in one of the graphs.

To reduce the amount of time needed for calculations, the location of each establishment is determined by the centroid of its post code area, rather than the exact address location (following the precedent of Rosenthal and Strange (2003), Marcon and Puech (2003b), and Duranton and Overman (2005)). Establishments are spread across 11,028 postcodes, with an average of 127 establishments per postcode (range 1 to 1,392 establishments). Most postcode areas are very small and are located less than 1 km away from the next closest postcode area. 50% of the establishments are found in postcodes areas less than 0.8 km from the closest other postcode area, 90% within 5.3 km, and 99% within 15.6 km. The average margin of error is about 2.5 km (Duranton & Overman, 2005).

Distance between establishments is measured as the spherical (geographical) distance between postcode centroids.[4] Spherical distance is used here as a proxy for travel distance. In a French study, Combes and Lafourcade (2005) found that the spherical distance's correlation with real travel distance and real travel time was 0.991 and 0.972 respectively. Calculations have been made for four distances: $r = 1$ km, $r = 5$ km, $r = 25$ km and $r = 125$ km.

Results

Values for localisation, concentration, and urbanisation for establishments with employees in the selected industries are presented in Table 2. (For the entire population of all establishments, see the Appendix.)

It should be noted that all of these calculations are performed using *total economic activity* (all industry sectors) as the reference distribution X. If instead *manufacturing* is used as the reference distribution[5] (as is often the case in studies such as this), the results differ dramatically. The reason behind this discrepancy is that manufacturing as a whole is rural (0.41) and dispersed (0.85). Concentration values are thus multiplied by 2.4 (1/0.41) and urbanisation values with 1.2 (1/0.85), giving localisation values that are multiplied by 2.8 (2.4 · 1.2). The choice of reference population is therefore a

[4] Because of Sweden's size, totalling a distance of more than 1,600 km from north to south, I have used spherical distances instead of Euclidian (straight line) distances. However, up to 125 km, as used in this paper, the difference is negligible.

[5] The manufacturing population is 68,417 establishments, of which 25,347 have employees.

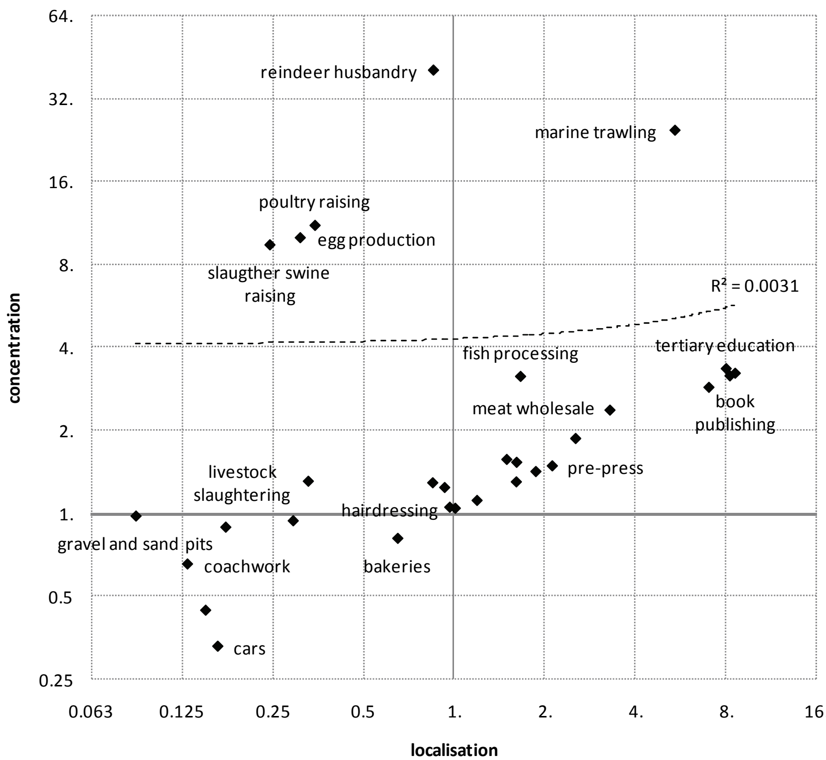
Table 2. Localisation, concentration, and urbanisation values for 30 Swedish industries

	1 km			*5 km*			*25 km*			*125 km*		
	loc	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*
Slaughter swine raising	1.48	21.58	0.07	0.24	9.39	0.03	0.66	3.81	0.17	1.22	1.23	0.99
Egg production	1.25	16.11	0.08	0.31	9.97	0.03	0.48	2.64	0.18	1.00	1.27	0.79
Poultry raising	1.90	23.41	0.08	0.35	11.05	0.03	0.89	4.65	0.19	1.92	2.44	0.79
Reindeer husbandry	6.52	58.93	0.11	0.85	40.42	0.02	0.32	30.75	0.01	0.89	18.13	0.05
Marine trawling	13.50	46.25	0.29	5.41	24.47	0.22	4.49	6.72	0.67	2.51	3.36	0.75
Gravel and sand pits	0.45	2.74	0.16	0.09	0.98	0.09	0.19	0.65	0.29	0.73	0.91	0.81
Livestock slaughtering	1.25	6.02	0.21	0.33	1.30	0.25	0.27	0.83	0.32	0.64	0.96	0.67
Fish processing	7.06	22.94	0.31	1.66	3.13	0.53	0.82	1.62	0.51	1.25	1.63	0.77
Bakeries	0.55	0.77	0.71	0.65	0.81	0.80	0.68	0.83	0.82	0.87	0.94	0.93
Book printing	1.09	1.31	0.83	1.19	1.11	1.07	1.17	1.08	1.08	1.12	1.06	1.05
Pre-press	2.03	1.54	1.32	2.12	1.48	1.43	1.92	1.39	1.38	1.36	1.18	1.15
Pharmaceuticals	2.57	4.95	0.52	1.61	1.53	1.06	1.40	1.27	1.10	1.25	1.16	1.08
Electronic components	1.14	2.36	0.49	0.93	1.24	0.75	2.01	1.43	1.40	1.34	1.20	1.12
Computers	0.29	0.53	0.55	0.97	1.05	0.92	1.31	1.15	1.13	0.97	0.97	1.00
Communications equipment	2.05	1.73	1.18	1.87	1.41	1.32	2.83	1.72	1.65	1.54	1.31	1.18
Cars	0.84	2.18	0.38	0.16	0.33	0.50	0.94	0.95	0.99	1.20	1.09	1.10
Coachwork	0.66	4.21	0.16	0.13	0.65	0.20	0.21	0.65	0.32	0.72	0.95	0.76
Vehicle parts and accesso-ries	0.82	2.78	0.29	0.29	0.94	0.31	0.35	0.86	0.41	1.06	1.16	0.91
Ship and boat repair	1.61	4.25	0.38	0.85	1.29	0.66	1.83	1.53	1.19	1.58	1.40	1.13
Meat wholesale	8.82	11.92	0.74	3.29	2.36	1.39	2.24	1.51	1.49	1.32	1.19	1.11

cont.	*1 km*			*5 km*			*25 km*			*125 km*		
	loc	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*
Agricultural wholesale	0.54	2.79	0.19	0.17	0.89	0.20	0.25	0.88	0.29	0.94	1.11	0.84
Meat retail	8.04	3.73	2.15	2.53	1.86	1.36	1.87	1.67	1.12	1.35	1.34	1.00
Fish retail	1.48	1.51	0.98	1.50	1.56	0.96	1.89	1.90	0.99	1.55	1.55	1.00
Book publishing	10.95	3.90	2.81	8.57	3.21	2.67	3.85	2.03	1.90	1.89	1.48	1.28
Non-life insurance	3.31	1.93	1.71	1.61	1.30	1.24	0.70	0.82	0.85	0.79	0.91	0.87
Security and commodity brokerage	18.95	5.49	3.45	7.01	2.86	2.45	4.21	2.12	1.99	1.90	1.51	1.26
Graphic design	7.63	3.41	2.24	8.23	3.14	2.62	4.43	2.20	2.01	2.00	1.55	1.29
Chimney cleaning	0.30	1.08	0.28	0.15	0.44	0.34	0.25	0.50	0.50	0.75	0.91	0.83
Tertiary education	25.78	8.89	2.90	8.00	3.34	2.39	2.55	1.70	1.51	1.17	1.13	1.04
Hairdressing	1.88	1.55	1.21	1.01	1.04	0.97	0.80	0.91	0.88	0.94	0.98	0.96

Note: Establishments with employees.

Figure 3. Localisation and concentration for 30 Swedish industries

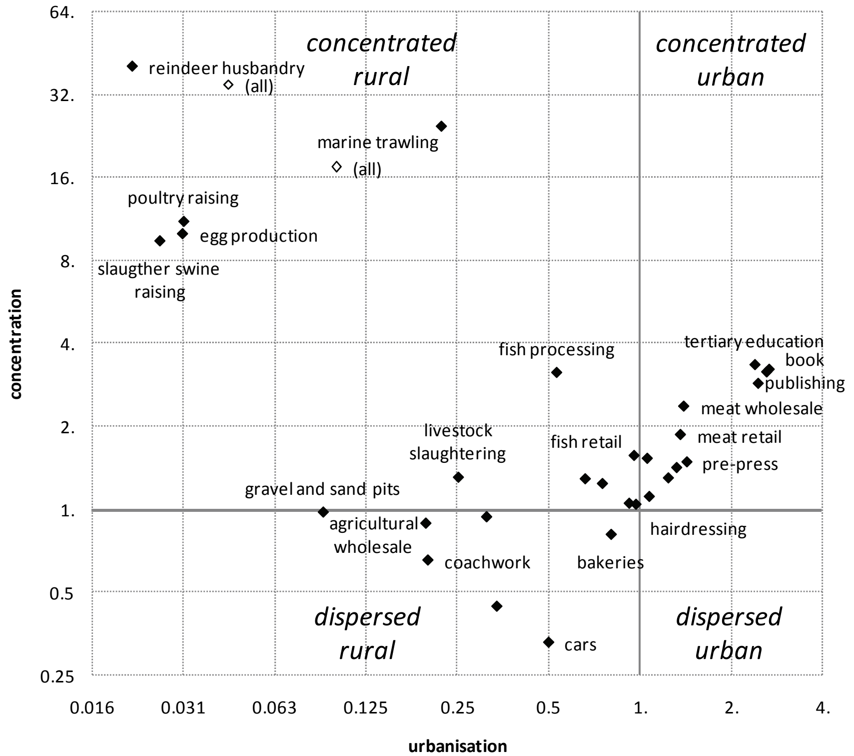


Note: Establishments with employees, *r* = 5 km.

critical determinant of outcome when estimating agglomeration effects.

The results suggest that localisation varies quite independently from concentration. Figure 3 shows localisation and concentration for *r* = 5 km. It is clear from this graph that although for many industries there is some correlation between localisation and concentration, the overall relationship is vague and ill-defined. For instance, agricultural industries such as poultry raising and egg production have a low localisation, but are highly concentrated. Figure 4 shows concentration and urbanisation for the 30 industries.

Figure 4. Urbanisation and concentration for 30 Swedish industries



Note: Establishments with employees, *r* = 5 km.

Correlation coefficients for all measures are given in Table 3. These data should be interpreted with some caution, since the table contains unweighted correlations for a selection of 30 industries only. Still, the tendency is quite clear: localisation is not an unproblematic proxy for concentration.

Table 3. Correlation between different agglomeration measures

		1 km			*5 km*			*25 km*			*125 km*	
		loc	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*
1 km	*conc*	.270										
	urb	.715**	−.287									
5 km	*loc*	.842**	.049	.827**								
	conc	.220	.952**	−.219	.056							
	urb	.629**	−.359	.933**	.852**	−.302						
25 km	*loc*	.656**	.051	.677**	.870**	.062	.739**					
	conc	.140	.823**	−.162	−.013	.922**	−.224	−.056				
	urb	.471**	−.423*	.784**	.725**	−.369*	.913**	.798**	−.302			
125 km	*loc*	.462*	.261	.373*	.637**	.219	.414*	.856**	.028	.507**		
	conc	.118	.777**	−.157	−.032	.883**	−.212	−.085	.993**	−.289	−.021	
	urb	.163	−.690**	.556**	.451*	−.697**	.685**	.571**	−.704**	.814**	.419*	−.711**

* correlation is significant at the 0.05 level (2-tailed)
** correlation is significant at the 0.01 level (2-tailed

Discussion

This analysis of 30 industries in Sweden shows clearly that localisation occurs as a combined result of concentration and urbanisation. Industries where establishments are particularly likely to locate close together are subjected to two different types of agglomeration proximity effects. They exhibit concentration, meaning that they are *more likely than establishments in general* to locate near establishments in their *own industry*. However, they also exhibit urbanisation, meaning that they are *more likely than establishments in general* to locate near other establishments *in general*. For many industries studied here, these two effects are somewhat correlated, but there are several exceptions. It is therefore somewhat difficult to determine concentration merely by measuring localisation.

Table 4. Decomposition of localisation for four industries

	localisation	=	*concentration*	·	*urbanisation*
Fish processing	1.66	=	3.13	·	0.53
Pharmaceuticals	1.61	=	1.53	·	1.06
Non-life insurance	1.61	=	1.30	·	1.24
Reindeer husbandry	0.854	=	40.420	·	0.021

Note: Establishments with employees, r = 5 km.

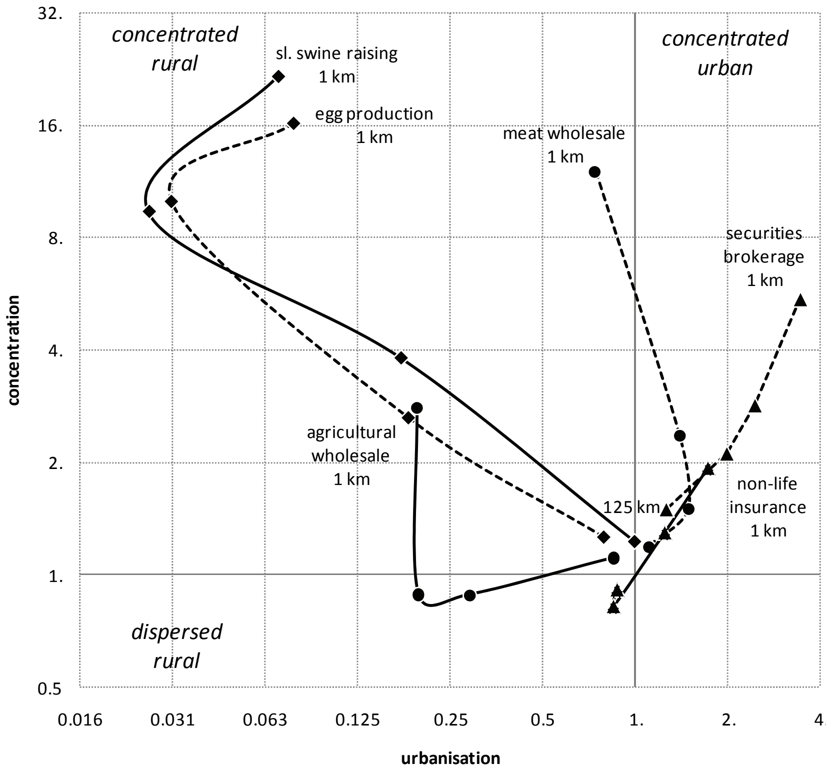
For instance, consider the examples of the fish processing, pharmaceuticals, and non-life insurance industries (see Table 4). For r = 5 km, they are roughly equally localised, with a localisation value of around 1.6. However, if we decompose localisation into concentration and urbanisation, it becomes clear that these industries are actually quite different. The localisation of non-life insurance is the result of a combination of moderate concentration and moderate urbanisation. Pharmaceuticals are concentrated but neither urban nor rural, whereas fish processing is highly concentrated but also rural. The same degree of localisation has thus come about through different combinations of concentration and urbanisation. If one measured localisation only, one would draw the erroneous conclusion that these three industries are subjected to similar proximity effects; however, by separating concentration from urbanisation, this supposition is shown clearly to be false.

Further, these results confirm the findings of Marcon and Puech (2003), who found that localisation patterns vary by distance. However, this study adds an additional layer of insight. First, Marcon and Puech studied establishments only in greater Paris at a maximum distance of 40 km, whereas this study covers multiple metropolitan areas as well as rural regions, measuring agglomeration effects up to 125 km. Second, the Paris study included only establishments in the manufacturing industry (except food production), while this study includes all industry sectors. Third, Marcon and Puech used two-digit industry groups, while this study uses 5-digit industries.

Figure 5 shows how concentration and urbanisation varies by distance *r* for three pairs of industries: slaughter swine raising and egg production; meat wholesale and agricultural wholesale (machinery, equipment and supplies); and securities and commodities brokerage and non-life insurance. The first two pairs share the same 2-digit industry code (01 and 46 respectively), and the last pair share the same letter (K). Swine raising and egg production show very similar patterns: both are most concentrated at 1 km distances, but most are rural at 5 km distances. On the other hand, the two wholesale industries evince very different patterns. Agricultural wholesale is rural and fairly dispersed at 5-25 km, while meat wholesale is urban and concentrated. These two wholesale activities are clearly subjected to very different agglomeration (dis-)economies. Non-life insurance is not only more dispersed than securities brokerage at all distances, but also less urban. These results suggest that industries in the same letter group, and even in the same 2-digit group, can differ considerably in their localisation patterns.

There are two chains of vertically linked food industries in this study. They are illustrated in Figure 6. In both chains, primary production is rural and concentrated. Marine trawling, however, relies on harbour facilities, which makes it both more concentrated and less rural than swine raising. The next step in the chains, fish processing and livestock slaughtering, is located closer to consumers, and thus is less rural but also less concentrated. Wholesale is an urban activity, while retail is closest to the consumers and hence is neither very urban nor very rural. However, there is a small degree of difference between fish and meat retail. In Sweden, most meat is sold in

Figure 5. Urbanisation and concentration variations for different distances

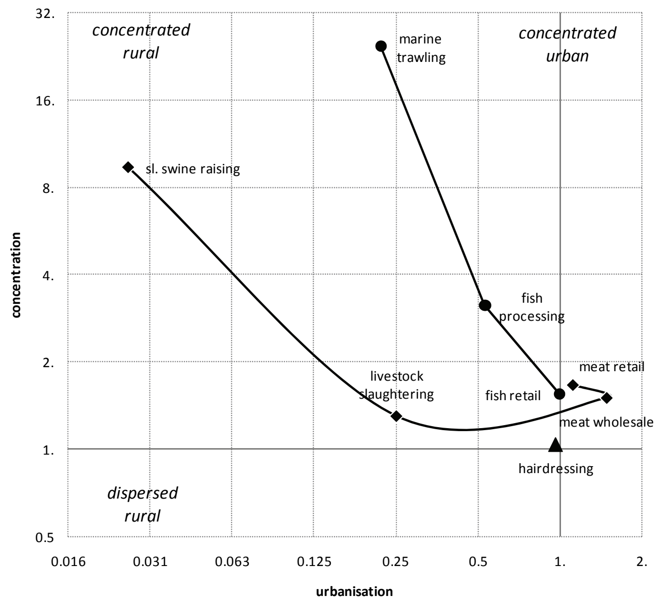


Note: The points represent distances *r* of 1 km, 5 km, 25 km, and 125 km respectively

general food stores, and butcheries are fairly uncommon and to some degree an urban phenomenon. Fishmongers, on the other hand, are more numerous and tend also to be non-urban. Also, it is significant to note the characteristic localisation of hairdressing, an industry that is distributed almost perfectly according to the population; it is neither concentrated nor dispersed, neither urban nor rural.

Reindeer husbandry provides a striking example of the ways in which concentration and urbanisation can offset one another. The reindeer is a nomadic grazer that migrates farther than any other terrestrial mammal. In some Swedish regions, reindeer herds move up to 250 km between summer and winter grazing areas. Reindeer are

Figure 6. Urbanisation and concentration variations for different distances



Note: Establishments with employees, *r* = 5 km.

therefore legally allowed to graze freely in about one-third of the Swedish territory, with habitats spanning public as well as private lands. Reindeer husbandry is traditional among the once nomadic Sami people, for whom the animals provided meat, milk, pelt, and bone, and who used reindeer as draught animals. Today, reindeer husbandry is used primarily to produce meat and pelt. Reindeer owners are self-employed, but also organise in larger firms. Although much of the work is carried out in the wild during certain intense work periods (such as migration periods, marking during the summer, autumn slaughter, forest herding in the winter), today's reindeer owners do not live in immediate proximity to their herds. Their establishments are therefore typically located in towns and villages in the same region as the herd.

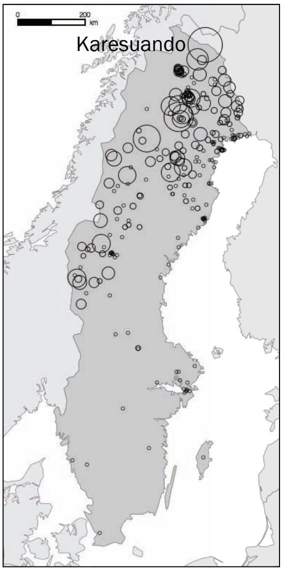
Reindeer husbandry is an extremely rural business. At 5 km, 25 km, and 125 km, it is more rural than any of the other studied indus-

Table 5. Location, concentration and urbanisation of reindeer husbandry

	Establishments with employees			*Establishments with or without employees*		
Range	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*
1 km	6.52	58.93	0.111	12.62	94.45	0.134
5 km	0.85	40.42	0.021	1.53	34.83	0.044
25 km	0.32	30.75	0.010	0.57	16.45	0.035
125 km	0.89	18.13	0.049	1.10	15.83	0.069

tries. This is not surprising, since reindeer graze in the most sparsely populated areas of Europe. However, unlike poultry or pig farmers, reindeer owners do not need to live in very close proximity to their animals (indeed, they cannot unless they choose to adopt a nomadic lifestyle), which means that they can settle in towns and villages without any economic disadvantage. At the 1 km range, they are therefore less rural than poultry and pig farmers, who would likely find costs in central urban locations to be prohibitive. (See Table 5.)

Figure 7. Location of reindeer husbandry establishments



Note: The area of the circles is proportionate to the number of establishments.

At the same time, reindeer owners are shown to be extremely concentrated. In general, they are not likely to have many neighbours, but among the few neighbours they have, there are many other reindeer owners. Sweden's northernmost village, Karesuando, with a population of about 300, is a good example of this phenomenon. (See Figure 7.) Out of 218 establishments, 101 are reindeer owners. Other small towns and villages have similar concentrations of reindeer ownership, and as few as 20 postcodes host half of all reindeer owners. This makes reindeer husbandry by far the most concentrated of the studied industries.

Reindeer husbandry is perhaps the clearest example of the ways in which concentration and rurality tend to offset one another. The resulting localisation measure shows a pattern that reveals nothing of the underlying relationship between concentration and rurality. Considered alone, localisation reveals very little about the agglomeration properties of this industry.

Conclusion

The aim of this paper has been to present a method of separating and distinguishing between two different agglomeration effects: concentration and urbanisation. Previous studies have measured these effects in combination by using a single measure of localisation. However, the results of this paper suggest that the assumption that localisation alone is an indicator of intra-industry agglomeration economies is flawed. Industries may be localised due to economic benefits which stem from co-location with establishments *in general*, i.e., urbanisation benefits. Conversely, industries may be highly concentrated but still may not show any tendency towards localisation, if they also are rural. To establish the strength of intra-industry agglomeration economies, these two effects must be separated, and a measure that captures concentration alone must be used as the indicator.

When plant-level data is available, Ripley's K can be used to calculate both concentration and urbanisation. Ripley's K, in the form of the Q function, has an intuitive interpretation that makes it particularly attractive for measuring agglomeration effects. The Q function gives the average share of an industry that is within a given range of a random establishment. Alternately, it can be interpreted as the share of all possible co-locations of plant pairs that occur within a given range. This value is therefore a direct and meaningful measure of agglomeration: a doubling of the *Q* value does indeed mean that agglomeration has doubled, in the sense that an establishment has twice as many other establishments "within range" of itself, or that twice as many establishment pairs are "within range" of one another. In contrast, a doubling of the Gini value has no meaningful interpretation other than indicating that overall disproportionality has increased.

In this paper, *concentration* is defined as an industry's tendency to co-locate with itself more than with establishments in general. Similarly, *urbanisation* is defined as an industry's tendency more than establishments in general to co-locate with establishments in general. Both values can be calculated as quotients of the *Q* function. The combination of these two effects is termed *localisation*.

The empirical study presented in this paper confirms that concentration and urbanisation vary independently of each other for different industries. It also shows that concentration and urbanisation vary with geographic range: industries that are concentrated (or urban) over short ranges may be dispersed (or rural) over long ranges. Agglomeration patterns may vary considerably between industries in the same industry classification group, suggesting that agglomeration economies are best examined on a more detailed industry level.

Finally, it is important to note that manufacturing industries as a group are dispersed and rural, and therefore have a low localisation value. If manufacturing as a whole is used as a reference distribution for agglomeration, the analysis will produce biased results, as industries will appear to be more concentrated and more urban than they would be compared to all economic activity. Concentration and urbanisation will therefore be over-estimated if total manufacturing is used as the reference distribution.

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Appendix

Localisation, concentration, and urbanisation values for 30 Swedish industries (all establishments)

	1 km			*5 km*			*25 km*			*125 km*		
	loc	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*
Slaughter swine raising	2.139	13.115	0.163	0.332	7.713	0.043	0.645	3.507	0.184	1.322	1.415	0.934
Egg production	1.433	8.089	0.177	0.202	2.846	0.071	0.293	1.496	0.196	0.967	1.179	0.820
Poultry raising	1.523	6.100	0.250	0.227	1.573	0.145	0.633	2.387	0.265	1.581	1.778	0.889
Reindeer husbandry	12.617	94.445	0.134	1.527	34.831	0.044	0.572	16.448	0.035	1.097	15.828	0.069
Marine trawling	6.120	37.287	0.164	1.734	17.394	0.100	1.187	3.952	0.300	1.358	1.942	0.699
Gravel and sand pits	0.760	2.074	0.367	0.162	0.641	0.253	0.253	0.664	0.382	0.805	0.941	0.856
Livestock slaughtering	2.344	8.130	0.288	0.359	1.317	0.273	0.250	0.798	0.314	0.725	1.029	0.705
Fish processing	4.916	10.621	0.463	1.070	2.071	0.516	0.597	1.253	0.476	0.924	1.213	0.761
Bakeries	0.687	0.907	0.758	0.645	0.826	0.781	0.693	0.842	0.823	0.865	0.940	0.920
Book printing	1.014	1.169	0.867	1.214	1.124	1.080	1.253	1.123	1.115	1.181	1.090	1.084
Pre-press	2.075	1.580	1.313	2.607	1.648	1.582	2.223	1.509	1.473	1.437	1.219	1.179
Pharmaceuticals	2.848	2.689	1.059	2.331	1.755	1.328	1.879	1.447	1.298	1.466	1.282	1.143
Electronic components	1.084	2.197	0.493	1.063	1.479	0.719	1.857	1.364	1.361	1.306	1.169	1.117
Computers	1.141	1.304	0.875	1.267	1.161	1.092	1.820	1.355	1.343	1.243	1.126	1.104
Communications equipment	2.050	1.697	1.208	2.254	1.528	1.475	3.100	1.790	1.732	1.611	1.333	1.209
Cars	0.256	0.589	0.435	0.340	0.607	0.559	0.789	0.871	0.907	0.958	0.968	0.990
Coachwork	0.640	2.545	0.252	0.180	0.679	0.265	0.264	0.639	0.412	0.747	0.938	0.796
Vehicle parts and accessories	0.708	1.736	0.408	0.285	0.725	0.393	0.416	0.769	0.541	1.047	1.084	0.966

cont.	*1 km*			*5 km*			*25 km*			*125 km*		
	loc	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*	*loc*	*conc*	*urb*
Ship and boat repair	1.172	2.239	0.524	0.909	1.243	0.731	1.678	1.484	1.131	1.550	1.376	1.127
Meat wholesale	2.139	13.115	0.163	0.332	7.713	0.043	0.645	3.507	0.184	1.322	1.415	0.934
Agricultural wholesale	5.388	6.321	0.852	2.535	1.977	1.282	1.771	1.348	1.314	1.177	1.110	1.061
Meat retail	0.552	1.864	0.296	0.178	0.776	0.229	0.297	0.824	0.360	0.950	1.097	0.866
Fish retail	4.133	3.091	1.337	2.483	2.196	1.131	1.354	1.447	0.936	1.215	1.242	0.978
Book publishing	1.600	2.089	0.766	1.216	1.621	0.750	1.504	1.864	0.807	1.498	1.538	0.974
Non-life insurance	4.914	2.402	2.046	4.490	2.201	2.040	2.866	1.728	1.659	1.540	1.296	1.188
Security and commodity brokerage	4.677	2.597	1.801	1.980	1.474	1.343	0.788	0.883	0.893	0.833	0.929	0.897
Graphic design	11.321	4.281	2.645	4.715	2.307	2.044	3.161	1.824	1.733	1.540	1.312	1.174
Chimney cleaning	6.633	2.958	2.242	7.442	2.878	2.586	4.477	2.192	2.042	2.038	1.555	1.310
Tertiary education	0.662	1.641	0.404	0.261	0.589	0.443	0.340	0.595	0.571	0.778	0.917	0.848
Hairdressing	27.422	9.392	2.920	9.047	3.471	2.606	2.971	1.810	1.641	1.308	1.193	1.096

Note: Establishments with or without employees.

Study 2

Swedish cluster maps

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Study 2

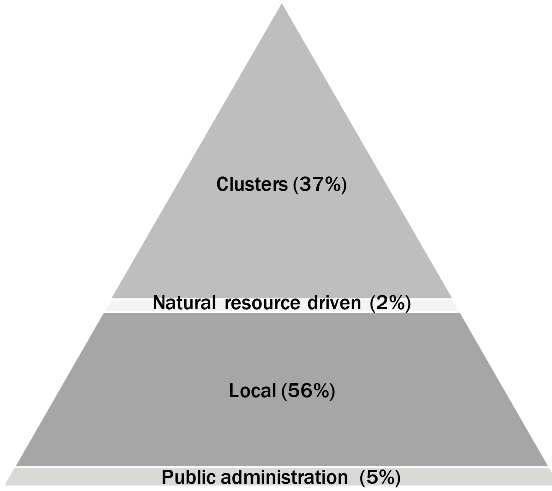
Swedish cluster maps

Summary

On behalf of the Swedish National Programme for Innovation Systems and Clusters, we have in this report carried out a preliminary statistical inventory of Swedish clusters. The data used are based on industry classifications (SNI) and labour market regions (LA regions). The industries which in the course of history have co-located themselves for the purpose of exploiting business and technology links are classified into 38 so-called industry clusters. The model for the definition of these clusters has been developed by Professor Michael E. Porter at Harvard University, and has now, for the first time, been applied outside North America. The interest in clusters is due to the fact that these industrial systems are extremely important for development and innovation in industry, and the fact that they constitute a building block for modern enterprise and regional policies.

The industry clusters and the regional and local clusters which have become apparent through our statistical processing present *one* image of Swedish clusters. Of course, traditionally based industry statistics cannot give a wholly accurate image of cluster structures and business dynamics in Sweden. It is, however, an image which can be of guidance to politicians and public authorities in their work on developing cluster initiatives. For a more nuanced and in-depth image of the dynamics in various parts of Sweden, finer-grained statistical processing as well as qualitative micro-level studies are needed.

It is complicated to transfer and adapt the system for aggregating industries into clusters from an American to a Swedish/European business structure and industry nomenclature. Results in this report should therefore be considered preliminary for the time being.



This report identifies 38 industry clusters, i.e. major industrial systems in Sweden, which are described with regard to employment and growth in recent years. The report focuses mainly on the cluster sector in its entirety, which supplies some 1.4 million jobs. Apart from this, Sweden has a local business sector comprising slightly more than 2 million jobs, a natural resource driven sector with almost 100 000 employees and a public administration sector with almost 200 000 employees. The cluster sector, which employs 37% of Sweden's total workforce, had the strongest growth in the period 1997–2003 increasing by 12%. In second place, we find local business with 6% growth. In both natural resource driven industry and public administration, employment contracted during this period.

A breakdown of employees by gender confirms the image of Sweden's labour market as gender segregated. The cluster sector comprises 68% men and only 32% women, albeit with a different distribution in different industry clusters. In the local sector, proportions are reversed with a workforce consisting of 60% women and 40% men.

There is a clear correlation between the size of a industry cluster and its distribution in Sweden. The largest clusters (100 000 employees or more), Business services, Transportation and logistics, Research and development, Construction and Metal manufacturing, are spread all over Sweden. In contrast, smaller clusters such as Tobacco, Footwear, Leather products, and Jewelry and precious metals (with less than 1000 employees) are highly concentrated in one or a few regions. Some fairly dominant industry clusters, such as Automotive and Forest products, have a greater tendency to be concentrated in fewer regions than expected, indicating strong specialisation and a ”Hollywood-type” concentration.

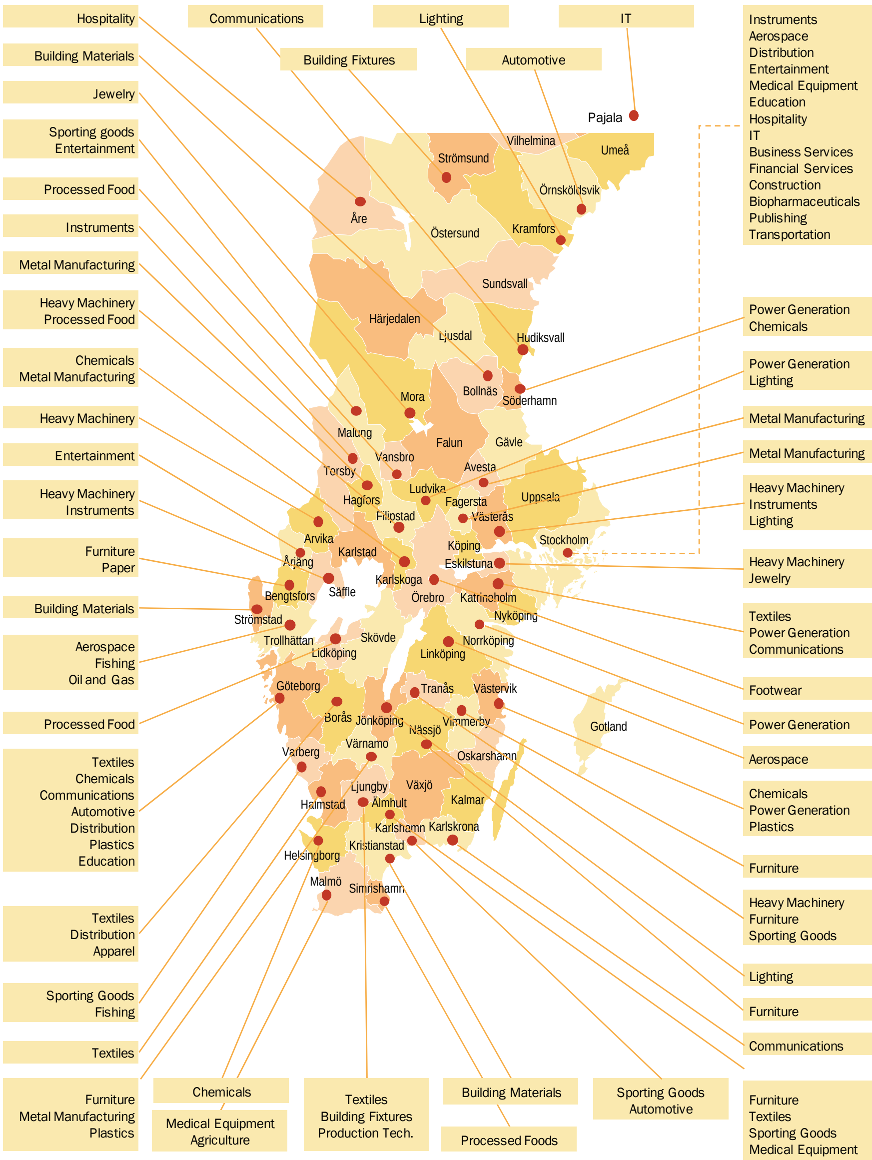
In some cases, there are clear regional patterns where several adjacent labour market regions are prominent in a certain industry cluster. One example is the aerospace industry in the Mälar region, around Linköping and in the Gothenburg region. Unsurprisingly, the two industry clusters Textiles and Apparel show similar patterns of localisation. There is a degree of a spread, but the industry is centred in South Sweden and the centre of gravity is still to be found in the Borås region.

Sweden’s sixth largest cluster is Automotive, comprising cars, buses and lorries in addition to surrounding suppliers. Some 75 000 people work in this cluster, which has its focus in West Sweden and in Småland. There are also some companies in the Mälar region and a minor cluster around Umeå. Metal manufacturing, comprising almost 100 000 jobs, is fairly evenly spread in Sweden, mainly in Central and Southern Sweden.

Furniture (wood laminates etc.) is a medium-sized cluster with almost 20 000 employees. The focus is to be found in Småland and Västergötland and in a few regions in North Sweden. Lighting and electrical equipment is located in the Bergslagen region (Västerås, Köping, Fagersta, Ludvika) and in Southern Sweden. Power generation and transmission is concentrated in the same region in Bergslagen, and to Norrköping (Finspång) and Söderhamn. Medical devices (medical apparatus, wheelchairs, etc.) shows clusters in Skåne and around Stockholm. The pharmaceutical industry is highly concentrated in Stockholm/Uppsala and in Skåne. This cluster is fairly large with some 20 000 employees.

One of the smallest clusters in Sweden is Footwear, at present employing less than 500 persons. It is centred in South Sweden, around Örebro and in Åre. Sporting and children’s goods is another small cluster, with foci in Småland and Malung.

During our work, we have identified some 100 local clusters which are or could become Sweden’s “Hollywoods”, i.e. leading local industrial environments and innovation hotbeds capable of developing goods and services for an international market.


Hospitality
Communications
Lighting
IT
Building Fixtures
Automotive
Building Materials
Jewelry
Sporting goods
Entertainment
Processed Food
Instruments
Metal Manufacturing
Heavy Machinery
Processed Food
Chemicals
Metal Manufacturing
Heavy Machinery
Entertainment
Heavy Machinery
Instruments
Furniture
Paper
Building Materials
Aerospace
Fishing
Oil and Gas
Processed Food
Textiles
Chemicals
Communications
Automotive
Distribution
Plastics
Education
Textiles
Distribution
Apparel
Sporting Goods
Fishing
Textiles
Furniture
Metal Manufacturing
Plastics
Chemicals
Medical Equipment
Agriculture
Textiles
Building Fixtures
Production Tech.
Building Materials
Processed Foods
Sporting Goods
Automotive
Instruments
Aerospace
Distribution
Entertainment
Medical Equipment
Education
Hospitality
IT
Business Services
Financial Services
Construction
Biopharmaceuticals
Publishing
Transportation
Power Generation
Chemicals
Power Generation
Lighting
Metal Manufacturing
Metal Manufacturing
Heavy Machinery
Instruments
Lighting
Heavy Machinery
Jewelry
Textiles
Power Generation
Communications
Footwear
Power Generation
Aerospace
Chemicals
Power Generation
Plastics
Furniture
Heavy Machinery
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Sporting Goods
Lighting
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Communications
Furniture
Textiles
Sporting Goods
Medical Equipment
Pajala
Vilhelmina
Umeå
Strömsund
Örnsköldsvik
Åre
Östersund
Kramfors
Sundsvall
Härjedalen
Ljusdal
Hudiksvall
Bollnäs
Söderhamn
Mora
Malung
Falun
Gävle
Vansbro
Torsby
Avesta
Ludvika
Hagfors
Fagersta
Uppsala
Filipstad
Västerås
Arvika
Köping
Stockholm
Karlstad
Årjäng
Eskilstuna
Karlskoga
Bengtsfors
Säffle
Örebro
Katrineholm
Nyköping
Strömstad
Trollhättan
Skövde
Norrköping
Lidköping
Linköping
Göteborg
Tranås
Västervik
Borås
Jönköping
Vimmerby
Nässjö
Gotland
Värnamo
Varberg
Oskarshamn
Ljungby
Växjö
Halmstad
Älmhult
Kalmar
Karlshamn
Karlskrona
Kristianstad
Helsingborg
Malmö
Simrishamn

Only 50 of Sweden's 81 labour market regions have these kinds of local clusters. Stockholm, representing about a quarter of Sweden's entire labour market, has 14 clusters, which is to be expected given the city's size. Gothenburg has seven and Malmö two. In North Sweden, only nine clusters can be identified: two in Söderhamn and one each in Bollnäs, Hudiksvall, Åre, Kramfors, Örnsköldsvik, Strömsund and Pajala.

Introduction

The use of concepts like "cluster" and "industrial systems" has moved to the forefront of business policy (for an overview, see Malmberg 2002.) This trend, which began in the 1990s, is now making an impact on Swedish policy making. New public authorities have been founded, and policy is increasingly contributing to creating innovation and development in the lattice of industry, academia and political agencies at various levels – the "triple helix". Of central importance in this process is the understanding that development and innovation to a great – and possibly increasing – extent take place through cooperation and interaction in local clusters.

In order for the political agencies to be able to refine their work, a thorough mapping of Swedish clusters is required. This can be carried out from two diverging starting points: a comprehensive statistical study or a qualitative study based on interviews and contacts in the clusters. In this first report, we have chosen to carry out a statistical analysis of clusters in the Swedish business environment as a whole (*industry clusters*) as well as clusters in local labour market regions (*local clusters*).

Underlying our work is a model developed by Professor Michael E. Porter of Harvard University. Professor Porter has kindly allowed the CIND to use the codes required for making comparable cluster maps. After the USA and Canada, Sweden is the first country in the world where the cluster keys are tested. The authors would like to sincerely thank Professor Porter who has thus been pivotal in making this study possible.

From macro-level to micro-level policy

A good macroeconomic environment is a necessary but insufficient precondition for the development of successful clusters in a country. The microeconomic preconditions for dynamic clusters are based on specific institutional factors, which drive business strategies, the starting-up of new companies and competition. Furthermore, access to sophisticated and specialised production factors (particularly human capital), proximity to and contact with demanding and leading customers internationally as well as close links to a number of supporting industries and suppliers of specialised goods and services constitute the foundations on which a cluster grows.

The emergence of fixed and mobile telecommunications in Sweden is a good example of the outcome of a new microeconomic environment in the 1980s and 1990s. A new regulatory framework, increased competition, the founding of new businesses and active measures contributed to an immense upturn. This process of renewal was in its turn based on a strong cluster of more than a hundred years' standing in telecommunications and a cluster of seventy years' standing in radio and mobile telephony. This should be kept in mind in a time when more and more countries and regions try to build new clusters rapidly.

Globalisation and increased importance of local clusters

Global realities make themselves known in our everyday lives and in the workplace. High technology products, both tangibles and intangibles, are traded globally, as are bulky raw materials like timber and pulp. Internet portals, advertising agencies, banks, insurance companies, restaurant chains, waste management companies and other service businesses are rapidly expanding their international networks, with concepts being created in one part of the world and marketed in a global marketplace. New patterns of manufacturing and trade are emerging, and businesses split their value chains according to the comparative advantages of countries.

The changed patterns have been made possible by the fact that both businesses and individual consumers now have dramatically increased access to information, goods, services and capital from the entire global market. Knowledge production is also starting to take place in increasingly global networks with software developers shaping new technologies in virtual groups via the net. In other words, we are seeing a completely new global mobility in the markets for goods, services, capital and production factors.

However, this perception of globalisation is only partially true. Global markets work well for standardised, preferably digitised information, for standardised services, production equipment, standard components and raw materials. Where rapid change and continuous innovation are central driving forces, proximity to sophisticated customers, leading competitors, prominent universities and training facilities, trust and speed are crucial. While physical capital moves easily, human capital is sluggish and social capital does not move at all.

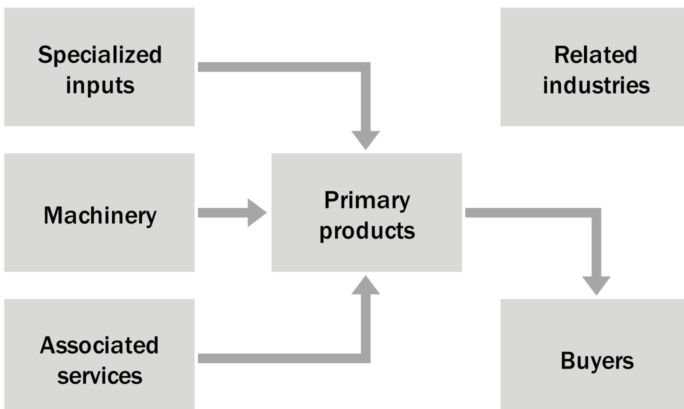
With this increased globalisation, it is justified to say that we are, paradoxically, seeing increased local specialisation. Above all, labour markets and "social capital" are mainly local. Social capital can be seen as the institutional glue emerging between individuals and organisations in a local context. This glue in turn serves as the basis for firms' renewal and innovation processes, which largely take place through daily contacts, in a spirit of mutual trust and in formal and informal networks. The advantages of local systems where players not only have regular planned meetings but, perhaps more importantly, meet spontaneously , is that they can more easily manage uncertainties surrounding new ideas in trusted relationships. Furthermore, the search for solutions is facilitated by trial and error and through frequent contacts. The closeness and intensity of the contacts also increase the possibilities for flexible specialisation and rapid retargeting. Finally, flow is boosted by so-called silent knowledge through the emergence of a common culture and a common language based on, for example, common schooling.

Are these local phenomena dying out and is it only a matter of time before they also go global? There are indications that this is not the case, but rather that the local context may actually be increasing in importance as globalisation continues. Above all, this applies to firms' innovation processes (but not scientific research, which has a large global component). The simpler and more inexpensive the flow of information, goods and services, the greater the possibility for local environments to be linked to the whole world. In other words, it is not a drawback to be situated in a local innovation system, provided it is fully linked to the global market. In addition, in a world of global flow of standardised goods and services accessible to all, it is becoming more and more important to be an insider in leading local environments, such as Silicon Valley or Stockholm's Wireless Valley.

Clusters and industry dynamics

An important part of business dynamics takes place in clusters. A cluster consists of a number of related industries (see Figure 1) linked through the flow of information, technology and other forms of knowledge (the flow of goods as such is often of limited importance, as this is becoming increasingly globalised).

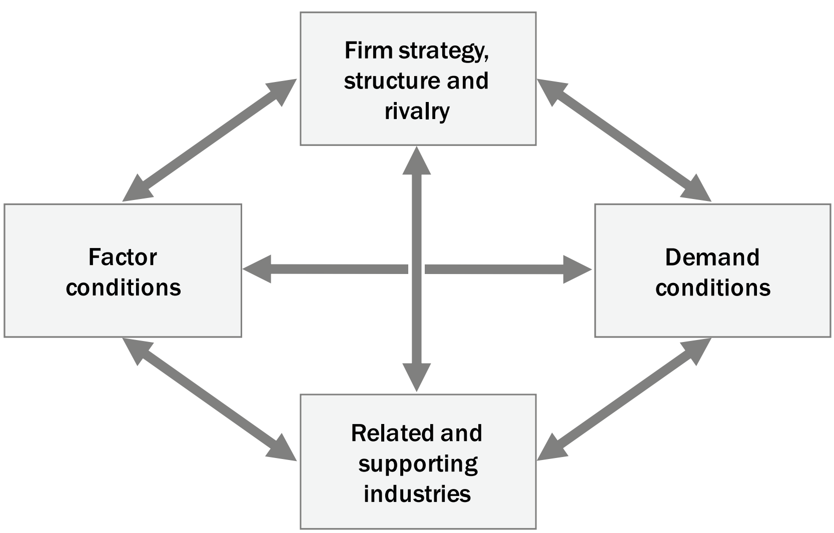
Figure 1. An industry cluster



Around the cluster core of firms and industries, we also find specialised institutions (organisations and regulatory systems), universities, political agencies and authorities and financial players. The main function of a cluster is to act as an innovation framework. Firms rarely create a continuous flow of innovations in isolation. On the contrary, research shows that a sustained innovation capacity is based on interaction with the environment. Frequently, firms facing technological or organisational problems turn to another enterprise nearby for help in developing a solution. The problem solving process developed between the two companies may then be the launching pad for a product which can later be marketed. This means that analyses of company contact networks and interaction patterns are of key importance if we wish to understand how innovation processes and industry dynamics arise.

The concept of clusters was launched by Michael Porter in the late 1980s (see Porter 1990.) In Sweden, one of ten countries in Porter's study, the concept was introduced in the book Advantage Sweden (see Sölvell, Zander and Porter, 1993.) The cluster concept focused on business and the links between different industries (customer–supplier, technology links etc.) Clusters were identified based on the companies supplying finished main products, but also included industries producing important production inputs (raw materials, services, machinery), buyers of finished products and technologically related industries. The driving forces underlying the development of a cluster were summarised in the so-called diamond model (see Figure 2). Recently, the cluster concept has come to include several interlinked institutions and public authorities in the so-called triple helix—the nexus of industry, government and academia, i.e. the diamond model is becoming integrated with the cluster concept.

Figure 2. Porter's diamond model



This industry dynamics model stresses that while the macro environment in a country is the same for everybody, industry clusters differ in terms of development, sophistication and international competitiveness. The greater the force of the diamond, i.e. the micro environment, the greater the change pressure and development power. Some clusters are driven by a high-powered engine, while the engine of other clusters has slowed down or never even started. The diamond model was developed during analysis of nationally based industry clusters, but it has also come to be regarded as a model for analysing and understanding industrial dynamics and competitiveness on other levels, both in large regions (groups of adjacent countries) and small regions such as parts of a country or individual city regions (local clusters).

Swedish clusters

The world is full of well-known local clusters such as Hollywood in the motion picture industry, Silicon Valley in IT, Detroit in cars and the City of London in financial services. These are examples of some of the most dynamic and rich clusters in the world. Other clusters may be more static with thinner links. One case in point is the cluster of IT companies attracted to Scotland, an area which is known as Silicon Glen. These companies are located close to one another, but the links between them are weak and the diffusion effects are limited.

Sweden's heaviest industrial clusters are well known, such as electrical power (concentrated in Västerås and Ludvika), forestry/wood/pulp (focusing on packaging around Karlstad and on furniture in Småland and Västergötland), car manufacture (West Götaland) and IT/telecommunications (in Telecom City and Kista). There are smaller, thinner cluster environments in Bohuslän (small boats around Orust/Lysekil/Smögen, shipping in Skärhamn and Donsö). Another case in point is the hydraulics cluster around Örnsköldsvik. In Skåne, there is a major food cluster (around the freezing technology in Helsingborg).

There are also several examples of clusters past their prime. In Sweden, the rich shipbuilding cluster in Gothenburg and Uddevalla, textiles and apparel around Borås and the steel cluster in Bergslagen have all faded away (while leaving clear traces in some niches). One of our oldest clusters, the glass-blowing region of Småland, survives in a renewed form.

In the following description, we will base the analysis on some 40 main clusters based on linked SNI-coded industries (according to Porter's model).

Methodology

One of the points of the cluster concept is that it cuts across the borders of traditional business statistics sector breakdowns. Thus, the cluster concept draws our attention to the fact that there are links and dependencies between activities in different industries and that these links are important to industry dynamics. This is, however, also one of the problems of the cluster as a concept, as it makes it harder to do simple empirical analyses based on sector data.

In this report, we use a method which tries to work around this problem by bringing together industries which we have reason to assume are strongly linked to one another. Such aggregates or collections of industries are referred to as industry clusters. The model of aggregation, described in more detail below, has been developed in the USA and is being applied here to Europe for the first time.

The method used in this report to describe of Sweden's industry from a cluster perspective is therefore three-fold:

- Gather data describing Swedish industry at a fine-grained sector level
- Group industry data in relevant industry clusters
- Analyse industry clusters with respect to geographical localisation in local clusters.

As a data source, we have used the Central business and workplace register (CFAR) of Statistics Sweden. This register should cover all companies, public authorities and organisations as well as workplaces. This means that workers can be linked to the place where they actually work, not just to the place of their employer's main office. The register covered some 3 700 000 employees in 2003, corresponding to approximately 90% of all employed persons in Sweden.

The data in CFAR are based on information from the Patent and Registration Office, the National Tax Board, a postal management company called Svensk Adressändring, questionnaires and contacts with companies. Reliability is generally high for enterprises with more than ten employees. Enterprises not subject to VAT are underrepresented, while there may be some overcoverage due to enterprises not being taken off the records. We have used data from 1997 and 2002 in order to get a current image as well as a rough idea of the change in the number of employees in a cluster over time.

For the gender analysis, we have also used data from RAMS (Regional labour market statistics) from Statistics Sweden. The latest available data in this context refer to 2000, and we have used 1993 as a baseline. In other words, the gender analysis refers to a different timeframe than the rest of the analysis.

The measure we have used to describe the size of the clusters is the number of employees. This is the most robust and widely available indicator, and it is also a key aspect of cluster importance to the economy of Sweden. Employment also provides a good comparison between clusters and over time.

The industry cluster breakdown is based on the sector codes used in CFAR, i.e. Swedish Standard Industrial Classification (SNI92). These have been aggregated into groups using the industry cluster definitions provided by Professor Michael E. Porter. Porter's breakdown is the result of a multi-annual research project studying which industries tend to actually be located together and where it can be assumed that there are links in the shape of the flow of knowledge or goods, for example. Porter has identified 41 main industry clusters. These definitions, based on an American nomenclature (1987 SIC), have been transferred to the Swedish SNI92 system. Due to the short time at our disposal when preparing this report, we have had to accept several approximations in this transfer. The breakdown given below should therefore be considered a first estimate rather than a final result.

Everything is not clusters

The first step in the breakdown is to identify industries that, for one reason or another, are not relevant for a cluster-based study. This applies to three kinds of activities (see Table 1):

- Local activities. This group comprises private as well as public producers of goods and services which are not traded significantly over regional borders but must be supplied locally. Health care, retail trade and hairdressing are examples.

- Natural resourcebased activities. These are localised wherever there are natural resources. Farming and mining are examples of this kind of activity.
- Public administration. Some public activities, such as public administration and defence, are localised according to political decisions and very rarely because of cluster effects.

Table 1. Industries not included in industry cluster breakdown

Excluded industries	*Examples*
Local	Small-scale construction, groceries retail and many other forms of retail, restaurants, health care, hairdressing, primary and secondary education.
Natural resource-based	Farming, forestry, pulp mills, mines, quarries
Public administration	Public administration, law enforcement, defence

In total, the excluded industries comprise almost half of all SNI codes on the five-digit level. They also comprise a majority of the employees (see Figure 3).

Figure 3. The cluster sector and other sectors

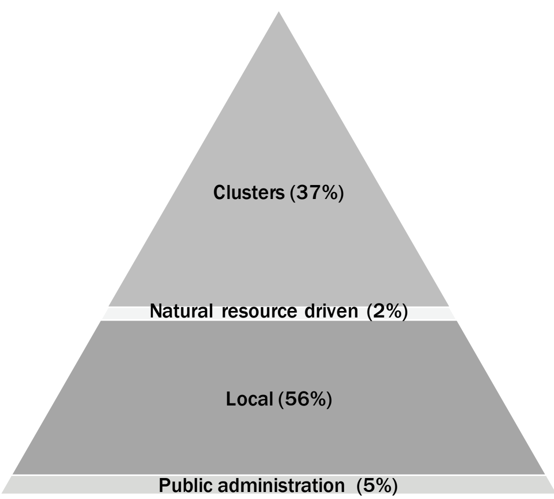
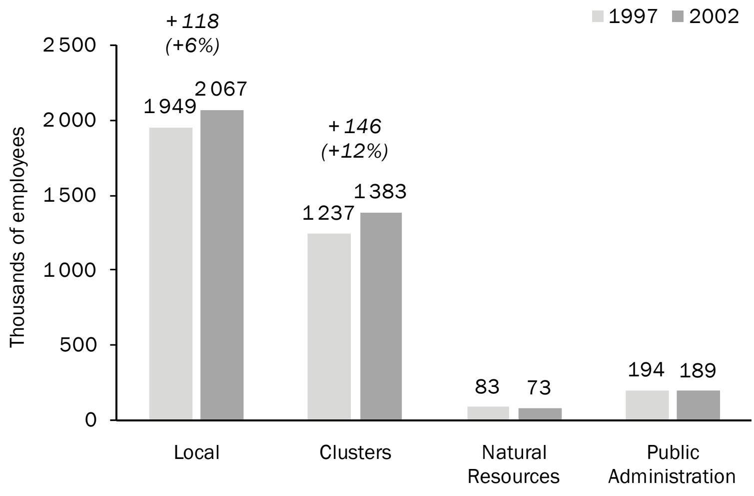


Figure 4. Number of employees by sector, 1997 and 2003



The different sectors have also shown different growth rates, as seen in Figure 4.

Local activities comprise considerably more than half of all persons employed in Sweden. Of these, health and dental care, primary and secondary education and social services employ some 900 000 persons. For the rest, this sector mainly consists of local services (such as restaurants, bank branches and hauliers), local retail, local construction and local public services (e.g. electricity distribution).

While the cluster sector is considerably smaller than the local sector, it has nevertheless accounted for greater growth. The local sector between 1997 and 2003 grew by 118 000 employees (a growth of 6%), while the cluster sector grew by 146 000 employees, reaching almost 1.4 million employees (a growth of 12%).

In the same period, both the natural resources-based sector (chiefly farming, forestry and mining) and the public administration sector (administration, law enforcement and defence) decreased.

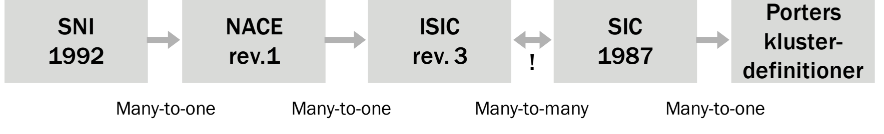
The cluster sector

After excluding these industries, the remaining industries are broken down into sector code groups according to Porter's system. In order to do this, a transfer must take place between the SNI system used in Swedish statistics and the SIC system used in American statistics and underlying Porter's definitions. Unfortunately, there is no simple transfer relationship between these systems (see Figure 5). The transfer must be done step by step, going from SNI via the European standard, NACE, and the UN standard, ISIC. Thus far, the transfer is straightforward, but between ISIC and SIC, there is unfortunately a many-to-many relationship rendering a simple transfer impossible. (In other words, one ISIC category may be mapped onto several SIC categories, and one SIC category may belong in several ISIC categories). For the purposes of this report, we have thus had to make some compromises and simplifications.

The transfer between SNI and SIC has necessitated a few significant changes to cluster definitions. First of all, Porter's classification contains one industry code group for aircraft engine manufacture and another for aircraft and defence supplies. Due to the structure of the SNI classification, these two groups have been combined to form one single group. Secondly, in the SIC system a number of industry codes together form the groups "Prefabricated enclosures" and "Motordriven products". The level of detail in SNI is so low that most of these activities are included in other industry code groups. Only a few of them can be accounted for separately. As these groups are far too narrowly defined, their relevance is questionable and they have therefore been excluded from this report. Thus, we account for only 38 industry clusters, as opposed to Porter's 41.

The remaining code groups comprise a varying number of SNI categories. At least one single and at most 37 five-digit SNI categories form one industry code group.

Figure 5. The relationships between the Swedish industry classifications and Porter's industry cluster definitions



These problems, and a large number of similar problems of distinction, mean that Porter's system should preferably be processed further in order to fit Swedish and European conditions. However, that is work that cannot easily be fitted into the framework of the present initial mapping, so we have chosen to use a simplified transfer in this report and accept the resulting weaknesses.

The geographical breakdown follows NUTEK's LA regions (local labour market regions). This breakdown is based on municipalities, which are added to LA regions according to commuting flow. A municipality where more than 20% of the working population commutes out, or where more than 7.5% commutes out to any one municipality, is added to the municipality to which the greatest commuter flow goes. The composition and number of LA regions according to this definition varies from one year to another, but, based on 1996 commuter statistics, NUTEK has compiled 81 regions which are supposed to remain fixed in the long term. We use these 81 regions for this report.

LA regions are an extremely useful concept in cluster analyses. An important function of clusters is the exchange of knowledge made possible by several activities being located in the same place. The shorter the distances, the easier it is for this exchange to take place and the tighter the cluster is knit. To a certain extent it could suffice that the activities are located in the same country for the exchange to be facilitated, but there is an important limit on commuting distance. Activities that lie within commuting distance of one another can more easily exchange staff or set up meetings.

The LA region is therefore suitable as the smallest unit for a cluster analysis. Of course, this does not imply that a regional cluster cannot comprise several LA regions.

Swedish industry clusters – a national overview

The method chosen generates data characterising the scope of 38 widely defined industry clusters in Sweden. These 38 clusters employ almost 1.4 million persons in Sweden (see Table 2.) The 38 clusters are different in many respects. Some are broad aggregates of several tens of industries, while others are narrower, consisting of only a few industries. In relation to the conceptual cluster definition discussed, it is probably the case that the biggest and broadest as well as the

Table 2. Industry clusters in Sweden, 2002

	Empl.	*Share of nat. empl.*	*Estab-lishments*	*Empl. per est.*	*Ac*
Business Services	196 857	5.30%	24 032	8	0.24
Transportation and logistics	148 747	4.00%	5 609	27	0.13
Educ. and Knowledge Creation	118 374	3.19%	3 116	38	0.28
Heavy Construction Services	103 914	2.80%	10 628	10	0.11
Metal Manufacturing	99 858	2.69%	5 330	19	0.38
Automotive	75 710	2.04%	662	114	0.44
Financial Services	59 486	1.60%	3 235	18	0.28
Processed Food	58 157	1.57%	2 290	25	0.30
Forest Products	56 664	1.53%	1 648	34	0.42
Hospitality and Tourism	56 368	1.52%	6 941	8	0.15
Entertainment	54 274	1.46%	10 141	5	0.11
Production Technology	50 723	1.37%	2 192	23	0.26
Publishing and Printing	31 336	0.84%	3 122	10	0.16
Distribution Services	29 843	0.80%	3 179	9	0.31
Communications Equipment	25 678	0.69%	373	69	0.42
Building Fixtures, Eqip. and Serv.	22 793	0.61%	1 204	19	0.33
Information Technology	21 583	0.58%	1 422	15	0.24
Biopharmaceuticals	19 767	0.53%	133	149	0.57
Furniture	17 969	0.48%	945	19	0.50
Heavy Machinery	17 013	0.46%	492	35	0.47
Plastics	16 915	0.46%	481	35	0.39
Chemical Products	11 542	0.31%	274	42	0.48
Lighting and Electical Equip.	10 836	0.29%	354	31	0.53
Aerospace Vehicles and Defense	10 519	0.28%	62	170	0.66
Medical Devices	10 339	0.28%	718	14	0.30
Textiles	10 074	0.27%	518	19	0.49
Analytical Instruments	9 758	0.26%	363	27	0.34
Power Generation and Transm.	8 111	0.22%	221	37	0.60
Agricultural Products	7 153	0.19%	843	8	0.34
Construction Materials	4 219	0.11%	412	10	0.36
Apparel	2 873	0.08%	271	11	0.58
Fishing and Fishing Products	2 681	0.07%	291	9	0.61
Sporting, Recr. and Child. Goods	2 188	0.06%	137	16	0.57
Oil and Gas Products and Serv.	1 806	0.05%	40	45	0.58
Jewelry and Precious Metals	757	0.02%	116	7	0.67
Leather Products	449	0.01%	96	5	0.60
Footwear	387	0.01%	41	9	0.76
Tobacco	381	0.01%	2	191	0.86

smallest and narrowest industry aggregates are the ones most likely to be problematic when considered as industry clusters.

The problem with the large, broad clusters is that they contain such diverse types of activities that there may be cause to question whether they really are linked industrial systems. In addition, when we come to show, as seen below, that some of the major industry clusters are widely geographically dispersed, there may be cause to think that they might as well be considered local activities or, alternatively, that they actually provide a support function other industry clusters rather than being industrial systems in their own right.

For the smallest clusters, the problem is different. Some industry groups which in the USA constitute large industrial systems are only insignificantly represented in Sweden. The extreme case here is the tobacco industry, which is large scale and has a clear cluster character in the USA, and which, in Sweden, only exists as a fragment within a specific niche: a site for the production of snuff in Gothenburg, with a subsidiary site in Borås. It is of course not reasonable to consider this a “Swedish cluster”, but for the sake of completeness we have nevertheless elected to let this virtually non-existent cluster remain in the account below.

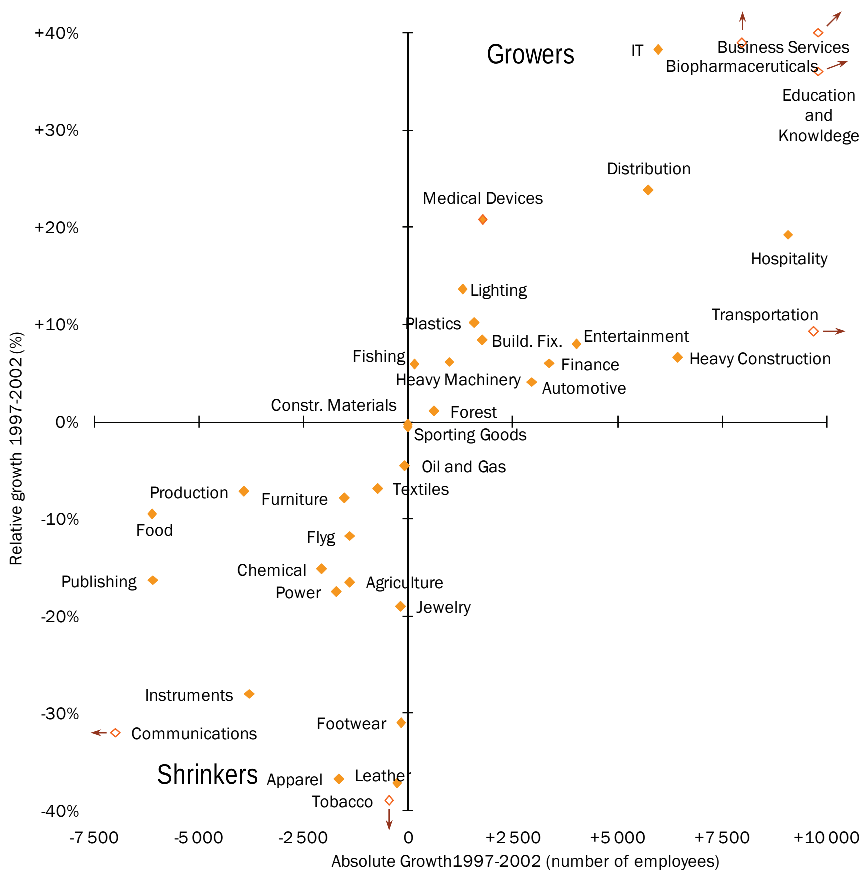
Clusters large and small

Bearing the above reservation in mind, we may now direct our attention towards the 38 clusters. The largest industry aggregates from an employment point of view all have a “support character”. The largest cluster is Business services, employing approximately 200 000 persons. This cluster is dominated by consultancy activities, such as IT and management consulting. Transportation and logistics is the second largest, with some 150 000 employees. The industry aggregates immediately below them can be partly characterised as support functions too. The industry clusters most clearly associated with Swedish international specialisation and competitiveness – Metal manufacturing, Automotive, IT, Biopharmaceuticals, Power generation and transmission, etc. – are mostly to be found in the range of 10 000–100 000 employees. The industry aggregates comprising only a few hundred employees are, as seen above, so insignificant that they can hardly be considered Swedish industry clusters.

Growing clusters

Globally, industry clusters have grown during the period of 1997–2003 by approximately 146 000 employees. This growth is unevenly distributed, however, and many industry clusters have contracted during this period. 19 of the clusters have grown during this period, with a total of 193 000 employees, while 21 have contracted with a total of 47 000 employees. (See Figure 6.)

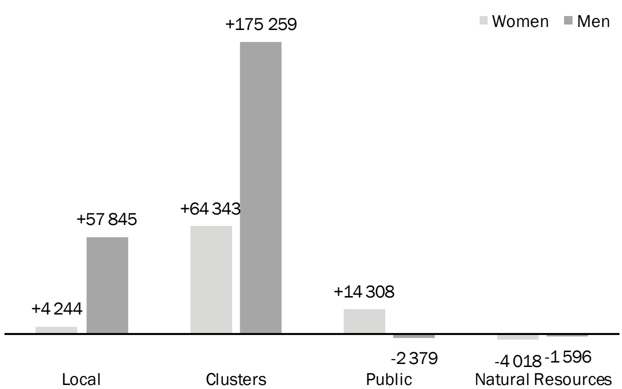
Figure 6. Absolute and relative growth in industry clusters 1997–2002.



In most clusters, the number of women has decreased. Women's share has decreased both in growth clusters (lower right-hand quadrant) and shrinking clusters (upper right). In some clusters however, women have received more than their proportional share of growth (Heavy machinery, Power generation, Building fixtures, IT and Distribution), and in others, they have been hit by decline more severely than the men (Footwear, Chemical products, Aerospace and Jewelry and precious metals).

Accordingly, we see in the cluster sector that women have not received their "fair share" of growth. This is the case to an even greater extent in the local sector, where women proportionally speaking should account for some 60% of growth. Actually, women account for only 7% of local sector growth. In the public sector (public administration, law enforcement, defence etc.) however, the number of women has increased while the number of men has decreased. The natural resource-based sector has decreased by more than twice the number of women as men. (See Figure 7.)

Figure 7. Number and percentage of women by industry cluster



The geographical structure of industry clusters

Let us now turn to the geographical distribution and structure of Swedish industry clusters. Thus far, we have discussed clusters as national bundles of industries, which we envisage as being characterised by internal links in the shape of the flow of knowledge and goods. However, the concept of clusters also has a more specific spatial dimension, since the idea is that the dynamics and development power in a cluster increase if the activities are also located close to one another, i.e. if the industry clusters are also agglomerated in individual labour market regions or adjacent regions. In this section, we will initially consider the location patterns of national industry clusters in a general manner. Using a simple yardstick, we will measure how the degree of spatial agglomeration or spread varies between clusters. Then we will illustrate, using a selection of maps, some types of regional patterns. Finally, we will study some local labour market regions which function as "gathering places" for groups of similar and related activities in various areas, i.e. the presence of what we call local clusters.

Agglomeration and dispersion

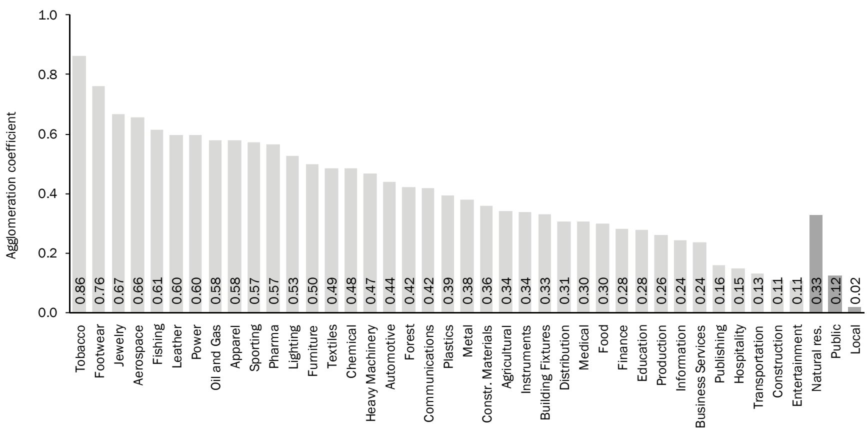
In the two figures below, we start from a calculation of what we call the agglomeration coefficient (Ac.) of the 38 industry clusters. This coefficient measures how the distribution of employment between regions (in this case, Sweden is divided into 81 local labour market regions, LA regions) in a given industry cluster differs from the distribution of overall employment (in all 38 clusters) between LA regions. By adding up all deviations from an imaginary even (proportional) distribution, a measure of the "skewness" of the localisation pattern is obtained. The more skewed the distribution (i.e. the closer to 1), the more agglomerated the pattern of localisation. The more even the distribution (i.e. closer to 0), the more spread out the pattern of localisation.

Figure 8 shows the agglomeration coefficient for the 38 industry clusters. We find that some ten industry clusters show coefficients of 0.6 or more, indicating that they are clearly overrepresented in some regions. The approximately ten clusters with a value between 0.5 and 0.4 are unevenly spread as well, while at the other end of the scale, the industry clusters with a coefficient of less than 0.2 are so spread out that they can hardly be expected to show any obvious examples of local or regional clusters[1]. Note that the coefficient of the local sec-

[1] There are a few exceptions. For instance, Hospitality is evenly spread, yet shows a local cluster in Åre.

tor is extremely low (0.02), confirming the local nature of these activities.

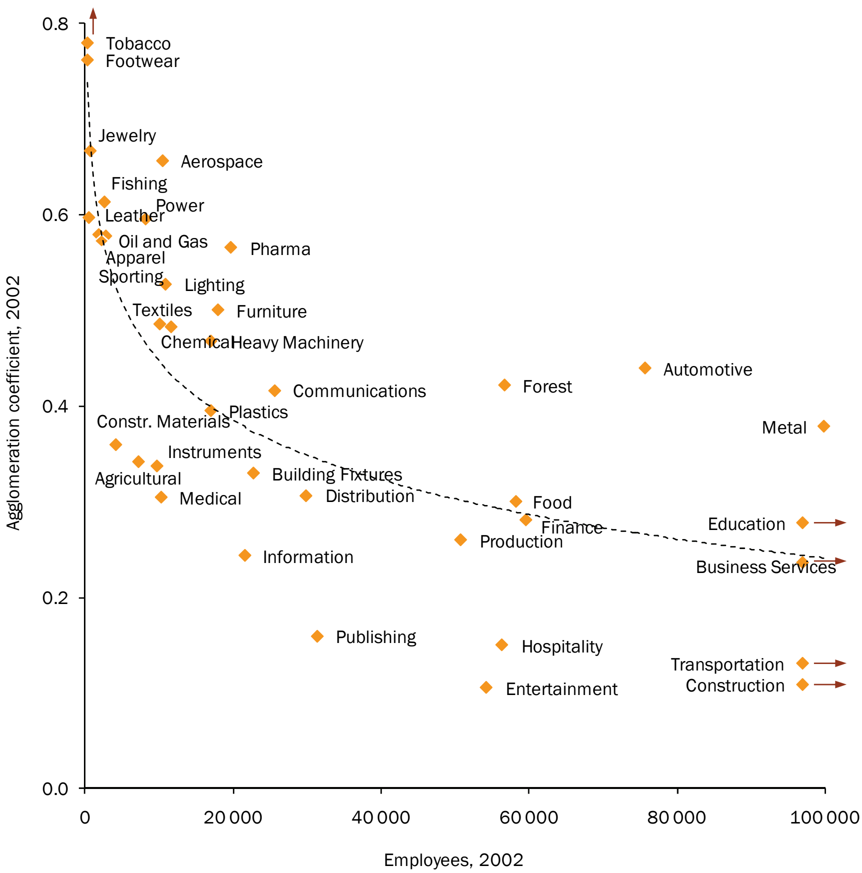
Figure 8. Agglomeration coefficient by industry cluster in 2002



Data source: CFAR, Statistics Sweden

Figure 9 shows a pattern which complicates the image. There is an obvious correlation between the importance (the size) of a industry cluster and its degree of agglomeration as measured by Aq. Small industry clusters, with few employees and few work sites, generally score high. This is easy to understand if one imagines the extreme case where an industry aggregate consists of one single work site, in which case Ac by definition will approach 1. Unsurprisingly, the highest agglomeration coefficients are therefore to be found in the three very smallest industry aggregates. The industry clusters which seem to show the type of agglomeration coefficient of interest in this context are rather those evidencing higher values than would be expected from their size, such as Aerospace, Biopharmaceuticals, Furniture, Forest products, Automotive and Metal manufacturing.

Figure 9. Agglomeration coefficient and number of employees by industry cluster, 2002



Data source: CFAR, Statistics Sweden

Some examples on the regional distribution of industry clusters

In order to describe the localisation of clusters, we have elaborated a number of maps. Here we show how each region has specialised. We have called the measure we use the Location quotient, a measure which when equal to 1 indicates that the region has a percentage of a cluster work force consistent with its size (normal quotient values range from 0.5 to 2). If the value is 2, the region has twice the percentage expected, and if the value exceeds 10 the region has an extreme specialisation in a given cluster. Using area proportional circles, the maps also indicate industry cluster employment in the labour market region in question in absolute numbers.

The industry clusters of Sweden show varying patterns of geographical localisation. Some industry clusters are fairly evenly distributed across the country. In others, e.g. Furniture or Automotive, several adjacent LA regions form larger cohesive regional clusters. In yet other cases, we see how a limited number of LA regions form separate, more local clusters.

Accordingly, the furniture industry (wood laminates etc.) forms a clear regional cluster, spanning a cohesive belt of LA regions in Småland and West Götaland all specialising in this area.

Sweden's sixth largest cluster is Automotive (see map), which includes cars, buses and lorries in addition to surrounding suppliers. Some 75 000 persons work in this cluster which is focused in West Sweden and in Småland. The Mälar region is also home to a number of enterprises. There is a minor cluster around Umeå.

Metal manufacturing, comprising almost 100 000 jobs, is relatively evenly spread over Sweden, above all in Central and Southern Sweden (see map in Appendix).

Lighting and electrical equipment is to be found in the Bergslagen region (Västerås, Köping, Fagersta, Ludvika) and in South Sweden (see map in Appendix). This is a medium-sized cluster. Power generation and transmissionis concentrated in the same region of Bergslagen and in Norrköping (Finspång) and Söderhamn.

Medical devices (such as medical apparatus and wheel chairs) shows clusters in Skåne, the Stockholm area and the Norrland regions of Östersund and Umeå. The pharmaceutical industry is strongly concentrated in Stockholm-Uppsala and Skåne. This cluster is fairly large comprising some 20 000 employees.

The Swedish aerospace industry (see map) is concentrated in three regions: in the Mälar region, the Linköping area and in Gothenburg (including Trollhättan). The cluster is medium-sized comprising some 10 000 employees. Another medium-sized cluster is Plastics and paint, concentrated in Gothenburg and Skåne (see map in Appendix).

Unsurprisingly, the two industry clusters of Textiles and Apparel show similar patterns of localisation (see map in Appendix). There is a bit of spread, but the focus remains in South Sweden, particularly in the Borås area. The Textile cluster is almost five times the size of the Apparel cluster.

The Processed food cluster and the Agriculture cluster show different patterns of localisation, with Agriculture remaining fairly evenly spread across the country (see map in Appendix). The food industry, one of Sweden's ten largest clusters, is to be found in South and West Sweden and in the Stockholm area. Fishing and fishing products, one of Sweden's smallest clusters, is to be found along the West Coast and the Bay of Hanö, in addition to some regions in Norrland (see map in Appendix).

One of Sweden's smallest clusters is Footwear, today employing less than 500 persons. The focus is in South Sweden, Örebro and Åre (see map in Appendix). Sporting, recreational and children's goods is also a minor cluster, concentrated in Småland and West Dalarna.

Maps of all industry clusters are to be found in Appendix 2.

Local clusters

As seen earlier, industry clusters may exist on a national level. Metal manufacturing is an example of this type of cluster, represented in all parts of the country, and where it can be assumed that national cluster effects are present. In other industry clusters, there are regional cluster formations, where activities are concentrated in a certain part of the country. The Furniture cluster in Småland and Västergötland exemplifies this.

In some cases, however, it is justified to talk about clusters on a purely local level, i.e. within one given LA region. In many industry clusters, there is so much activity in one LA region that it can be considered a local cluster.

We have tried to map these local clusters by establishing two definitions. A local cluster is assumed to exist if one of the following two criteria is met:

- an LA region accounts for not less than 15% of the nation's employees in a industry cluster, and employs a minimum of 1 000 persons distributed over at least two work sites *or*
- an LA region has a location quotient of at least 10 for a industry cluster, and employs at least 100 persons distributed over at least two work sites.

The first criterion is intended to identify LA regions important in absolute terms, while the second one identifies regions with a relative specialisation within a given industry cluster.

Using these criteria, 99 local clusters can be identified. The result is shown in Figure 13. According to the first criterion, 30 local clusters can be identified and an additional 69 clusters answer to the second criterion.

Stockholm, due to its size, shows 14 local clusters, all conforming to the first criterion. With almost 25% of all employees in the nation, Stockholm can relatively easily account for more than 15% of several industry clusters. The same reasoning applies to Gothenburg, with 11% of the nation's employees. The smaller LA regions satisfy the second criterion instead.

Data underlying the map in Figure 10 are shown in Table 3.

Of course, it can be said that the criteria used here to define what we consider a local cluster have been chosen arbitrarily. We maintain, however, that they are reasonable. No matter where the limits are drawn, there are always problems with marginal cases falling just below the limit. This applies to, for example, Bioharmaceuticals in Uppsala and Automotive in Skövde. In both cases we are dealing with local LA regions which we earlier placed in a wider regional context (the Mälar region Pharmaceutical cluster and the Automotive cluster in West Sweden respectively), but when considered as separate local LA regions they have neither the importance nor the degree of specialisation defined by our criteria.

Figure 10. Local clusters 2002

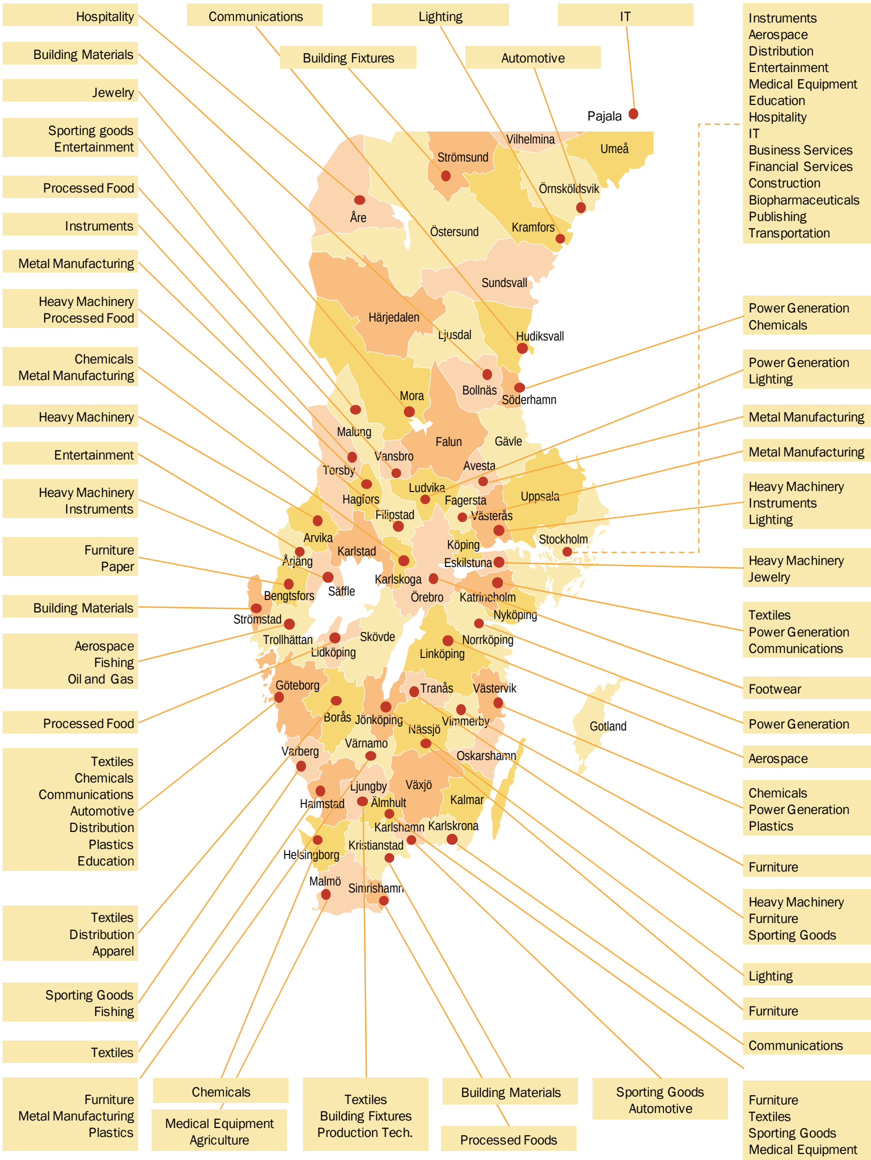


Table 3. Local clusters 2002

		Stockholm	Katrineholm	Eskilstuna	Linköping	Norrköping	Värnamo	Jönköping	Nässjö	Tranås	Älmhult	Ljungby	Vimmerby	Västervik	Karlshamn	Karlskrona	Simrishamn	Helsingborg	Kristianstad	Malmö	Halmstad	Varberg	Göteborg	Trollhättan	Strömstad	Bengtsfors	Borås	Lidköping	Torsby	Årjäng	Filipstad	Hagfors	Arvika	Säffle	Örebro	Karlskoga	Västerås	Fagersta	Vansbro	Malung	Mora	Avesta	Ludvika	Söderhamn	Bollnäs	Hudiksvall	Kramfors	Örnsköldsvik	Strömsund	Åre	Pajala
		14	3	2	1	1	3	1	1	3	4	3	1	3	2	1	1	1	1	2	1	2	7	3	1	2	3	1	1	1	2	1	1	2	1	2	3	1	1	2	1	1	2	2	1	1	1	1	1	1	1
Heavy Mach.	6			8						9																					6		13	6			6														
Furniture	6						6		7	13	8		7													10																									
Textiles	6		9								5	13									7		16%				18%																								
Chemicals	5													5				25%					15%													6								7							
Power	5		7			26%								10																												28	31								
Metal	5						5																									8				8		9				6									
Sporting Goods	5									25	24				23							11																		55											
Lighting	4							5																													19%						21				7				
Food	4																6											5			6								5												
Instruments	4	28%																											6					7			7														
Communications	4		6													6							18%																							8					
Automotive	3														6								17%																									6			
Constr. Materials	3																		10						11																				22						
Distribution	3	35%																					15%				7																								
Aerospace	3	33%			32%																			16%																											
Medical Devices	3	28%									7									18%																															
Plastics	3						10							7									16%																												
Entertainment	3	30%																												8										7											
Build. Fixtures	2											6																																					6		
Fishing	2																					6		17																											
Education	2	30%																					18%																												
IT	2	36%																																																	12
Jewelry	2			29																																					65										
Hospitality	2	31%																																																11	
Construction	1	22%																																																	
Finance	1	51%																																																	
Bus. Services	1	46%																																																	
Publishing	1	31%																																																	
Agriculture	1																			16%																															
Apparel	1																										53%																								
Biopharm.	1	62%																																																	
Production	1											6																																							
Forest	1																									15																									
Oil and Gas	1																							17																											
Footwear	1																																		16																
Transportation	1	33%																																																	

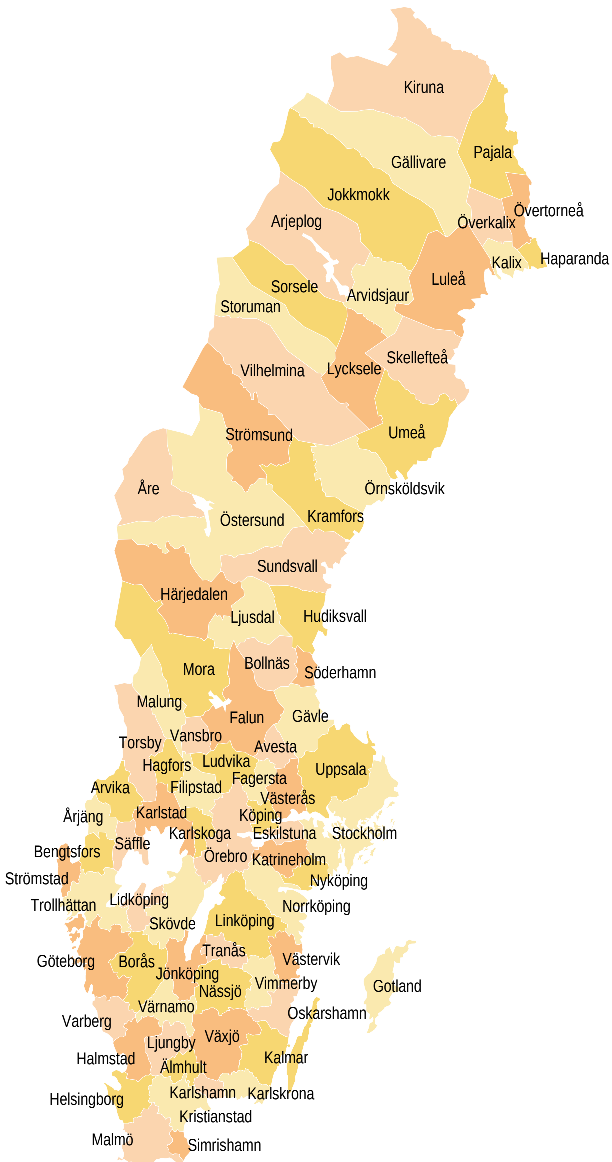
Dark squares mark local clusters with at least 15% of employees nationally in a given industry cluster and at least 1 000 employees at at least two work sites. The number in the square indicates the region's percentages of employees in that industry cluster. Light squares mark local clusters with a location quotient greater than 5 and at least 100 employees at at least two work sites. The number in the square indicates the region's location quotient.

In closing, we also would like to reiterate that the industry grouping used in this report for building up clusters is still far from finished. However, continued methodology development will in time give a more nuanced and correct image. The probable outcome is that none of the 99 local clusters identified here will fall away, but rather that additional local clusters will be added.

What the present report clearly shows is that it is possible and useful to create an image of regional and local cluster structures in Sweden using publicly available business statistics. This is important, as experience clearly shows that a cluster-based regional business and development policy has greater chances of succeeding if it departs from, builds on and is aimed at increasing dynamism in the competence and activity concentrations actually existing in the regions.

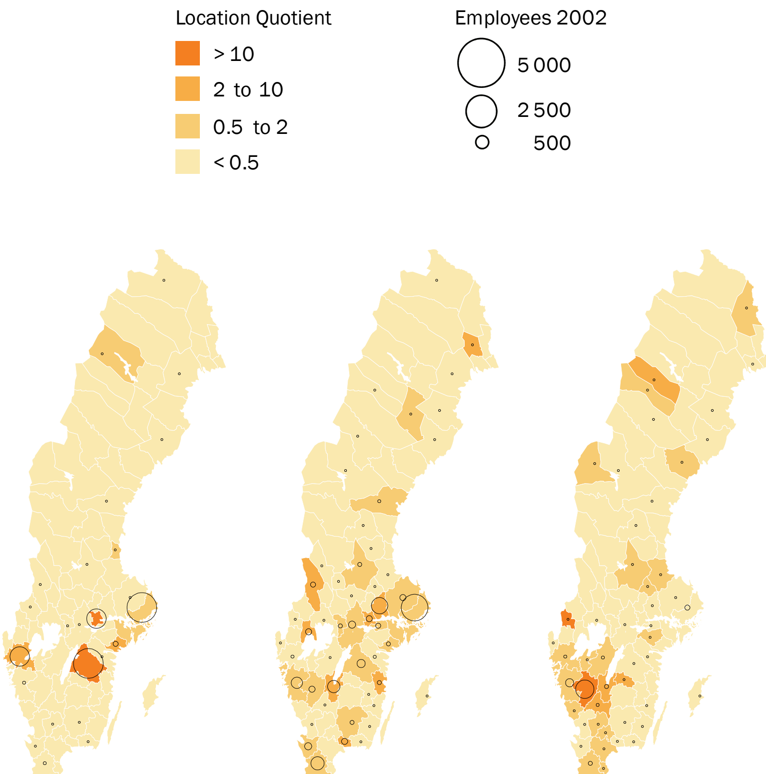
Appendices

Appendix 1. Region map

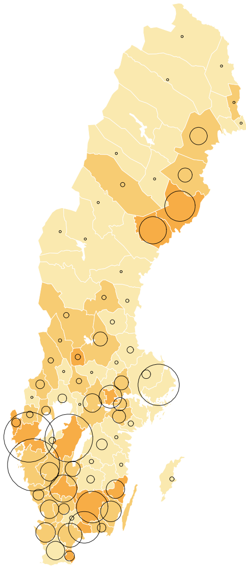


Appendix 2. Cluster maps

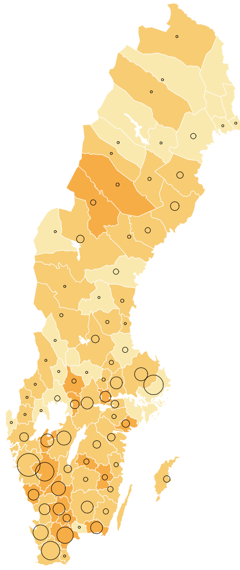
These maps indicate, for each industry cluster, the outcome of the statistical analysis based on data from the CFAR database of Statistics Sweden. Area proportional circles are used to indicate the number of persons employed in the industry cluster and colour denotes the location quotient.



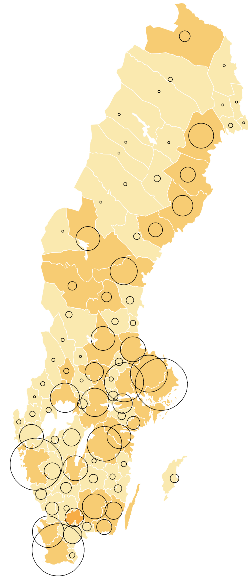
Aerospace   Analytical instruments   Apparel



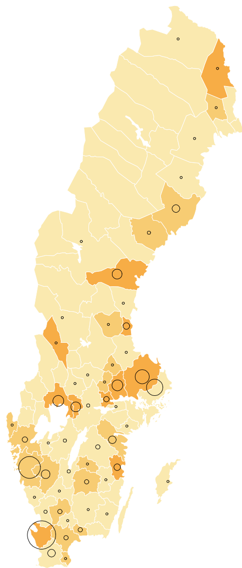
Automotive



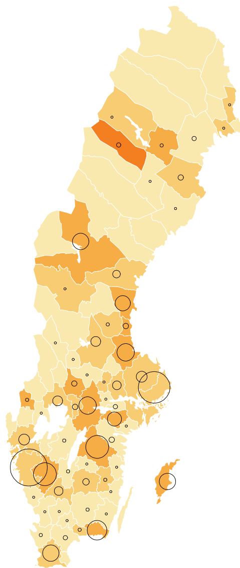
Building fixtures



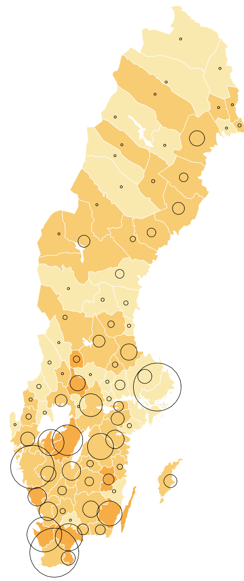
Business services



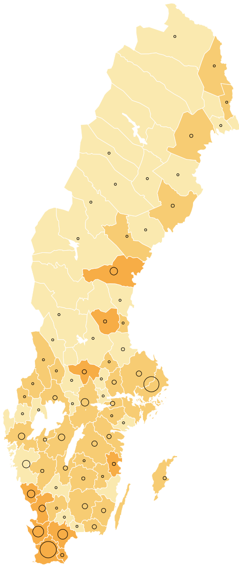
Chemical products



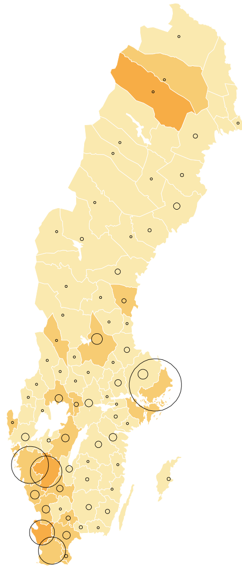
Communications equipment



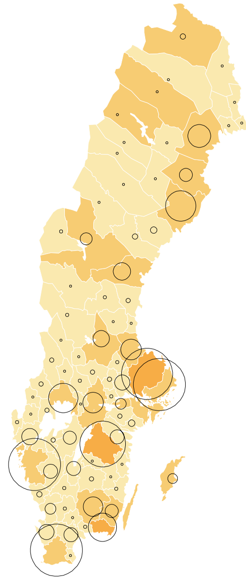
Food



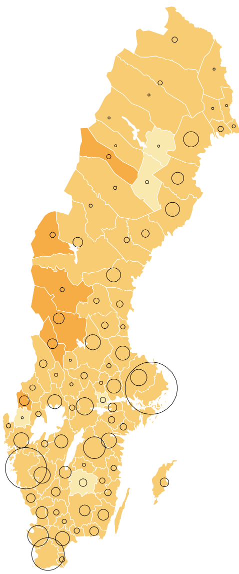
Agricultural products



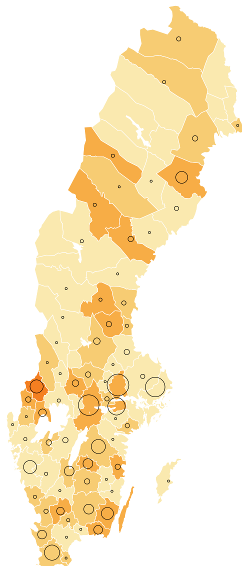
Distribution services



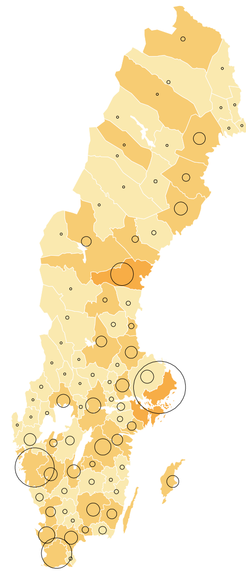
Education and knowledge creation



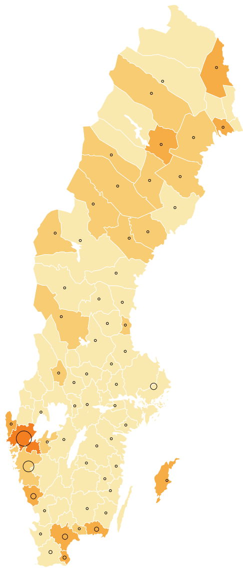
Entertainment



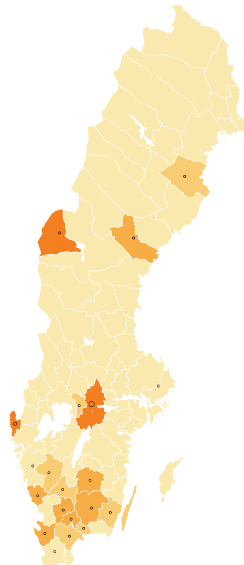
Heavy machinery



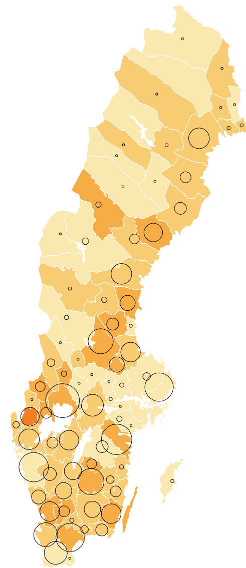
Financial services



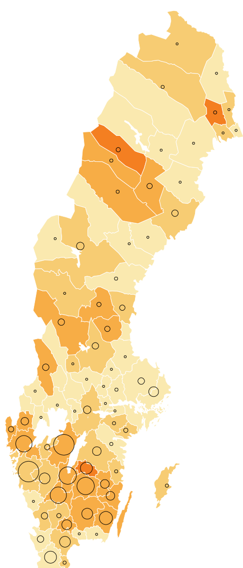
Fishing



Footwear



Forest products



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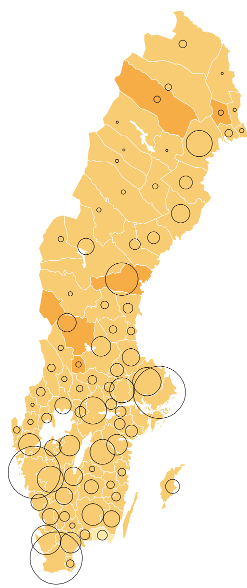

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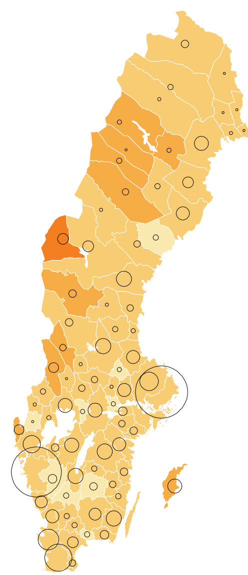

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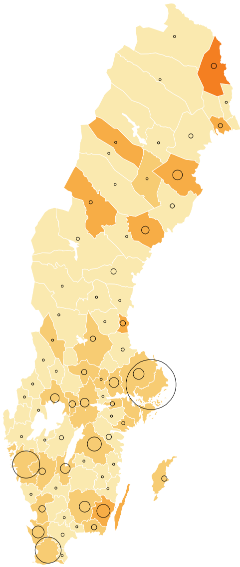
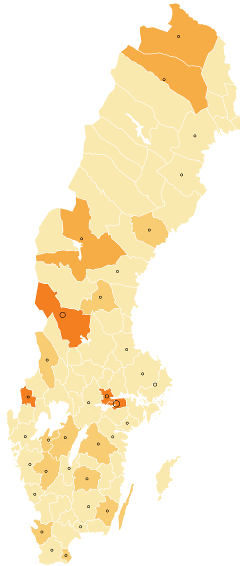
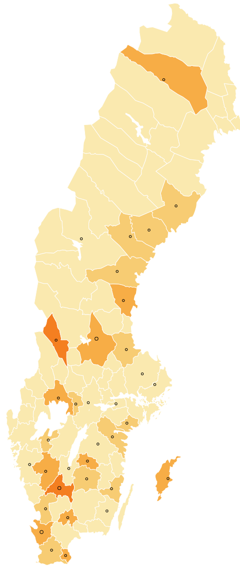


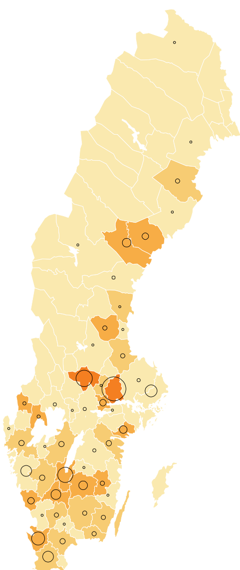
Information technology



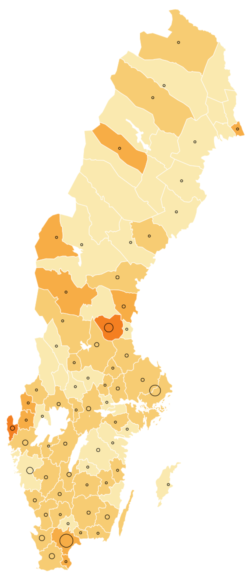
Jewelry and precious metals



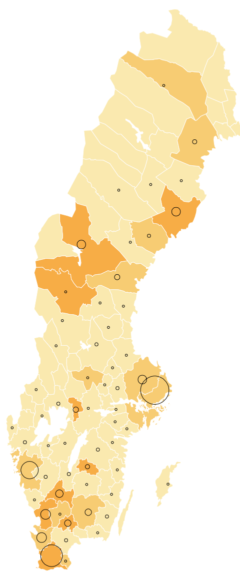
Leather products



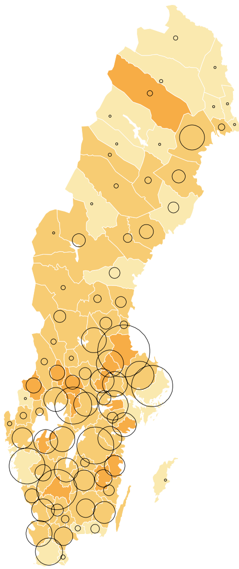
Lighting and electrical equipment



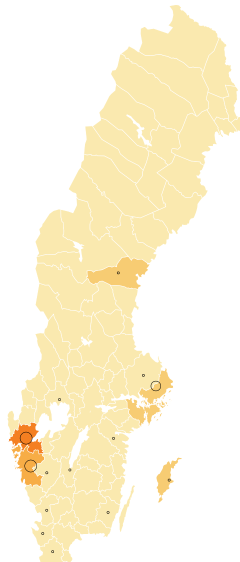
Construction materials



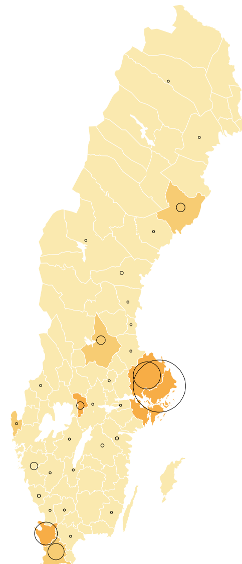
Medical devices



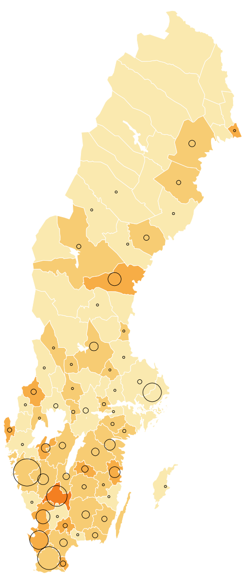
Metal manufacturing



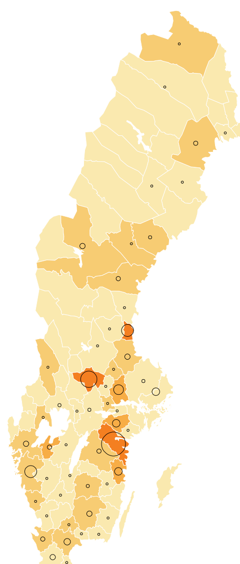
Oil and gas



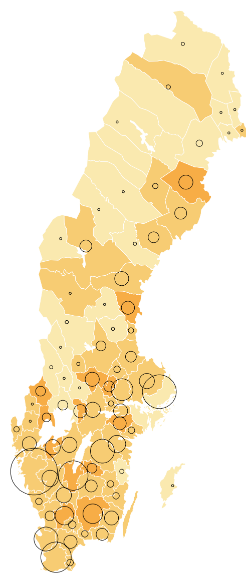
Biopharmaceuticals



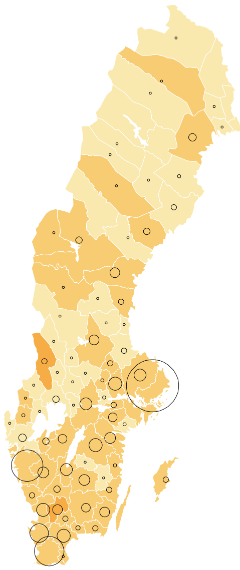
Plastics



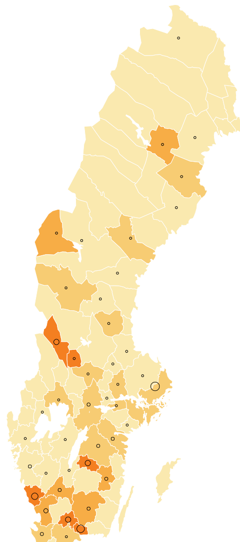
Power generation



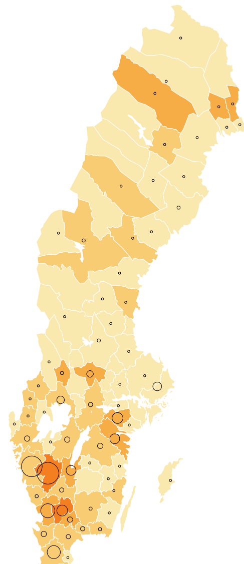
Production technology



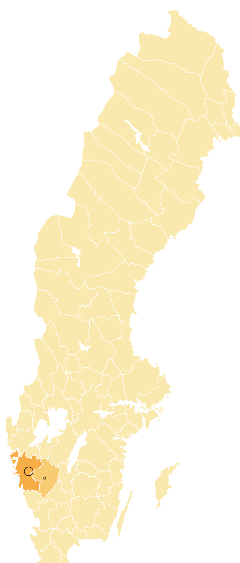
Publishing and printing



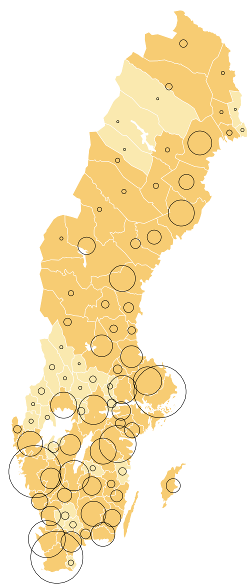
Sporting, recreational, and children's goods



Textiles



Tobacco



Transportation and logistics

Appendix 3. List of LA regions

This table comprises all 81 LA regions. The table contains the following data:
Name of region; percentage of all employees nationally to be found in the region.
Percentage of employees in a region working in the cluster sector; industry coefficient, indicating how evenly cluster sector employees are spread over the various industry clusters.
The industry cluster where the region has the highest percentage of all employees nationally; number of employees of the industry cluster; the region's share of all employees nationally in that industry cluster; the corresponding location quotient.
The largest industry cluster in the region in terms of number of employees; number of employees in the industry cluster; the region's share of all employees nationally in the industry cluster.

Region	*% of nat. emp.*	*% in cl. sector*	*Indust. coeff.*	*Highest percentage of all national employment*				*Highest number of employees*		
				Industry cluster	*Empl.*	*% of nat. empl.*	*Lq*	*Industry cluster*	*Employees*	*% of nat. empl*
Stockholm	24.5%	38.0%	0.27	Biopharmaceuitcals	12 246	62.0%	2.5	Business Services	89 710	45.6%
Uppsala	2.8%	32.7%	0.25	Biopharmaceuitcals	2 662	13.5%	4.7	Education/Knowledge	8 062	6.8%
Nyköping	0.6%	32.3%	0.33	Lighting	265	2.4%	3.9	Metal	2 160	2.2%
Katrineholm	0.6%	34.7%	0.40	Textiles	489	4.9%	8.7	Communications	861	3.4%
Eskilstuna	0.9%	37.5%	0.32	Jewelry	193	25.5%	28.6	Metal	3 039	3.0%
Linköping	2.6%	41.0%	0.29	Aerospace	3 329	31.7%	12.1	Education/Knowledge	6 620	5.6%
Norrköping	1.8%	32.6%	0.30	Power	2 142	26.4%	14.6	Transportation	4 425	3.0%
Värnamo	1.0%	53.3%	0.50	Leather	82	18.3%	18.9	Metal	5 228	5.2%
Jönköping	1.6%	40.1%	0.26	Lighting	940	8.7%	5.3	Transportation	3 192	2.1%
Nässjö	0.9%	34.7%	0.42	Furniture	1 146	6.4%	6.8	Forest	2 479	4.4%
Tranås	0.3%	43.2%	0.50	Sporting goods	154	7.1%	25.3	Furniture	645	3.6%
Älmhult	0.3%	40.8%	0.42	Sporting goods	161	7.3%	24.1	Business Services	1 328	0.7%
Ljungby	0.4%	41.6%	0.46	Textiles	553	5.5%	12.7	Production	1 301	2.6%
Växjö	1.5%	39.7%	0.20	Automotive	3 378	4.5%	3.0	Automotive	3 378	4.5%
Vimmerby	0.3%	40.7%	0.46	Sporting goods	61	2.8%	9.4	Metal	1 240	1.2%

Region	% of nat. emp.	% in cl. sector	Indust. coeff.	Highest percentage of all national employment				Highest number of employees		
				Industry cluster	Empl.	% of nat. empl.	Lq	Industry cluster	Employees	% of nat. empl
Kalmar	1.2%	37.8%	0.29	Heavy machinery	677	4.0%	3.2	Food	1 915	3.3%
Oskarshamn	0.5%	30.4%	0.40	Furniture	398	2.2%	4.5	Automotive	1 388	1.8%
Västervik	0.4%	34.3%	0.51	Power	311	3.8%	9.6	Metal	1 606	1.6%
Gotland	0.6%	31.7%	0.40	Leather	20	4.4%	7.4	Communications	1 081	4.2%
Karlshamn	0.5%	38.5%	0.50	Sporting goods	268	12.2%	23.0	Automotive	3 443	4.5%
Karlskrona	1.0%	35.4%	0.35	Communications	1 490	5.8%	5.9	Education/Knowledge	2 789	2.4%
Simrishamn	0.3%	35.1%	0.43	Fishing	66	2.5%	9.4	Food	852	1.5%
Helsingborg	3.1%	37.1%	0.24	Chemicals	2 851	24.7%	8.0	Transportation	4 572	3.1%
Kristianstad	1.7%	33.5%	0.30	Constr. materials	689	16.3%	9.6	Forest	2 908	5.1%
Malmö	6.9%	36.5%	0.18	Medicin	1 850	17.9%	2.6	Education/Knowledge	13 885	11.7%
Halmstad	1.2%	35.1%	0.29	Textiles	859	8.5%	7.0	Metal	1 962	2.0%
Varberg	0.9%	29.8%	0.31	Sporting goods	224	10.2%	11.3	Food	1 203	2.1%
Göteborg	10.8%	40.2%	0.16	Tobacco	371	97.4%	9.0	Business Services	26 533	13.5%
Trollhättan	2.1%	36.1%	0.34	Oil and gas	656	36.3%	17.1	Automotive	7 583	10.0%
Strömstad	0.2%	33.7%	0.38	Footwear	60	15.5%	70.0	Hospitality	410	0.7%
Bengtsfors	0.2%	25.9%	0.55	Forest	1 349	2.4%	14.6	Forest	1 349	2.4%
Borås	1.7%	42.1%	0.36	Apparel	1 522	53.0%	31.6	Distribution	3 469	11.6%
Lidköping	0.8%	37.8%	0.46	Food	2 461	4.2%	5.4	Food	2 461	4.2%
Skövde	1.9%	38.5%	0.39	Automotive	6 985	9.2%	4.8	Automotive	6 985	9.2%
Torsby	0.3%	27.2%	0.41	Processkontroll	153	1.6%	5.7	Hospitality	443	0.8%
Karlstad	1.7%	32.2%	0.24	Forest	3 812	6.7%	4.1	Forest	3 812	6.7%
Årjäng	0.1%	36.2%	0.54	Jewelry	16	2.1%	23.4	Entertainment	403	0.7%
Filipstad	0.2%	48.1%	0.55	Food	960	1.6%	9.0	Food	960	1.6%
Hagfors	0.1%	39.7%	0.55	Metal	923	0.9%	7.6	Metal	923	0.9%
Arvika	0.3%	34.9%	0.45	Heavy machinery	735	4.3%	12.6	Metal	993	1.0%

Region	% of nat. emp.	% in cl. sector	Indust. coeff.	Highest percentage of all national employment				Highest number of employees		
				Industry cluster	Empl.	% of nat. empl.	Lq	Industry cluster	Employees	% of nat. empl
Säffle	0.3%	28.6%	0.44	Processkontroll	210	2.2%	7.2	Forest	574	1.0%
Örebro	2.3%	30.9%	0.17	Footwear	146	37.8%	16.2	Transportation	3 072	2.1%
Karlskoga	0.6%	43.4%	0.58	Metal	4 515	4.5%	8.1	Metal	4 515	4.5%
Västerås	1.9%	40.1%	0.27	Lighting	2 076	19.2%	10.1	Business Services	5 101	2.6%
Fagersta	0.2%	44.8%	0.58	Metal	2 058	2.1%	8.7	Metal	2 058	2.1%
Köping	0.5%	39.2%	0.52	Aerospace	1 605	15.3%	28.4	Automotive	1 931	2.5%
Vansbro	0.1%	36.3%	0.52	Sporting goods	38	1.8%	24.5	Food	224	0.4%
Malung	0.1%	38.0%	0.50	Leather	45	9.9%	82.9	Entertainment	454	0.8%
Mora	0.4%	33.5%	0.46	Jewelry	175	23.1%	65.0	Heavy construction	1 308	1.3%
Falun	1.5%	30.8%	0.18	Leather	49	10.8%	7.2	Forest	2 281	4.0%
Avesta	0.4%	34.0%	0.52	Metal	2 698	2.7%	6.2	Metal	2 698	2.7%
Ludvika	0.5%	41.0%	0.49	Power	1 062	13.1%	28.2	Business Services	1 362	0.7%
Gävle	1.7%	34.8%	0.34	Metal	8 192	8.2%	4.8	Metal	8 192	8.2%
Ljusdal	0.2%	28.8%	0.28	Furniture	99	0.5%	2.5	Business Services	458	0.2%
Söderhamn	0.3%	31.5%	0.39	Power	671	8.3%	31.0	Power	671	8.3%
Bollnäs	0.4%	30.4%	0.39	Constr. materials	362	8.6%	22.1	Forest	635	1.1%
Hudiksvall	0.5%	28.3%	0.39	Communications	906	3.5%	7.6	Forest	991	1.7%
Sundsvall	1.7%	30.7%	0.26	Plast	763	4.5%	2.7	Heavy construction	3 531	3.4%
Kramfors	0.4%	22.4%	0.33	Lighting	325	3.0%	7.5	Heavy construction	513	0.5%
Örnsköldsvik	0.6%	41.2%	0.34	Automotive	2 571	3.4%	5.7	Automotive	2 571	3.4%
Strömsund	0.1%	21.8%	0.45	Building fixtures	161	0.7%	5.8	Building fixtures	161	0.7%
Åre	0.1%	37.8%	0.57	Footwear	28	7.2%	83.8	Hospitality	532	0.9%
Härjedalen	0.1%	34.5%	0.36	Hospitality	301	0.5%	4.6	Business Services	352	0.2%
Östersund	1.0%	30.3%	0.22	Communications	1 143	4.4%	4.3	Business Services	2 059	1.0%
Storuman	0.1%	30.7%	0.50	Heavy machinery	67	0.4%	6.3	Hospitality	139	0.2%

Region	*% of nat. emp.*	*% in cl. sector*	*Indust. coeff.*	*Highest percentage of all national employment*				*Highest number of employees*		
				Industry cluster	*Empl.*	*% of nat. empl.*	*Lq*	*Industry cluster*	*Employees*	*% of nat. empl*
Sorsele	0.0%	36.7%	0.60	Furniture	89	0.5%	17.9	Communications	95	0.4%
Vilhelmina	0.1%	22.3%	0.38	Hospitality	195	0.3%	2.9	Hospitality	195	0.3%
Umeå	1.4%	35.1%	0.26	Automotive	3 246	4.3%	3.0	Automotive	3 246	4.3%
Lycksele	0.2%	20.9%	0.29	Furniture	150	0.8%	3.8	Metal	210	0.2%
Skellefteå	0.8%	33.1%	0.22	Heavy machinery	624	3.7%	4.5	Business Services	973	0.5%
Arvidsjaur	0.1%	20.5%	0.52	Sporting goods	7	0.3%	4.3	Transportation	113	0.1%
Arjeplog	0.0%	18.2%	0.54	Hospitality	86	0.2%	4.3	Hospitality	86	0.2%
Jokkmokk	0.0%	36.1%	0.46	Heavy construction	204	0.2%	4.1	Heavy construction	204	0.2%
Överkalix	0.0%	33.7%	0.52	Furniture	73	0.4%	10.9	Heavy construction	141	0.1%
Kalix	0.2%	20.5%	0.41	Fishing	16	0.6%	3.4	Heavy construction	279	0.3%
Övertorneå	0.0%	23.8%	0.47	Textiles	31	0.3%	7.8	Heavy construction	51	0.0%
Pajala	0.1%	24.4%	0.45	IT	134	0.6%	11.9	IT	134	0.6%
Gällivare	0.2%	16.9%	0.36	Jewelry	8	1.1%	4.6	Heavy construction	241	0.2%
Luleå	1.6%	29.9%	0.20	Forest	1 677	3.0%	1.9	Heavy construction	2 390	2.3%
Haparanda	0.1%	22.1%	0.41	Plast	34	0.2%	2.6	Heavy construction	113	0.1%
Kiruna	0.3%	21.9%	0.31	Jewelry	6	0.8%	3.0	Business Services	509	0.3%

Appendix 4. Explanation of terminology

Below, some important concepts are explained. In cluster research and practice, there are many concepts used in various senses. Our intention is not to give a generally valid definition of these concepts, but rather to state the sense in which the concepts have been used in the present report.

Location quotient (LQ): The ratio of a certain region's percentage of employees in a given industry to the region's percentage of all employees nationally. A quotient greater than 1 means that the region has a disproportionately large number of employees in that industry. The location quotient LQ for an industry *i* in a region *r* is calculated as:

$$LQ_{i,r} = \frac{a_{i,r}/A_i}{t_t/T}$$

where $a_{i,r}$ = number of employees in industry i in region r

A_i = number of employees in industry i nationally

t_r = total number of employees in region r

T = national total number of employees

Agglomeration coefficient (AC): This measures the skewness of the distribution of labour in a given industry. The agglomeration coefficient is in the range of 0 to 1. An industry in which the agglomeration coefficient is 0 is perfectly evenly distributed across the nation, i.e. the industry has an equal percentage of employees in each region. In this case, noting indicates that the industry has formed any clusters. An industry with a high agglomeration coefficient (close to 1) has most employees concentrated in few and/or small regions. The agglomeration coefficient *AC* for an industry *i* is calculated as:

$$AC_i = \frac{1}{2}\sum_{n=1}^{R}\left|\frac{a_{i,n}}{A_i} - \frac{t_n}{T}\right|$$

where R = number of regions

$a_{i,n}$ = number of employees in industry i in region n

A_i = national number of employees in industry i

t_n = total number of employees in region n

T = national total number of employees

(In economic-geographical literature, this is occasionally referred to as “location coefficient”).

Industry cluster: A group of business activities which tend to be co-located and can be assumed to be interdependent in a way that may lead to the formation of *clusters*. Industry clusters are thus aggregates of businesses connected to one another by the flow of knowledge and products. The definition encompasses the part of the cluster which can, with reasonable ease, be identified and described using public statistics, i.e. companies — one of four cluster components (companies, higher education, public authorities, associations).

Industry coefficient (IC): Measures how skewd the labour distribution is in a given region. The industry coefficient ranges from 0 to 1. A region with an industry coefficient of 0 has its labour distributed as a perfect average between industries, i.e. the region has an equal percentage of employees nationally in each industry. In this case, nothing indicates that the region has any local clusters. A region with a high coefficient (close to 1) has most of its employees concentrated in few and/or small industries. The industry coefficient *IC* of a region *r* is calculated as:

$$IC_r = \frac{1}{2}\sum_{n=1}^{I}\left|\frac{a_{n,r}}{t_r} - \frac{A_n}{T}\right|$$

where I = number of industries

$a_{n,r}$ = number of employees in industry n in region r

t_r = total number of employees in region r

A_n = number of employees in industry n nationally

T = total number of employees nationally

LA region (Local labour market region): Municipalities grouped by outgoing commuting pattern. Municipalities which, by virtue of a high percentage of commuters, share a significant part of their labour can be considered as part of the same labour market. Groups of such municipalities form an LA region.

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Study 3

Geographical industry concentration in Europe compared to USA

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Study 3

Geographical industry concentration in Europe compared to USA

ABSTRACT Studies comparing industry concentration in Europe and USA have faced three challenges: obtaining data on sub-national level in Europe and sub-state level in the USA, disaggregating data into relevant and comparable industry groups, and devising a method for a consolidated comparison between the two continents. This paper reviews five previous studies, and presents a new comparison. It is based on considerably more granular data than previously used, a new grouping of industries, and applies the polarisation measure as a consolidated indicator of total industry concentration. The results confirm the previous conclusion that concentration is higher in the USA than in Europe, and show that this result is robust for different measures.

Introduction

In his seminal study, Krugman (1991) concluded that regional specialisation and industry concentration is higher in USA than in Europe, something that has since become a stylised fact. However, although the study has been much cited, Krugman stressed that the methodology had a number of weaknesses. In terms of regions, “the data are grossly overaggregated”. (ibid., p. 75) In terms of industry groups, it is “a crude comparison.” (ibid., p. 75) And in terms of producing a measure for Europe and US respectively to compare, Krugman noted that he did not “trust the comparability of the data enough” to make a direct comparison between the US and Europe. (ibid., p. 76).

Over the following decade, four studies revisited the issue, comparing agglomeration in Europe and the US with increasingly more sophisticated methods. However, although they improved on Krugman's initial analysis, the same methodological difficulties remained: finding detailed European data below the national level and US data below the state level; disaggregating data into relevant and comparable industry groups; devising a method for making a consolidated comparison between the two continents. Nevertheless, in general, their results and conclusions were similar to Krugman's.

The aim of this study is to overcome the methodological limitations of previous studies. Using data that is disaggregated into regions well below the national/state level, and split into a large number of industry groups specifically designed to capture agglomeration patterns, I calculate consolidated and comparable measures for Europe and USA. The results support Krugman's initial conclusion: industry concentration is higher in USA than in Europe.

The paper proceeds as follows. The next section reviews the literature and considers the methodologies previously applied and the implications. The third section describes the data and methods used. The fourth section presents the results of the comparison between Europe and USA. The fifth section concludes.

Literature review

As more granular economic data has become available for Europe, increasingly detailed studies of European industry localisation have been conducted. They employ a wide range of methods varying in terms of regional aggregation, industry aggregation, and the choice of agglomeration measures.

In previous studies, limited data availability has often meant that greater geographical disaggregation has come at the cost of less industry disaggregation or coverage of fewer countries. Some studies have opted for data on the national level (Amiti, 1999; Brülhart & Torstensson, 1996; Krugman, 1991; Midelfart-Knarvik, Overman, Redding, & Venables, 2000), while other have used data for NUTS1 regions (Braunerhielm, Faini, Norman, Ruane, & Seabright, 2000) or NUTS2 regions (Ezcurra, Pascual, & Rapún, 2006). In some studies, a mix of NUTS levels have been used to best utilise data of varying granularity or in order to create more equally sized regions (Brülhart & Traeger, 2003; Hallet, 2000; Molle, 1997). Geographical coverage for Europe has varied from 4 countries (Krugman, 1991) to 17 countries (Brülhart & Traeger, 2003), and the number of geographic units from 4 (Krugman, 1991) to 236 (Brülhart & Traeger, 2003).

There is a corresponding variation in the aggregation of industries. Some studies have made comparisons for a single industry (automotive, in the case of Krugman, 1991, and Midelfart-Knarvik et at.). The most common approach is to include only manufacturing industries (Amiti, 1998; Helg, Manasse, Monacelli, & Rovelli, 1995; WIFO, 1999), but some studies also include services (Brülhart & Traeger, 2003; Molle, 1997; Pons-Novell & Tirado-Fabregat, 1995). The main reason for excluding services is that services are assumed to be more local in nature than manufacturing, and that industry classification systems are not sufficiently granular for services. Some authors regard this as a reason inclusion of services in order not to overestimate agglomeration (Bayoumi & Prasad, 1997; Hallet, 2000) while others regard it as a reason for exclusion in order to avoid skewing results when employment shifts from manufacturing towards services.

Finally, previous literature has used a variety of measures to quantify the degree of agglomeration, often using different names for the same measure. The Gini measure was suggested by Krugman (1991) and is the most commonly used measure, although Kim (1995) refers to it as Hoover's coefficient.[1] Krugman (1991) also suggested a more intuitive measure, most commonly referred to as Krugman's index, but also as specialisation index (Hallet, 2000), sum of absolute differences (WIFO, 1999), location coefficient (Molle, 1997), or the relative Hoover-Balassa index (Braunerhjelm, Faini, Norman, Ruane, & Seabright, 2000). Other recurring measures are the concentration ratio (CR), the Herfindahl index, and the coefficient of variation (CV). CV is closely related to a class of measures referred to as entropy or generalised entropy, and applied by Brülhart and Traeger (2003) and Aiginger and Pfaffmayr (2004). One of these entropy measures is also called the Theil index. To conclude, Pons-Novell and Tirado-Fabregat (1995) apply a measure similar to both Herfindahl and Krugman's index, while Midelfart-Knarvik et al. (2000) introduce spatial separation, a measure that takes into account how regions are located to each other.

Of the extensive literature on industrial agglomeration in the US and Europe, only a small number of studies actually make a com-

[1] Gini was proposed by Hoover (1936) as a measure of industry localisation.

parison between the two continents. I will review these here, and describe what method they use to compare the two economies, and what conclusions they draw.

Krugman (1991) is by far the most cited study. It uses employment data for an unkown number of "(more or less) two-digit industries", apparently in manufacturing only. The data is aggregated to four large European countries (1985) and four large US regions (1977). Krugman compares Europe with USA in two ways. First, he calculates pairwise Krugman indices for specialisation of each pair of European countries and each pair of US regions, and notes that the European differences in general are smaller than the US differences. He does not calculate a consolidated value for Europe to use for comparison with the US. He finds that, although "the data is grossly overaggregated", "European nations are less specialised than U.S. regions." (Krugman, 1991, p. 76.) Second, he studies the automotive industry (presumably employment again), and compares the concentration ratios of the top region(s), and finds higher concentration in the US. Krugman concludes that "localization has gone much further in America than in Europe." (ibid., p. 78).

Bayoumi and Prasad (1997) double the number of regions by compiling output data (value added) for eight European countries and eight US regions. They also extend the analysis to a time series 1970-97 (US 1970-89). They analyse 8 sectors covering both manufacturing and services, which compared to Krugman's study is most likely a reduction in disaggregation but an increase in scope. These sectors are defined based on the top level of their respective classification systems. For each country or region, they calculate the sectors share of the continent's total output, and then analyse the coefficient of variation for these shares. Like Krugman, they refrain from calculating some consolidated value for all sectors to compare Europe with the US. However, they find that variation in only two sectors (primary industries and manufacturing) is higher in the US than in Europe, meaning that the US is more concentrated for them, but that Europe has higher variation in all the other six sectors. Their conclusion, contrary to Krugman's, is that "if anything, EU countries are somewhat more specialised than U.S. regions in industries other than manufacturing and primary goods [...] Manufacturing may, therefore not necessarily provide an adequate basis for comparing the structure of the U.S. and EU economies." (ibid, p. 42).

Like the preceding studies, Midelfart-Knarvik et al. (2000) use national European data, extending the coverage to 14 EU countries, but disaggregate the US data into 51 states (incl. District of Columbia). Their time series includes production data for four four-year periods from 1970 to 1997. The European classification system's 36 manufacturing groups are aggregated into 21 groups, which correspond to 21 US manufacturing groups.

This data set is then used for three comparisons. For the first comparison, the unweighted average Gini for the 21 industry groups in each continent is calculated, and the authors find that the US concentration is decreasing more rapidly than the European. The numbers indicate that both US specialisation and concentration is higher than European, but they point out that the large difference in geographical disaggregation (14 countries versus 51 states) makes a direct comparison of levels difficult.

In the second comparison between Europe and the USA, like Krugman (1991), they turn to the automotive industry and employ a method based on concentration ratios. They compare for 1970, 1982 and 1996 the number of top European regions and top US states needed to produce about 60% or about 85% of motor vehicles on each continent. They find that in Europe the top countries required represent a much greater share of total manufacturing production than the states required in the USA. In other words, "these states are […] much more specialised than the equivalent European countries." (ibid., p. 45)

In the third comparison, Midelfart-Knarvik et al. apply the concept of spatial separation, which takes into account the relative location of the regions studied, so that a concentration measure does not only reflect how an industry is divided between regions, but also how distant those regions are from each other. Otherwise, two industries may appear equally concentrated, although in one case it is concentrated to two neighbouring regions, while in the other case it is concentrated to two regions at either end of the continent. However, a direct comparison between the spatial separation between Europe and the US is not possible, since "their geographies are inherently different, and that there are different size units of observations in the US." (ibid., p. 45) To compensate for the smaller area of the US (excluding Alaska and Hawaii), the European spatial separations are divided by the spatial separation for all European manufacturing, and similarly the US values are divided with the value for all US manufacturing. These normalised values are called "conditional spatial separation", and for each of the 21 sectors the European value is divided by the US value. Finally, the unweighted average for the 21 sector ratios is calculated. A clear majority of the quotients are greater than 1, and the averages are greater than 1 for all four time periods. The authors conclude that "on average, the EU is more conditionally spatially separated than the US." (ibid., p. 46)

Braunerhjelm et al. (2000) in their opening chapter present a brief comparison between Europe and US. They do not reveal much detail about the method employed, so neither geographical aggregation, geographic coverage, nor the indicator of economic activity used is reported. However, the data covers 8 manufacturing sectors for 1970 and 1994. The measure used is the relative Hoover-Balassa, which is not defined, but presumably identical to the Krugman index. Braunerhjelm et al. find that clearly "regional specialization [...] remains substantially higher in the United States compared with Europe in six of the eight sectors". (ibid., p. 3) They also make a second comparison using data on GDP and GDP per capita. In this case, European data is aggregated in 50 NUTS1 regions and US data in 49 continental states, for the years 1978, 1990, and 1995. There is no disaggregation of industries. They measure the coefficient of variation and find that "GDP per capita shows less concentration in the United States than in Europe."(ibid., p. 4)

Aiginger and Leitner (WIFO, 2002) are the first to combine subnational European data with disaggregated industries. Their data set refers to 76 European NUTS1 regions covering all 15 EU countries at that time, and the 49 continental states of USA (incl. District of Columbia). Value added data represents the period from 1987 to 1995 (Europe, 70 regions only) or 1996 (USA), and employment data covers roughly the same period. The data disaggregation is based on the classification systems NACE-CLIO RR17 and SIC respectively. Of NACE's 17 sectors, the eight manufacturing ones were selected, and the largest of these was further split into three subsectors, for a total of 10 sectors used in the analysis. Aiginger and Leitner then apply four different measures of concentration: CR10% (top 7 regions in Europe, top 4.9 states in the US), CR30%, CV and Gini. The unweighted average is then calculated for each measure and results are found to be fairly consistent. For total manufacturing (no industrial disaggregation), they find that "according to three of the four indicators, the level of regional concentration is higher in the USA." (ibid.,

p. 15). Only CR10% indicated a slightly higher degree of concentration in Europe. For the individual sectors, the analysis indicates higher concentration for most sectors in USA, but higher concentration for some in Europe. The authors conclude that "while overall concentration is higher in the USA, this does not hold for all sectors". (ibid., p. 16) They do not calculate a consolidated value for all sectors.

This overview raises four methodological issues. First, it is notable that all studies use data which are *highly aggregated in terms of geography, industry, or both*. Table 1 shows the number of regions and industry groups for each previous study. The study with the highest number of industry groups has only 14 European (national) regions, and the study with the greatest geographical disaggregation has only 10 industry groups. All studies have either at most 14 regions or at most 10 industry groups. Also, only the WIFO study makes a comparison with sub-national European data National data is sufficient, of course, for studying cross-national patterns, but to analyse regional industry concentration, more detailed data is required. The WIFO study uses sub-national data, but does not go further than to the NUTS1 level, and then only disaggregates into ten industry groups. To analyse agglomeration patterns on an even lower regional level, more granular data is required. Unfortunately, regional industry statistics is not available in Europe to the same extent as in the US. In their review of the data situation, Combes and Overman (2003) find data availability to be a major problem, and that "no widely available, suitably detailed EU regional data set has yet emerged." (ibid., p. 7)

Second, the *industry scopes* of the previous studies are based on the assumption that manufacturing and services can be considered as homogenous groups in terms of industrial concentration. The studies either focus on all manufacturing, or on all manufacturing and all services. However, all service industries do not share the same agglomeration properties. While some, like food retail, are highly dispersed, others, like publishing, are clearly concentrated to certain regions. To include both or exclude both merely because they are both classified as services seems unsatisfactory. From an agglomeration perspective, whether an industry is in manufacturing or service is *per se* not relevant. We need to separate agglomerating industries from non-agglomerating ones, and for this the classification system's division into manufacturing and services will not help us. Some analytical method is needed.

Table 1. Previous studies comparing industry agglomeration in Europe and USA

Study	*Comparison*	*Regions*		*Industries*		*Measure*	*Consolidated value*
		EUR	*USA*	*groups*	*coverage*		
Krugman, 1991	employment	4 (nat)	4	not reported	manufacturing	Krugman index	none
	auto production	4 (nat)	4	1	single sector	CR	not applicable
Bayoumi and Prasad, 1997	"real output"	8 (nat)	8	8	manufacturing and services	CV	none
Braunerhjelm et al., 2000	not reported	not reported	not reported	8	manufacturing	Krugman index	none
	GDP, GDP per capita	50	49	1	not applicable	CV	not applicable
Midelfart-Knarvik et al., 2000	production	14 (nat)	51	21	manufacturing	Gini	unweighted average
	vehicle produc-tion	14 (nat)	51	1	single sector	CR	not applicable
	production	14 (nat)	49	21	manufacturing	spatial separation	unweighted average
WIFO, 2002	VA	70	49	1	manufacturing	CR10%, CR30%, CV, Gini	not applicable
	employment	76	49	1	manufacturing	CR10%, CR30%, CV, Gini	not applicable
	VA	70	49	10	manufacturing	CR10%, CR30%, CV, Gini	none
	employment	76	49	10	manufacturing	CR10%, CR30%, CV, Gini	none

Third, not only the scope but also the *aggregation of industries* is based on the industry classification systems. Industry groups at a certain level of the classification system are presumed to be relevant units of analysis. For studies with 8 or 10 groups, it is apparent that the level of agglomeration is quite high. For example, WIFO (2000) note that the group "metal industry" is large in terms of its total value added, and thus splits it into three sub groups: "metal product", "machinery", and "electronics and electrical equipment". However, size in itself seems a not very relevant basis for the disaggregation. A group of industries that are typically co-located can and should be treated as one industry group in terms of agglomeration, even if it is a large group. The problem is rather that groups may consist of industries with different location patterns. So the question becomes how to construct groups of industries that are relevant from an agglomeration perspective. The industry classifications are not designed with that purpose in mind. For example, the "chemical manufacturing" group contains production of basic chemicals as well as pharmaceuticals, two industries which we cannot assume are typically agglomerated together. Similarly, computers, telecom equipment, generators and medical instruments will be grouped together. Aggregating industries according to the industry classification system's structure could combine industries that do not agglomerate together, and split industries that do. An analytical method for grouping industries is clearly needed.

Fourth, all comparisons show a higher concentration in the US for some industries and in Europe for others. In order to draw a general conclusion about the difference between the continents, we need a method to make a *consolidated comparison of all industries*. Previous authors have addressed this problem in different ways, but neither of those solutions produces a reliable comparison between the continents. Agglomerating all industries into a single group (Braunerhjelm, Faini, Norman, Ruane, & Seabright, 2000; WIFO, 1999) gives a comparison of economic concentration in general (urbanisation), but tells us nothing about industry concentration patterns. Analysing only the automotive industry (Krugman, 1991; Midelfart-Knarvik, Overman, Redding, & Venables, 2000) can, as the authors point out, be instructive but is no substitute for a full analysis. Counting the number of industry groups more concentrated in Europe versus USA (Braunerhjelm, Faini, Norman, Ruane, & Seabright, 2000; WIFO, 1999) gives only a crude measure, which neither takes into account the size of each industry group, nor how big the differences are. Only one study actually presents a consolidated measure of concentration in Europe and USA (Midelfart-Knarvik et al.). They do so by calculating the unweighted concentration values for each industry group and comparing these averages between Europe and USA. The problems associated with this method are not discussed. While the strengths and weaknesses of different measures are considered, there is no comment on how to finally consolidate these separate values in a way that allows a comparison between European and US industries as a whole. We need an analytically sound method for consolidated comparisons.

In summary, previous studies have faced a number of methodological difficulties. *Regional disaggregation* is limited, both for Europe and for USA, although industry agglomeration clearly occurs on a sub-national/sub-state level. *Industry disaggregation* is also limited, and is based on the structure of the industry classification systems, although there is no analysis to show that the resulting industry groups actually are meaningful units of analysis for agglomeration. The *scope of industries* is based on the dichotomy of manufacturing versus services, although it would be more relevant to select industries based on their tendency to agglomerate. And, finally, although the studies find that the European-US comparison turns out differently for different industry groups, most studies do not calculate a *consolidated comparison* value for all industries, and the one that does applies a simple unweighted average. My aim with this study is to address each of these issues.

Data and methods

To increase both geographical and industry disaggregation, we have used data from two databases specifically designed for studying industry location patterns. The European data comes from the European Cluster Observatory at the Center of Strategy and Competitiveness, Stockholm School of Economics, and is an assembly of statistics from Eurostat and from national statistical agencies. It covers 31 nations, and is divided into 259 regions, mostly NUTS2 level.[2] Most of the data (213 regions) refers to year 2004, while the remaining regions range from 2001 to 2006.

The US data is from the Cluster Mapping project, Institute of Strategy and Competitiveness, Harvard Business School. The data derives from the County Business Patterns series from the U.S. Census Bureau, and is divided in 179 Economic Areas, covering all US states (including District of Columbia) for year 2002.

On the whole, the two sets of regions are of similar size, although within each set region sizes vary considerably. The average employment (in traded and local industries, see below) for the European regions is 649 thousand persons, and for the US regions 650 thousand persons. Details about the regional division of data is found in Table 2.

For the industry aggregation, this study follows Porter (2003), who applies a method that addresses both the issue of how to separate non-agglomerated industries from agglomerated ones and the problem of how to create industry groups that are relevant for agglomeration analysis. The method treats observed collocation patterns as revealed local externalities. Actual collocation patterns (in combination with input-output data) are used to determine groups of related industries. The method starts by analysing the employment localisation patterns of all industries. It then excludes a large group termed local industries which show no or very low tendencies to agglomeration (regardless of whether they are services or manufacturing). It also excludes industries that locate depending on some natural resource, such as mining and forestry (but not paper mills). The remaining industries, referred to as traded industries and representing roughly a third of total employment, are then grouped depending on their co-location patterns with other industries.

Spurious correlations are eliminated from the analysis with the help of input-output data. This produces 41 groups of 4-digit SIC industries, called cluster categories. These SIC codes are then trans-

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[2] Data has been disaggregated to the NUTS2 level, with the following exceptions. Belgium and Netherlands merged to NUTS1 due to small land area sizes of NUTS2 regions. Greece and Turkey merged to NUTS1 due to small populations in NUTS2 regions. Ireland merged to NUTS1 due to data unavailability at NUTS2 level. Brandenburg regions (DE) merged to NUTS1 due to NUTS2 code changes in 2004. In addition, the small island regions Ceuta (ES), Melilla (SP) and Åland (FI) were merged with the closest mainland region, and overseas possessions Azores (PT), Madeira (PT), Guadeloupe (FR), Martinique (FR), Guyane (FR) and Réunion (PT) were excluded from the analysis.

Table 2. Sources and regional, and industry disaggregation of data

Country	*Source*	*Year*	*Regions*		*Avg empl.**	*NACE*
			level	*no.*	*('000)*	*level*
France	INSEE (FR)	2004	NUTS2	22	768	4
Austria	Eurost. (LX); St. Aust. (AU)	2004	NUTS2	9	351	4
Belgium	Nat. Off. of Soc.l Sec. (BE)	2004	NUTS1	3	1 044	4
Bulgaria	Nat. Stat. Institute (BG)	2005	NUTS2	6	371	4
Switzerland	Swiss Statistics (CH)	2005	NUTS2	7	457	4
Cyprus	Statistical Service (CY)	2004	NUTS2	1	194	3
Czech Rep.	Eurostat (LX)	2004	NUTS2	8	507	3
Germany	Bundesag. für Arb. (DE)	2004	NUTS2	40	604	4
Denmark	Statistics Denmark (DK)	2004	NUTS2	1	2 419	4
Estonia	Eurostat (LX)	2004	NUTS2	1	504	3/4
Spain	Eurostat (LX)	2004	NUTS2	17	922	3
Finland	Statistic Finland (FI)	2004	NUTS2	4	487	4
Greece	Nat. Stat. Service (GR)	2006	NUTS1	4	866	3
Hungary	Eurostat (LX)	2004	NUTS2	7	477	3
Ireland	Central Statistics Office (IE); Eurostat (LX)	2004	NUTS1	1	1 479	2
Iceland	Statistics Iceland (IS)	2004	NUTS2	1	138	4
Italy	Eurostat (LX)	2004	NUTS2	21	931	3
Lithuania	Statistics Lithuania (LI)	2004	NUTS2	1	787	4
Luxemburg	Eurostat (LX)	2004	NUTS2	1	149	3
Latvia	Centr. Stat. Bureau (LV)	2004	NUTS2	1	778	4
Malta	Eurostat (LX)	2004	NUTS2	1	128	3
Netherlands	Eurostat (LX)	2004	NUTS1	4	1 581	3
Norway	Statistics Norway (NO)	2004	NUTS2	7	271	4
Poland	Centr. Stat. Office (PL)	2001	NUTS2	16	413	4
Portugal	Statistics Portugal (PT)	2004	NUTS2	5	668	4
Romania	Eurostat (LX)	2004	NUTS2	8	697	3
Sweden	Statistics Sweden (SE)	2004	NUTS2	8	463	4
Slovenia	Statistical Office (SI)	2004	NUTS2	1	674	4
Slovakia	Eurostat (LX)	2004	NUTS2	4	456	4
Turkey	Turkish Stat. Inst. (TR)	2002	NUTS1	12	509	4
UK	Dep. of Ent., Trade and Innov. of N. Ireland (UK); Office for Nat. Stat.(UK)	2004 N. Irl: 2003	NUTS2	37	663	4
				259	649	
USA	U.S. Census Bureau	2002	EA	179	650	

* Total of local and traded industries

lated to the 4-digit NACE codes, for which most of European Table 2. Regional data employment statistics is available.[3] Due to differences between the SIC system and the NACE system, two small categories (representing less than 2% of traded industry employment) are poorly defined in the NACE system, and are therefore excluded from this study. Also, while categories for aerospace vehicles and aerospace engines can be distinguished in the US data, they are only available in aggregated form in European data, so in this analysis we have treated aerospace as a single category both for USA and Europe. The result is 38 cluster categories, details for which are found in Table 3.

The resulting dataset consists of two region-industry matrices with 9,842 cells for Europe (259 regions by 38 industry groups) and 6,802 cells for USA (179 by 38), in total 16,644 cells. This represents a more than tenfold increase compared to the previously most granular studies, which used data for 1,365 cells (Midelfart-Knarvik et al.) and 1,190 cells (WIFO, 2002).

Results

The degree of industrial concentration is calculated for each of the 38 cluster categories using eight different concentration measures, and the results are reported in Appendix 1. The measures I use are: the Gini index, the Krugman index, the Theil index, GE(2), GE(3), SLQ(2), CR(10%) and Herfindahl. SLQ(λ) is the share of employment in regions with a location quotient (LQ) above λ. (All measures are defined in Appendix 2.)

We find, for example, that the Gini values are higher in Europe than in USA for 6 cluster categories and higher in USA for the remaining 32. Other measures of concentration produce similar results, with Herfindahl giving the largest difference between the continents and CR(10%) the smallest. This method of counting, used in most of the previous studies, gives an indication that concentration is higher in USA.

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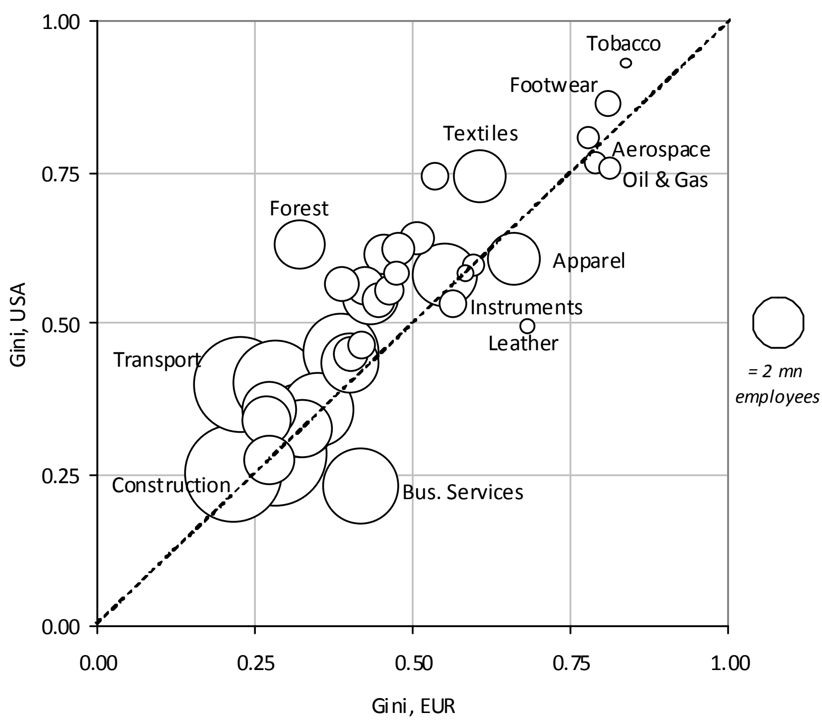
[3] There are 514 codes on NACE 4-digit level. For some countries, data is only available on 3-digit level, on which there are 224 codes. In many cases, this aggregation presents no problem since all 4-digit codes within a 3-digit code fall into the same cluster category. We have thus been able to allocate 81% of all traded employment unambiguously into a cluster category. However, the remaining 19% have been assigned to cluster categories by splitting the 3-digit level evenly between the 4-digit codes.

Table 3. Cluster categories

Cluster category	*Examples of industries*	*EUR empl. (th.)*	*USA empl (th.)*
Aerospace	Aerospace industry, aerospace engines	365	445
Agricultural Products	Sugar, agricultural services, alcoholic drinks	853	349
Analytical Instruments	Measurement instruments, process control	532	677
Apparel	Clothes	1 872	411
Automotive	Motor vehicles, components	2 667	1 351
Biopharmaceuticals	Pharmaceuticals	825	290
Building Fixtures, Equipm.& Serv.	Kitchen furnishing, plaster	2 373	714
Business Services	Management consultancy, rental of off. machinery	3 983	5 352
Chemical Products	Chemicals, nuclear fuels, industrial gases	971	458
Communications Equipment	TVs, Cable, telephony equipment	790	358
Construction Materials	Scrap, ceramic sanity fixtures	588	213
Distribution Services	Mail order, wholesale trading	1 643	1 816
Education & Knowledge Creation	Universities, libraries	3 493	2 504
Entertainment	Video- and music recording, sport events	2 168	1 151
Financial Services	Banks, insurance companies	7 119	2 789
Fishing & Fishing Products	Fishing, hunting	355	56
Footwear	Shoes	488	25
Forest Products	Paper machines, pulp	1 717	444
Furniture	Furniture, laminated boards	1 165	396
Heavy Construction Services	Construction businesses, rental of constr. mach.	6 447	1 598
Heavy Machinery	Forest machinery, tractors, locomotives	830	359
Hospitality & Tourism	Hotels, taxies, amusement parks	3 628	2 530
Information Technology	Electronic components, computer manufacturing	1 991	964
Jewellery & Precious Metals	Jewellery, cutleries	315	127
Leather Products	Bags, furs	182	117
Lighting & Electrical Equipment	Lamps, electricity distribution's equipment	531	298
Medical Devices	Medical equipment, wheelchairs	440	397
Metal Manufacturing	Rolling mills, casting, tools, screws	3 934	1 315
Oil & Gas Products and Services	Refineries	359	403
Plastics	Plastics, colours	822	834
Power Gen. and Transmission	Generators, isolators	517	78
Processed Food	Beer, dairies, glass packages/wrapping	5 032	1 520
Production Technology	Bearings, tanks, machine tools	2 240	652
Publishing & Printing	Publishing services, printing	1 674	996
Sporting, Recr. & Childr. Goods	Bicycles, toys	196	107
Textiles	Fabrics	1 887	428
Tobacco	Cigarettes, snuff	76	33
Transportation & Logistics	Inventories, air transports	6 062	1 550

However, for a more thorough assessment it is useful to take into account how big the differences are and how large each category is in terms of employment. Figure 1 illustrates this for the Gini measure, with the size of the circle indicating the employment size in Europe. The horizontal axis indicates the category's Gini value in Europe, and the vertical the Gini value in the US. Six categories are found below the 45 degree line, and are thus more concentrated in Europe; the remaining 32 are more concentrated in the US.

Figure 1. Industry concentration values (Gini) for Europe and USA



The comparison for a selected cluster category can turn out differently depending on what measure is used. On one hand, for some cluster categories, such as Biopharmaceuticals, Furniture or Hospitality and tourism, there is no variation: all measures indicate that they are more concentrated in the US. Almost as consistent is Leather Products, which is indicated to be more concentrated in Europe by all measures except Herfindahl. On the other hand, Aerospace and Financial Services get mixed indications, with three measures suggesting higher concentration in the Europe, and five in the US.

We now turn from individual industry groups to the issue of consolidating all groups. Indices like Gini and Krugman are in their basic form designed to be applied to a vector. When we study industrial concentration, as in this study, the vector can contain each region's employment for a selected industry group. By comparing the Gini value of a European vector with that of a US vector, we can assess on which of the continents concentration is highest for that particular industry group. However, Gini and other indices can be generalised to analyse an entire matrix, and thus produce a consolidated value for all industry groups at once, termed polarisation (Bickenbach & Bode, 2006). If we use the polarisation value, it means that the calculation of data *between* industry groups is done in the same way as the calculation *within* the groups. In contrast, if we simply consolidate industry groups by calculating the unweighted average between them, we will combine two inconsistent calculation methods.

Polarisation values for Gini, Krugman, GE and Theil have been generalised by Bickenbach and Bode (2006), and they are also easily calculated for SLQ. For CR and Herfindahl, however, we have not generalised the measure, and we rely on weighted averages, using total traded industry employment as the weight. (For definitions, see Appendix 2.)

Table 4 shows the comparison between the total degree of concentration in Europe and USA, using both the polarisation value and the industry group counting method.

Discussion

With one exception, all measures show that agglomeration is higher in USA than in Europe. The exception is SLQ(2), which shows that a marginally higher share of employment in Europe is found in regional clusters where LQ>2. If we count cluster categories, however, all measures indicate that most cluster categories are more concentrated

Table 4. Consolidated industrial concentration comparison between Europe and USA.

	Polarisation value		*No. of cluster categories*	
Measure	*EUR*	*USA*	*EUR higher*	*USA higher*
Gini	0.504	0.587	6	32
Krugman	0.709	0.844	7	31
Theil	0.502	0.719	7	31
GE(2)	0.985	1.824	6	32
GE(3)	5.352	15.357	10	28
SLQ(2)	0.207	0.206	16	22
CR(10%)*	0.391	0.568	1	37
Herfindahl*	0.011	0.033	1	37

* Averages weighted by employment in traded industries.

in USA than in Europe. Because the measures operate in different ways, the results can vary greatly for individual categories. Details are given in Appendix 1.

There are five cluster categories that show a somewhat consistent tendency to be more concentrated in Europe: Analytical instruments, Apparel, Business services, Leather products, and Oil and gas products and services. Results are ambiguous for Aerospace and Financial services.

One of the purposes of the present study is to apply a new methodology. It is therefore difficult to make direct comparisons between these findings and those of previous studies. Nevertheless, keeping in mind that the present results are based on higher geographical disaggregation and a fundamentally different approach to industry groups, some broad conclusions can be drawn. First, the present study clearly supports Krugman's (1991) general conclusion that localisation has gone further in the US than in Europe, and it confirms that in particular the automotive industry is more concentrated.

In contrast, we do not see the dual patterns that Bayoumi and Prasad (1997) identify. They found higher US concentration in manufacturing (confirmed for several cluster categories in this study) and primary industries (agriculture and mining excluded in this study; confirmed for Fishing and Forest products). However, they also found higher European concentration in Finance (ambiguous results in this study), Transportation (largely rejected for Distribution and Transportation), Trade (largely excluded) and Services (confirmed for Business services, rejected for Entertainment, Hospitality and tourism, and Publishing). The present results therefore do not support the notion that manufacturing and primary industries in general are more concentrated in the US, while remaining sectors are more concentrated in Europe.

Braunerhjelm et al. (2000) found Europe to be more concentrated in Food and beverages and Paper and pulp. Neither of these results is confirmed in the present study.

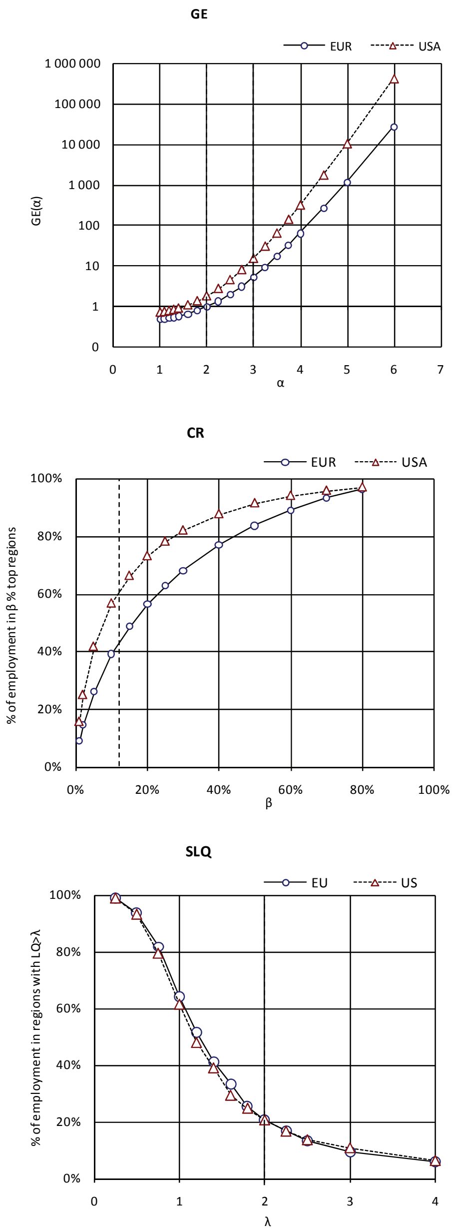
Midelfart-Knarvik et al. (2000) calculated Gini values for Europe and US respectively, but incomparable datasets prevented a direct comparison. However, such a comparison in the current study confirms the tendencies indicated by Midelfart-Knarvik's data.[4]

GE, SLQ and CR are measures that can be adjusted using a parameter. The parameter α for GE(α) determines the relative importance of over-proportional regions compared to under-proportional. For low values of α, the low end of the distribution plays a larger role, while for high values the highly concentrated regions influence the GE value more (Brülhart & Traeger, 2003). For SLQ(λ), the λ parameter determines the cut-off point for what is considered a high concentration, as SLQ is calculated as the share of employment in regions with LQ > λ. For CR(β), finally, the calculation is based on the top β % regions in terms of employment. These parameters can be varied arbitrarily, and Figure 2 shows how the comparison between Europe and USA changes with varying parameter values.

First, GE, the least intuitive of the measures, shows a higher concentration for the US for all α values. The difference increases with higher α values, suggesting that Europe and USA are similar when it comes to having regions with very *low* concentrations of industries, but that the US has more regions with very *high* concentrations. Next, the graph for CR shows that USA has higher shares of employment in its largest regions. For β values up to about 10%, European values are about one third lower than US values. The two curves must necessarily converge for high β values, but the US continues to show a higher concentration for β well above 50%. The SLQ graph,

[4] Midelfart-Knarvik et al. (2000) also calculate the conditional spatial distances for Europe and USA. This study indicates that the conditional spatial separation is higher in Europe for 20 cluster categories and in USA for 18. The weighted average for Europe is 0.944 and for USA is 0.960. The unweighted ratio for all categories (the method used by Midelfart-Knarvik et al.) is 1.062. Using spatial separation as the measure, our data thus show a smaller and more ambiguous difference between Europe and USA. However, the construction of this measure is such that it appears to be a measure of *centrality* rather than concentration.

Figure 2. Parameter variations for GE, CR, and SLQ



finally, shows very small differences between USA and EU. Since the overall size (total employment) of each region is taken into account, the distributions are very similar: slightly more than 60% of employment is in regional clusters with LQ above 1, and 20% above 2. However, there are small differences. It so happens that the main λ I have chosen for this analysis, λ = 2, is a crossover point. For λ values below 2, European agglomeration is slightly higher, whereas for λ values above 2 the US is higher. Similar to the GE graph, this indicates that the US has more regions with particularly high LQ values.

Conclusions

The current study, using data of higher industry and geographical granularity, applying a more analytically founded industry coverage selection and industry grouping methodology, and calculating a mathematically more rigorous comparison value than previous studies, confirm the conclusion that industry concentration is higher in USA than in Europe. The results are consistents for different types of measuers. The results do not support the notion of a dichotomy between manufacturing and services in terms of industry concentration.

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Appendix 1.

Cluster category	*Gini*		*Krugman*		*Theil*		*GE(2)*		*GE(3)*		*SLQ(2)*		*CR(10%)*		*Herfindahl*		*EUR: USA*
	EUR	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	
Aerospace	.788	.767	1.26	1.16	1.29	1.35	2.47	4.33	9.53	39.12	.670	.489	.653	.776	.024	.064	3:5
Agricultural	.386	.566	.55	.84	.25	.74	.27	1.83	.38	8.26	.170	.358	.350	.487	.008	.027	0:8
Apparel	.658	.605	1.04	.91	.79	.69	1.16	1.14	2.78	3.18	.559	.442	.570	.689	.020	.072	5:3
Automotive	.551	.581	.82	.87	.54	.59	.77	.78	1.80	1.50	.442	.544	.459	.575	.013	.038	1:7
Biopharma	.504	.641	.73	.96	.45	.76	.62	1.06	1.49	2.67	.348	.410	.502	.703	.015	.095	0:8
Building Fixtures	.325	.327	.48	.46	.17	.19	.18	.25	.22	.41	.168	.080	.334	.472	.008	.020	2:6
Business Serv.	.416	.232	.60	.33	.29	.09	.31	.09	.42	.11	.237	.075	.463	.622	.013	.034	6:2
Chemical	.423	.562	.61	.82	.34	.60	.62	1.00	2.26	2.75	.255	.245	.415	.504	.011	.020	1:7
Communications	.477	.623	.67	.93	.44	.70	.72	.87	2.16	1.84	.239	.340	.427	.672	.011	.044	1:7
Constr. Materials	.417	.465	.59	.69	.31	.38	.44	.52	.89	1.00	.335	.323	.445	.464	.017	.017	2:6
Construction	.214	.251	.30	.36	.08	.11	.10	.14	.13	.19	.093	.146	.316	.402	.007	.014	0:8
Distribution	.272	.273	.39	.39	.12	.12	.14	.14	.19	.18	.099	.004	.381	.615	.010	.038	2:6
Education	.350	.358	.50	.52	.21	.21	.20	.23	.23	.29	.086	.123	.379	.601	.009	.036	1:7
Entertainment	.271	.356	.40	.51	.12	.22	.12	.29	.14	.51	.074	.217	.381	.582	.010	.038	0:8
Finance	.282	.283	.39	.41	.14	.14	.16	.16	.24	.22	.164	.194	.402	.631	.012	.048	3:5
Fishing	.776	.807	1.22	1.27	1.34	1.69	3.70	8.37	26.59	133.49	.639	.621	.623	.731	.028	.066	1:7
Food	.281	.403	.40	.57	.13	.28	.15	.35	.22	.62	.109	.192	.279	.436	.006	.017	0:8
Footwear	.807	.863	1.28	1.48	1.44	1.71	3.48	3.66	19.36	17.30	.747	.739	.754	.756	.040	.045	2:6
Forest	.319	.631	.45	.94	.17	.78	.18	1.41	.24	4.46	.131	.451	.313	.422	.008	.016	0:8
Furniture	.454	.614	.66	.92	.36	.80	.49	2.15	.95	14.27	.335	.430	.364	.544	.008	.032	0:8
Heavy Mach.	.445	.537	.65	.81	.33	.53	.39	.84	.62	2.08	.343	.367	.370	.399	.009	.015	0:8
Hospitality	.322	.338	.45	.49	.20	.24	.28	.43	.49	1.19	.121	.162	.348	.530	.008	.023	0:8
Instruments	.563	.534	.81	.80	.58	.50	.83	.65	1.98	1.39	.357	.294	.477	.668	.014	.041	6:2
IT	.433	.544	.63	.81	.32	.59	.34	1.18	.48	4.22	.194	.316	.438	.691	.011	.039	0:8
Jewelry	.595	.596	.89	.89	.65	.71	1.03	1.35	2.66	4.71	.533	.530	.634	.754	.024	.108	2:6

cont.	*Gini*		*Krugman*		*Theil*		*GE(2)*		*GE(3)*		*SLQ(2)*		*CR(10%)*		*Herfindahl*		*EUR: USA*
	EUR	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	*EUR*	*USA*	
Leather	.680	.495	1.03	.71	.90	.44	1.60	.64	5.53	1.41	.514	.172	.629	.538	.026	.030	7:1
Lighting	.462	.554	.67	.81	.37	.55	.45	.71	.77	1.53	.371	.261	.405	.573	.011	.032	1:7
Medical	.474	.582	.69	.85	.39	.67	.48	1.35	.88	5.66	.268	.155	.432	.641	.011	.036	1:7
Metal	.384	.452	.56	.67	.24	.34	.28	.40	.41	.60	.251	.308	.371	.545	.009	.025	0:8
Oil and Gas	.810	.756	1.25	1.26	1.55	1.18	4.98	2.28	43.11	8.71	.575	.645	.640	.690	.028	.061	4:4
Plastics	.401	.450	.58	.65	.27	.34	.30	.38	.42	.57	.244	.182	.367	.519	.009	.022	1:7
Power	.534	.744	.79	1.16	.55	1.11	1.10	1.92	5.02	7.33	.338	.531	.468	.596	.015	.029	0:8
Production Tech.	.400	.435	.58	.64	.27	.31	.33	.33	.53	.44	.242	.257	.401	.517	.010	.022	1:7
Publishing	.268	.339	.38	.49	.11	.20	.12	.27	.13	.49	.061	.079	.411	.582	.010	.034	0:8
Sporting	.582	.584	.87	.88	.60	.61	.81	.86	1.67	1.87	.464	.360	.536	.583	.020	.027	1:7
Textiles	.606	.744	.92	1.22	.68	1.13	1.13	2.09	3.14	6.74	.547	.629	.563	.722	.021	.061	0:8
Tobacco	.837	.930	1.36	1.63	1.59	2.44	3.87	9.15	24.70	91.18	.722	.845	.687	.892	.025	.118	0:8
Transportation	.226	.399	.31	.58	.09	.31	.10	.57	.12	1.75	.071	.086	.339	.598	.008	.029	0:8
EUR:USA	6:32		7:31		7:31		6:32		10:28		16:22		1:37		1:37		54:250

Appendix 2. Measure definitions

L_{ir} = number of employees in cluster category *i* (*i* = 1, … , *I*) in region *r* (*r* = 1, … , *R*)
Π_r = number of employees in all traded and local industries in region *r* (reference distribution)
Following the taxonomy and notation of Bickenbach and Bode (2006), we use unweighted relative measures for Gini, Krugman, Theil and GE, with the constant weights 1/R and 1/I.

Measure	*Concentration*	*Polarisation*
Gini index	$G_i = \frac{1}{2}\frac{1}{\sum_r \frac{1}{R}\frac{L_{ir}}{\Pi_r}}\sum_r\sum_s \frac{1}{R^2}\left\lvert\frac{L_{ir}}{\Pi_r}-\frac{L_{is}}{\Pi_r}\right\rvert$	$Gp = \frac{1}{2}\frac{1}{\sum_{i,r}\frac{1}{RI}\frac{L_{ir}}{\Pi_r}}\sum_i\sum_j\sum_r\sum_s \frac{1}{I^2R^2}\left\lvert\frac{L_{ir}}{\Pi_r}-\frac{L_{is}}{\Pi_r}\right\rvert$
Krugman index	$K_i = \frac{\sum_r \frac{1}{R}\left\lvert\frac{L_{ir}}{\Pi_r}-\sum_r\frac{L_{ir}}{\Pi_r}\right\rvert}{\sum_r\frac{1}{R}\frac{L_{ir}}{\Pi_r}}$	$Kp = \frac{\sum_i\sum_r \frac{1}{IR}\left\lvert\frac{L_{ir}}{\Pi_r}-\sum_r\frac{L_{ir}}{\Pi_r}\right\rvert}{\sum_{i,r}\frac{1}{IR}\frac{L_{ir}}{\Pi_r}}$
Theil index	$T_i = \sum_r \frac{1}{R}\frac{\frac{L_{ir}}{\Pi_r}}{\sum_r\frac{1}{R}\frac{L_{ir}}{\Pi_r}}\ln\left(\frac{\frac{L_{ir}}{\Pi_r}}{\sum_r\frac{1}{R}\frac{L_{ir}}{\Pi_r}}\right)$	$Tp = \sum_r \frac{1}{IR}\frac{\frac{L_{ir}}{\Pi_r}}{\sum_{i,r}\frac{1}{IR}\frac{L_{ir}}{\Pi_r}}\ln\left(\frac{\frac{L_{ir}}{\Pi_r}}{\sum_{i,r}\frac{1}{IR}\frac{L_{ir}}{\Pi_r}}\right)$
GE(α) Generalised entropy	$GE(\alpha)_i = \frac{1}{(\alpha^2-\alpha)}\sum_r\frac{1}{R}\left[\left(\frac{\frac{L_{ir}}{\Pi_r}}{\sum_r\frac{1}{R}\frac{L_{ir}}{\Pi_r}}\right)^{\alpha}-1\right]$	$GEp(\alpha) = \frac{1}{(\alpha^2-\alpha)}\sum_i\sum_r\frac{1}{IR}\left[\left(\frac{\frac{L_{ir}}{\Pi_r}}{\sum_{ir}\frac{1}{IR}\frac{L_{ir}}{\Pi_r}}\right)^{\alpha}-1\right]$

Measure	Concentration	Polarisation
SLQ(λ) Share of employment in regions with LQ above λ	$SLQ(\lambda) = \sum_r \frac{\rho(\lambda)_r L_{ir}}{\sum_r L_{ir}}$ $\rho(\lambda)_r = \begin{cases} 1: & L_{ir}/\Pi_r \geq \lambda\left(\sum_r L_{ir}/\sum_r \Pi_r\right) \\ 0: & L_{ir}/\Pi_r < \lambda\left(\sum_r L_{ir}/\sum_r \Pi_r\right) \end{cases}$	$SLQp(\lambda) = \sum_i \sum_r \frac{\rho(\lambda)_r L_{ir}}{\sum_{ir} L_{ir}}$
CR(β) Concentration ratio in top β % of regions	$CR(\beta)_i = \sum_r \frac{\sigma(\beta)_r L_{ir}}{\sum_r L_{ir}}$ $\sigma(\beta)_r = \begin{cases} 1: & \tau < \lfloor \beta R \rfloor \\ 1: & \tau = \lfloor \beta R \rfloor = \beta R \\ \beta R - \lfloor \beta R \rfloor: & \tau = \lfloor \beta R \rfloor < \beta R \\ 0: & \tau > \lfloor \beta R \rfloor \end{cases}$ where $\lfloor\ \rfloor$ denotes the integer function and τ is the rank order of the region ordered by L_{ir}	$CRp(\beta) = \sum_i \frac{L_{ir}}{\sum_r L_{ir}} \sum_r \frac{\sigma(\beta)_r L_{ir}}{\sum_r L_{ir}}$
Herfindahl	$H_i = \sum_r \left(\frac{L_{ir}}{\sum_r L_{ir}}\right)^2$	$Hp = \sum_i \frac{L_{ir}}{\sum_r L_{ir}} \sum_r \left(\frac{L_{ir}}{\sum_r L_{ir}}\right)^2$

Note: CR(β) calculates the share of employment in the βR top regions in terms of employment. The European data used has 259 regions (R = 259). CR(10%) therefore measures the employment in the top 25.9 regions, which is the employment in the top 25 regions plus 90% of employment in the 26th region. Correspondingly, since the US data has 179 regions, CR(10%) measures the employment in the top 17 regions plus 90% of the 18th.

Study 4

The effect of clusters on the survival and performance of new firms

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Study 4

The effect of clusters on the survival and performance of new firms

ABSTRACT This paper contributes to the literatures on entrepreneurship and economic geography by investigating the effects of clusters on the survival and performance of new entrepreneurial firms where clusters are defined as regional agglomerations of related industries. We analyze firm-level data for all 4,397 Swedish firms started in the telecom and consumer electronics, financial services, information technology, medical equipment, and pharmaceuticals and pharmaceutical sectors from 1993 to 2002. We find that that firms located in strong clusters create more jobs, higher tax payments, and higher wages to employees. These effects are consistent for absolute agglomeration measures (firm or employee counts), but weaker for relative agglomeration measures (location quotients). The strengths of the effects are found to vary depending on which geographical aggregation level is chosen for the agglomeration measure.

Introduction

Clusters, which are defined as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions (Porter, 1998:197), have attracted much attention in the academic literature. Numerous studies have examined the effect of clusters either on the level of individual firms or on the aggregate level of regions or nations. Clusters have also become a tool or framework for economic policy (European Commission, 2003). Since the 1990s, a large number of cluster organizations have been formed as public-private partnerships with the purpose to promote the growth and competitiveness of clusters (Ketels, Lindqvist, & Sölvell, 2006; Sölvell, Lindqvist, & Ketels, 2003).

Entrepreneurship is commonly held to be enhanced in regions with strong clusters. New entrepreneurial firms are attracted to clusters by the pool of skilled and specially trained personnel, access to risk capital, favorable demand conditions, reduced transaction costs, and motivational factors such as prestige and priorities (Krugman 1991; Marshall, 1920; Storper, 1997). Conversely, entrepreneurship strengthens clusters through the increased rivalry that new entrants bring (Krugman, 1991; Porter, 2003). Despite the considerable body of existing empirical cluster research, few studies have systematically investigated the effect of cluster on the performance of new entrepreneurial firms and existing research shows inconsistent results whether new firms are positively affected, not affected, or even negatively affected by locating in a cluster (Rocha, 2004). While a number of studies have found that clusters enhance the probability of entry, survival and growth of new firms (Beaudry & Swann, 2001; Dumais, Ellison & Glaeser, 2002; Pe'er & Vertinsky, 2006; Rosenthal & Strange, 2005; Stough, Haynes & Campbell, 1998), other studies indicate that location in a cluster decreases the survival chances of new firms (Folta, Cooper & Baik, 2006; Sorenson & Audia, 2000).

An economic explanation for such a potentially negative effect is that while moderate levels of clustering are beneficial for new firms, very strong clusters might produce adverse effects due to congestion and hyper-competition among firms for resources and personnel (Beaudry & Swann, 2001; Folta et al., 2006; Prevezer, 1997). An alternative sociological explanation suggests that specific socio-cognitive effects account for the presence of clusters, independent of economic advantages. In this perspective, clusters arise from easier access to resources for launching a new firm and from exaggerated expectations of success due to skewed perceptions of entrepreneurial opportunities, leading to an increase in start-up rates (Sorenson & Audia, 2000; Sørensen & Sorenson, 2003). This explanation challenges the assumption that the existence of clusters implies the existence of some underlying economic benefit.

The effect of clusters on entrepreneurship is therefore an area where further empirical research is needed (Rocha, 2004). In this paper, we examine the effect of clusters on the economic performance of new firms. Specifically, we investigate how the relative strength of the cluster in which a new firm is located influences the firm's probability of survival and its ability to create jobs and pay taxes and salaries. In an attempt to bridge the conflicting evidence of earlier studies, we approach the problem in a manner which is distinct from previous studies in three ways. First, we attempt to bridge the empirical gap between firm-level cluster effects and region level outcomes. Second, we apply the cluster framework by operationalizing clusters as aggregate groups of related industries. Third, we rely on a large and unbiased dataset that tracks the full population of Swedish firms started in one of five different cluster categories over a period of 10 years.

The attempt to establish a micro-level link between firm-level cluster effects and region level outcomes represents the first contribution of this paper. It is believed that the economic benefits of clusters represent mechanisms that enhance the productivity of the individual firms through the proximity to other firms (e.g. Marshall, 1920; Saxenian, 1985; Storper, 1997). These economic benefits, such as labor pooling, the presence of specialized suppliers and knowledge spillovers, do not benefit the regional economy directly but rather indirectly by allowing firms to expand more rapidly, pay higher salaries and have higher rates of innovation (Audretsch & Feldman, 1996; Porter, 2003). *Regional-level* studies that identify a relationship between greater cluster strength and regional economic performance (e.g. Braunerhjelm & Borgman, 2004, de Blasio & Di Addario, 2005, Porter, 2003) imply – but do not show – that the benefits found on the regional level have come about as the aggregated result of the corresponding benefits for the individual firm. *Firm-level* studies of cluster are usually concerned with performance indicators relevant for the firm itself, such as profitability or the ability to attract external capital (Folta et al., 2006). Such studies provide evidence of economic benefits from clusters for the individual firm, but do not demonstrate that cluster effects actually translate to economic benefits for the region. Our study thus responds to a call for studies investigating ”the way in which fortunes of firms and regional clusters intertwine“ (Feldman 2003: 311) by conducting a firm-level analysis of not only survival but also of economic output variables that are directly relevant for the regional economy: job creation, salary payment levels, and tax payment levels.

The second contribution of this paper is an operationalization of clusters as aggregate groups of *related industries*. When studying industrial agglomeration one can aggregate industries in different ways, from narrowly defined industries to widely defined sectors, such as

”manufacturing industry”. Yet, there is evidence that upstream-downstream linkages produce co-localization patterns between certain industries (Dumais et al., 2002), and furthermore that technological linkages between related industries are an important factor for innovation in those industries (Scherer, 1982; Feldman & Audretsch, 1999). The presence of such external economies from linkages in shared factor inputs, technologies, knowledge, skills, and institutions, suggest that neither the individual industry nor the wide industry sector (operationalized as a higher level of some industry classification system) is the best unit for studying cluster effects. Following Porter (2003) we therefore define aggregate groups of related industries to form cluster categories which are wider than the industry level but narrower than the broad sector level.

The third contribution of this paper is that it is based on a complete and unbiased population sample of all firms started within an industry in one of five different cluster categories. While many prior studies have relied on regional populations of firms or samples of firms drawn across a whole nation, our analysis is based on a full population consisting of every Swedish firm started within an industry in one of five different cluster categories over a period of 10 years, in total 4,397 firms. We are thus confident that our findings are not driven by the specific sampling procedure.

In this study, we find evidence that location in strong clusters is highly related to economic benefits for new entrepreneurial firms. Cluster strength is found to have a strong and significant effect on firm survival, job creation, VAT payments and salary payments. These effects vary depending on which geographical level the data is aggregated, indicating one possible reason for the conflicting evidence in earlier studies. For salary payments the results are stronger if cluster effects are measured on the largest geographical level, whereas for firm survival the results are most prominent if cluster effects are measured on the smallest geographical level. We also find that absolute agglomeration values (counts) have overall stronger impact than relative agglomeration values (location quotients).

This study provides theoretical and empirical contributions to the discussion of agglomeration in entrepreneurship and economic geography research. To the best our knowledge, it is the first study to actually measure the firm-level the micro-economic impact of clusters on new firms in terms of job creation, wage levels and tax payments.

The study also has policy implications in that it lends support to entrepreneurship policy programs based on clusters.

ECONOMIC BENEFITS OF CLUSTERS

Industrial agglomerations have been a topic of economic theory for more than a century. Over time, a number of theories have been formulated that suggest effects that could explain the existence of industrial agglomerations. In general, two fundamental types of external economies have been proposed. *Urbanization economies* convey the benefits of the concentration of economic activity, regardless of its type, in a specific city or a region while *localization economies* convey the benefits of a specific industry or a group of related industries that are localized in a region. (For overviews, see Malmberg, Sölvell & Zander, 1996; Rosenthal & Strange, 2004). In this study we will focus on localization economies, while including urbanization effects as a control variable.

In broad terms, localization effects can be categorized as related to three theoretical areas: transportation costs, external economies and socio-cognitive effects. Transportation costs and external economies represent economic benefits for the firm which can potentially translate to economic benefits for the region; socio-cognitive effects do not. The first line of theory suggests that industries locate close to resources in order to minimize transportation costs. This theoretical approach traces its roots to von Thünen (1826), who explained the distribution of different types of agricultural production around a town center with transportation costs to the buyer. Later, Weber (1909) attributed the location patterns of industrial production units to the transportation costs from suppliers.

Contemporary focus has shifted towards the second theoretical approach which suggests that firms benefit from industrial agglomerations through efficiency gains related to *specialization*. Marshall (1920) points to three mechanisms: industry specialization, labor pooling, and knowledge spillovers.

With the presence of many similar firms, firms can pursue a higher degree of intra-industry specialization and thus achieve higher productivity. In addition to these gains from intra-industry specialization, economic benefits can also be gained from inter-industry specialization where specialized suppliers and subsidiary industries provide inputs that enhance the performance of the core industry. *Transaction-cost* effects can be seen as a variation of Marshall's specialization argument (Rocha, 2004; Storper, 1997), where proximity of buyers and sellers in an industrial agglomeration makes it easer to make deals and deliver products to each other, reducing the costs associated with vertical disintegration. Similarly, lower *search costs* make it easier for entrepreneurs to find buyers and to be found themselves (Stuart, 1979). Regions with higher agglomeration also offer greater communicational advantages as firms develop better knowledge of each other (Saxenian, 1985).

Marshall also stresses the local labor market as a source of economic benefits. Specialization allows firms to benefit from access to a *pool of specialized labor* which also enhances economic performance.

Marshall's third main mechanism has to do with the flow of knowledge between firms. *Knowledge spillover* occurs when knowledge flows between firms through social interaction or, to use Marshall's famous quote, "[t]he mysteries of the trade are [...] in the air" (Audretsch & Feldman, 1996; Marshall, 1920:IV.X.7). The argument is based on the flow of information between individuals working in the same region. Knowledge is more likely to spill over between firms and workers in geographic proximity and geographic proximity facilitates the formation and transmission of social capital, thus enhancing trust and the ability to share vital information. Further, increased *rivalry* implies that neighboring agglomerated firms stimulate each other to reach a higher level of innovation and performance. Local competitors create a higher degree of rivalry and may lead to a local struggle for "bragging rights" (Porter, 1990).

A final theoretical approach explains the existence of industrial agglomerations from the perspective of organizational sociology. Here, *sociological and cognitive effects* are resources needed to start a firm if it is located far away from those resources. This increases the entry rate in clusters but is not necessarily coupled with enhanced performance for those newly started firms. Locally increased ease of entry and exaggerated expectations of success would therefore account for cluster formation (Sørensen & Sorenson, 2003). In a study of the U.S. shoe industry, Sorenson and Audia (2000) found that both entry rates and failure rates were higher among concentrated plants, leading them to conclude "that variation in the structure of entrepreneurial opportunities, rather than variations in the economics of production and distribution, maintains geographic concentration in the shoe industry." (Sorenson & Audia, 2000:427)

Many of these theoretically proposed benefits of clusters have been studied empirically. Some of these studies have investigated these economic benefits of cluster on the firm level. For instance, Baptista and Swann (1999) investigated 674 American and 1,339 British firms in the computer industries and found that new entrepreneurial firms were more likely to be started in clustered regions. Beaudry and Swann (2001) studied 137,816 UK firms in 57 two-digit SIC industries and found that firms grew faster in clusters, and also that new firms were attracted to clusters, especially in the finance, computer, motor, aerospace and communications manufacturing industries. Beaudry and Breschi (2003) examined the impact of agglomeration on patenting among firms in 65 UK counties and 95 Italian provinces. Their findings indicated that high cluster employment in a firm's own industry in itself did not contribute to patenting, but that there was a significant effect if one measured only employment in co-located firms that were themselves innovative and produced patents. Globerman, Shapiro and Vining (2005) studied the sales growth and survival of 204 Canadian IT firms but found only limited location effects on sales growth for the Canadian province or metropolitan levels, and no location effects on two-digit postal code level. For firm survival, location effects were found to be even weaker. However, results were inconclusive due to the limited number of firms studied.

Other studies have investigated economic benefits of cluster on the regional level. Porter (2003) studied wages and patenting in all industry sectors across 172 economic areas covering the entire United States from 1990 to 2000. He found that high regional wages and high regional patenting were related to strong clusters, measured as the share of employment in those industry groups which were over-represented in a region. Braunerhjelm and Borgman (2004) examined 143 industries in 70 regions in Sweden from 1975 to 1999, and found that geographic concentration was positively related to labor productivity growth in a region. de Blasio and Di Addario (2005) examined a sample of 230 Italian regions and divided them into two groups: industrial districts (meeting certain criteria on manufacturing employment share, small and medium firm share, and sector specialization) and non-industrial districts. They found that industrial districts increased worker mobility and the likelihood of being employed or of starting a business, while reducing the returns to education. Fritsch and Mueller (2008)studied new firm formation between 1983 and 2002 in the 74 West German planning regions and found that new firms founded in agglomerations led to higher job creation both in the short term (direct effects) and in the long term (supply-side effects) compared to new firms founded in rural or moderately congested areas.

These studies indicate that firms in general benefit from clustering and also that agglomerated clusters are beneficial for regional economic development. But what effects do cluster have on *new* entrepreneurial firms, given that new firms are seen as an integral part of cluster development?

DO NEW FIRMS BENEFIT FROM LOCATING IN CLUSTERS?

New firms are subject to particular difficulties in that they face a general lack of resources (Audretsch, 1995), are more vulnerable to external economic shocks (Delmar, Hellerstedt & Wennberg, 2006) and frequently face cost disadvantages by operating farther from the industry's minimum efficient scale (Pe'er & Vertinsky, 2006). Further, their individual founders might pursue goals that are of non-economic nature (Gimeno et al., 1997). However, many of the cluster effects that generate economic benefits for incumbent firms could apply also to new firms. Economies of specialization, labor supply and specialized skills could make it easier for new firms to overcome their initial liabilities; local demand effects could increase likelihood of sales and decrease transaction costs; and the competitive environment of clusters could reduce entry as well as exit barriers (Rocha & Sternberg, 2005). Knowledge created by research labs and in incumbent firms flows between firms and individuals through social interaction, spurring the establishment and growth of new firms as suggested by the 'knowledge spillover theory of entrepreneurship' (Audretsch & Lehmann, 2005). Whether or not such economic benefits of clusters affect new firms is the topic of this paper.

There is still little research investigating the effects of clusters on the performance of new entrepreneurial firms. Existing studies show conflicting results as to whether new firms are positively affected, not affected, or even negatively affected by locating in a cluster: Pe'er & Vertinsky (2006) investigated new entrepreneurial entrants in the

Canadian manufacturing sectors from 1984 to 1998 and found that clustered firms had higher survival rates than non-clustered firms. Stough, Haynes and Campbell (1998) investigated the economic development of the greater Washington D.C. area in the United States over several decades and determined that the founding and growth of new firms could be linked to a high concentration of a technically skilled population with engineering and business technology degrees. Rosenthal and Strange (2005) investigated all new plants in the greater New York metropolitan area in 2001 and found that specialization, measured as employment quotients in a local area, was positively related to job creation among new firms.

These results are contradicted, however, by other studies suggesting that new firms are adversely affected by locating in a cluster. Sorenson & Audia (2000) studied 5,119 shoe manufacturing plants in the US between 1940 and 1989 and found that plants located in concentrated regions of shoe manufacturing failed at a higher rate than isolated plants. A comprehensive study by Dumais and colleagues (2002) of all U.S. manufacturing plants sampled at five-year intervals from 1972 to 1992 found that new firms in strong clusters had higher survival probabilities but did not positively enhance job creation in a region. Folta and colleagues (2006) investigated 789 U.S. biotech firms started between 1973 and 1998. They found that stronger clusters had negative effects on the survival of new firms and that stronger clusters had positive effects on firm patenting, alliance formation, and attracting private equity partners, but only up to a certain point of cluster size, from which the positive effect decreased or turned negative as clusters grew.

We suspect that one reason for the inconsistent results of these studies is the variation in methodologies applied. Previous studies have tended to apply different levels of geographical aggregation and different measures of agglomeration but more importantly, they have applied different levels of industry aggregation. Theoretically, the main research gap in how clusters impact new entrepreneurial firms concerns how industries are aggregated when agglomeration patterns are calculated. Table 1 gives an overview of the methodologies applied in previous studies.

Table 1 shows that most studies have examined either a single aggregation of all manufacturing industries, multiple sectors aggregated through an industry classification system (2-digit or 3-digit SIC), or a single industry. None of the empirical studies of cluster ef-

Table 1. **Prior empirical studies of cluster effect on new entrepreneurial firm**

Study	Sample	Agglomeration model			Results	
		Geogr. aggregation	Ind. aggregation	Measure	Surv.	Performance
Baptista and Swann (1999)	674 US and 1 339 UK computer firms in 1991	39 US states, 10 UK Central Statistical Office regions	8 groups (computer industries)	Employee count		+ (employment growth)
Sorenson and Audia (2000)	All 5,119 US new footwear plants in the, years 1940–1989	Distance measures applied to each plant, no geographic aggregation	1 group (footwear manufacturing)	(i) Local density: inverse distance between plant and all other plants (ii) national density: number of plants	–	
Nicolini (2001)	84 small firms in Lombardy, Italy, years 1992–1994	21 Lombardian districts	3 groups (textile, mechanical, wood & furniture)	Number / density of firms in a district providing service to a sector		+ (export ratio)
Dumais, Ellison and Glaeser (2002)	300,000+ old and new US manufacturing plants, years 1972–1992	50 U.S. States + District of Columbia	134 SIC-3 level groups (manufacturing industries)	Industry concentration based on employees in 3-digit SIC industries.	+	– (employment growth)
Globerman, Shapiro and Vinning (2005)	240 new Canadian IT firms, years 1998–2001	(i) 11 provinces, (ii) 10 metropolitan areas, (iii) distance to the two largest clusters	1 group (IT industries)	No agglomeration measure (model compares outcome for each region)	0	+ (sales growth)
Folta, Cooper and Baik (2006)	789 new US biotech firms, years 1973–1998	85 Metropolitan Statistical Areas (based on headquarter location)	1 group (biotechnology) but with controls for 4 subsectors	Headquarter counts	–	+ / – (non-linear effects on patents, alliances and getting equity)
Pe'er and Vertinsky (2006)	All 48,406 new Canadian manufacturing firms, years 1984-1998	Two levels: 3,908 local Canadian areas; 289 Census Divisions	109 SIC-3 level groups (manufacturing industries)	(i) # of firms operating in same 3-SIC sector in a chosen radius around the firm (ii) region with LQs larger than the median	+	
Fotopoulos and Louri (2000)	209 new Greek manufacturing firms founded 1982-1984, years 1982-1992.	2 regions, inside or outside Greater Athens	manufacturing firms	No agglomeration measure (dummy for firms inside or outside Greater Athens)	+	

fects on new firms have aggregated multiple groups of related industries, despite the strong theoretical claims that firms in a cluster benefit from the competition and cooperation in geographic concentrations of firms in *related* industries. In this paper we therefore investigate how new firms in several different industries are affected by their location in clusters of related industries. In order to reconcile the contradictory findings in earlier studies we examine several different performance variables and we also try to account for the potential bias introduced by firms' attrition from the sample. Finally, we validate our findings on different geographical levels.

METHOD

Data

The dataset in this study was derived from a combination of several detailed longitudinal databases maintained by Statistics Sweden. Firm-level variables were gathered from the databases CFAR and financial variables such as revenues and assets were collected from the Swedish tax authorities. In addition, we measure the human capital of firms by counting the number of employees with various types of post-secondary education, using the comprehensive individual-level database LOUISE.

We investigate all firms that were started between 1993 and 2002 in the areas of Telecom and Consumer Electronics, Financial Services, Information Technology (IT), Medical Equipment, and Biopharmaceutical Industries. We chose these particular industries since they represent a wide range of knowledge-intensive manufacturing and service sectors. Statistics Sweden maintains data on all firms that register for commercial activities and/or file taxes in Sweden. The sample represents the whole population of new firms in these industries; in total 4,397 firms started during the studied period.

A common problem in studies of new firm dynamics is the change in the identification code when a firm switches ownership, industry classification or regional affiliation (Mata & Portugal, 2002). This makes an on-going firm appear as a termination and later as a new firm, while in reality it is the same firm. We minimize these problems by applying multiple identifiers as the tracking criterion and combining data from the tax authorities with identity codes from Statistics Sweden.

Cluster strength variable

In this study we use Porter's (1998:199) definition of a cluster as a "geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities". Because of data limitations we must exclude associated institutions such as universities and government agencies from our model and focus on competing and cooperating firms in related industries. We thus operationalize cluster strength by measuring the degree of agglomeration of firms in interconnected industries. This was achieved by (i) aggregating our data geographically into regions; (ii) aggregating related industries into clusters; (iii) finding an indicator of economic activity relevant for cluster effects; and (iv) selecting a measure to turn these indicator values into agglomeration values.

(i) We measure agglomeration on a sub-national level. Although some prominent studies (Amiti, 1999; Krugman, 1991; Midelfart-Knarvik et al. 2000) have examined the effect of industry localization on a national level, nations are not industrially homogenous regions and strong agglomeration patterns occur within them. Lindqvist, Malmberg and Sölvell (2003) demonstrated how the five clusters examined in this study are unevenly dispersed across 87 *labor market areas* in Sweden. These areas constitute our baseline regional aggregation level and they cover all of Sweden, not just urban areas. However, cluster effects may reach across labor market areas, and since Sweden is a small country comparable to a mid-sized US state like Ohio, we also consider two alternative higher levels of aggregation: 21 *counties* and 6 *NUTS-2 regions*, respectively.[1] Rosenthal and Strange (2004) found that different drivers of agglomeration are most pro-

[1] Labor market areas are statistically defined regions used primarily to investigate regional flows of goods, workers, and production. Counties are administrative regions responsible for governmental issues such as taxation and health care. In comparison to federal nations like Germany or the U.S., Swedish counties have limited political independence. Counties combine to form NUTS-2 regions, which are statistical units used by the European Union to allow for the comparisons of regions of similar geography and population.

nounced on different geographical levels, suggesting that the effects of agglomeration may vary by geographical level too.

(ii) Industry aggregation levels in previous research have varied from single (Sorenson and Audia (2000) or multiple industries (Pe'er and Vertinsky, 2006) to broadly defined groups of industries (Nicolini, 2001) or a single group for all industries (Baptista & Swann, 1999). In this study we collected data for 23 individual industries coded on the 5-digit SIC level. Similar to Gilbert, McDougall and Audretsch (forthcoming) we therefore grouped these industries into five clusters following Porter's (2003) methodology, which in turn is based on a statistical analysis of co-location patterns of industries combined with input-output data. Porter's cluster definitions have been translated to the Swedish industry classification system, SNI-92. To test the statistical consistency of our classification, we also examined the correlation of employment quotients over time between the different industries composing a cluster. The full list of industries is shown in Appendix 1. The statistical granularity in the material varies: the Financial Services cluster comprises as many as 11 different industry codes, while Medical Equipment and Biopharmaceuticals are made up of 2 industry codes each.

(iii) As an indicator of economic activity in a cluster we base our measure on employees in the selected industry (e.g. Beaudry & Swann, 2001; Glaeser et al., 1992; van Oort & Stam, 2006). Specifically, we use the number of employees belonging to one of the 23 SIC-5 equivalent industries as a measure the relative strength of this particular cluster. Using the actual number – the count – of employees in a particular industry to measure cluster necessitates that one can control for other effects that differ between regions. In this study, we control for urbanization effects by using regional control variables for population density, employment in other industries and the presence of universities and research institute. Because own-cluster employment is highly nonlinear and varies between 0 and 26,735 results would be difficult to interpret in a linear or hazard model. Akin to many earlier studies, we instead used the logarithmic value of own-cluster employment which is more evenly distributed between 0 and 10.19. This eases interpretation of the models. Measuring clusters based on employment has great advantages in its comparability across industry sectors. However, there are also reasons to consider cluster effects on the firm or plant level rather than the employee level. While the potential for labor specialization can be approximated by measuring the number of employees, rivalry between firms in the cluster may be more closely related to the number of firms in the cluster. Thus, to validate the findings we also estimate the empirical models using the number of plants in a cluster as an alternative base for cluster strength. We measure plants instead of firms since the latter approach would bias our measure towards headquarter-rich regions, notably large metropolitan areas.

(iv) Finally, we apply two different agglomeration measures. Agglomeration can be measured in absolute terms, by using the *counts* of employees and plants respectively in each region. Alternatively, one can apply relative measures, *location quotients*, and relate the number of employees or plants to a reference distribution (Braunerhjelm & Carlsson, 1999). In the debate on absolute versus relative measures we do not take sides, but test both measures. As reference base for the quotients we use the total employment and total number of firms in all industries respectively, including industries outside the five clusters examined. The location quotient is thus calculated as the cluster's share of total regional employees (or plants) divided by the cluster's share of total national employees (or plants).

Dependent variables

This study investigates the local economic impact of clusters on new firms. To assess economic impact we use four different dependent variables measured at the level of the individual firm:

Survival was measured as the time from registration to the discontinuance of a firm. Similarly to prior studies of agglomeration effects on firm survival, we distinguish between firms that fail and firms that merge with or become acquired by competitors (Folta et al., 2006; Globerman et al., 2005). While termination is generally a negative outcome, merger or acquisition need not represent a sign of failure. On the contrary, divesting of their equity share can be seen as the apex of success for entrepreneurs. This suggests that terminated and merged firms should not be pooled in the survival analysis. Two statistical tests, based on a discrete choice model of the multinomial logit type, were used to examine the validity of this assumption. We used Wald test to compare the vector of coefficients of the terminated and the merged firms relative to surviving firms. The test revealed a statistically significant difference between the coefficients (x^2 =38.20, d.f.= 19, $p < 0.05$), indicating that the two alternatives should not be pooled. A Hausman test of the Independence of Irrelevant Alternatives (IIA) showed that the coefficients for surviving and terminated firms were not affected by excluding firms that exited by merger from our analysis (x^2 =20.02, d.f.= 19, $p < 0.39$). We therefore eliminated 598 merging firms from the 2,722 exiting firms, leaving us with a final 2,124 terminations.

VAT payments: For tax payments made by firms, corporate tax was not deemed a suitable measure. Swedish tax legislation allows privately held firms to substitute corporate tax for firm founders' earnings from outside sources, and furthermore firms can defer taxes during the first five years of existence. Instead, we use the logged value of VAT payments. The VAT tax rate is 25% in Sweden and it represents 71% of total tax payments from a firm.

Job creation has frequently been examined in studies measuring the impact of entrepreneurship on economic development (Delmar et al., 2006; Hart & Hanvey, 1995; Reynolds, Miller & Maki, 1995). To estimate the impact of cluster strength on firms' abilities to create jobs we measure the net addition of jobs in terms of newly added employees in the firm (i.e. organic growth).

Wages per employee. While job creation is generally seen as an attractive outcome of entrepreneurship by policy makers, job creation *per se* tells little of the quality of those jobs. In order to measure the human and social dimensions of economic development (Rocha, 2004) we therefore also estimated models predicting the average wages (in logarithmic form) of the jobs created by clustered and non-clustered new firms.

Control variables

We used a number of relevant control variables that prior studies have indicated as important in studies of a firm's survival patterns and performance. All control variables were updated yearly, and similar to our cluster measures, lagged one year to avoid problems of endogeneity.

Age. One of the most persistent finding in studies of new firms' development is a tendency of reduced hazard of termination as firms age (Audretsch, 1995; Fotopoulos & Louri, 2000). We therefore include age as a control variable in all models.

Legal form. New firms started as incorporations generally show much higher economic resilience than firms started as partnerships or sole proprietorships (Delmar et al., 2006). In the survival analysis we control for legal form by a dummy indicator for incorporations, which is the base category. Since the performance models were estimated by fixed effects, legal form could not be used in these because it almost never changes over time.

Presence of local universities: The presence of university research is argued to be an important factor for the development of a cluster and the knowledge spillovers attracting new firms to clusters (Audretsch & Feldman, 1996; Beaudry & Swann, 2001). As a coarse control variable for knowledge spillovers generated by public research institutions, we use the number of medical research institutions, universities, technical colleges and business schools present in the region each year.

Living costs. To control for the fact that wage payments do not merely depend on the individual firm's productivity but also on regional differences in costs of living, we include a time-variant measure of mean housing prices in the region taken from Statistics Sweden's public databases.

Firm's human capital. Human capital has been found to be an important predictor of firm survival (e.g., Mata & Portugal, 2002) and performance (Karlsson, 1997). In particular, Pe'er and Vertinsky (2006) found that human capital had a stronger survival effect for firms at lower levels of cluster strength. We used the LOUISE database to create a variable measuring the proportion of employees with a college or university degree for each firm in our dataset.

Firm specific human capital. A key characteristic for several of the industries in this study is the reliance on innovation and technological development to gain a competitive edge. Since innovation and product development in new firms are facilitated by engineering skills (Stough et al., 1998), controlling for skilled engineering personnel is important to avoid our agglomeration measure being confounded by between-group differences in such skills. Similar to Karlsson (1997), we measure the proportion of employees with an engineering or science degree working in the firm, also taken from LOUISE, to control for firm specific human capital.

Finally, we include two variables to control for urbanization effects.

Other-sector employment/plants: Models based on counts will suffer a bias in that for larger or more densely populated regions higher cluster strength values will also reflect the general size of the region, confounding cluster effects with urbanization effects. We therefore include a control variable for other-sector employment, namely the total employment in the region minus the employment in the specific cluster. In alternative models using plant measures, this control variable is also based on plants.

Population density: Varying degrees of urban agglomeration is not the only confounding effect in our data. Our regions are fundamentally based on administrative regions and the delimitation between theses is to some degree arbitrary. High other-sector employment could both be an effect of a higher degree of urban agglomeration (larger cities) or a wider regional scope (a larger region). To control for both these effects we also add a control variable for population density, measured as the number of inhabitants per square kilometer in the region.

Statistical Analyses

To investigate the effect of cluster strength on firm survival, we used event history analysis. Similarly to prior studies of firm exit where time is measured in discrete intervals, we estimated a piecewise exponential hazard model that does not require any specific parametric assumption regarding the shape of the hazard function (Blossfeld & Rohwer, 1995). This model allows the hazard to vary over yearly intervals but constrains the covariates to shift the hazard by the same proportion each year.

To investigate the effect of cluster strength on firm performance (job creation, VAT payments, wages), we used pooled time-series regression based on generalized least squares. Model estimates with no effects, random effects, and fixed effects provided qualitatively similar results on the effects on cluster strength on the various performance metrics, but the Hausman (1978) specification test indicated that random effects were inconsistent (i.e. did not have a minimal asymptotic variance) and that fixed effects was preferable. We therefore used fixed effects estimation in all three models. To check for the presence of residuals autocorrelation we used Drukker's (2003) implementation of the Wooldridge test (Wooldridge, 2002). This indicated the autocorrelation in the residuals were present in the models on job creation and VAT payments, at or above the 1 percent significance level. We therefore included a control for autocorrelation (AR1) in these models.2 This did not qualitatively alter the results; however it significantly decreased the model fit (R^2 value). The means and standard deviations of all outcome and predictor variables, together with the correlation matrix, are displayed in Table 2 and the correlations between different cluster variables are displayed in Table 3.

RESULTS

The strength of the five clusters is shown in county-level maps in Figure 1. Absolute agglomeration (employee counts) is shown as circles where the areas of the circle represent the number of employees. Relative agglomeration (location quotients) is shown as the shades of the region; darker shades represent higher quotients. Figure 1 shows that the five clusters display quite different agglomeration patterns. As the capital and largest city of Sweden, Stockholm is strong in all of the clusters in absolute terms, but other regions are also significant. In Telecommunications, some inland regions have high counts, and Gotland has the highest relative level of agglomeration. For Financial Services, Stockholm dominates but the region around Sundsvall in the north is also fairly specialized due to the large number of insurance firms located there. Information Technologies are spread over several regions with the Southeastern area of greater Karlskrona exhibiting the highest specialization. In Medical Equipment, Malmö-Lund has as high counts as Stockholm, but even higher relative agglomeration, as does the adjacent greater Halmstad region. For Pharmaceuticals and biotech, Stockholm dominates together with the neighboring Uppsala region. Also the Malmö-Lund area is fairly agglomerated in Pharmaceuticals and biotech.

All empirical models are displayed together in Table 4. The first model is the hazard model of firm survival. The exponential form of the hazard model constrains the variables to affect the hazard multiplicatively and the coefficient estimates indicate the multiplicative effect of each variable. The coefficients are therefore more easily interpreted for variables that are measured in uniform units. For ex-

[2] In unreported models we also include the lagged dependent variables to account for the endogenous nature of organic growth. The presence of this variable however made estimates with firm fixed effects unstable and we excluded the lagged dependent variable in the final model. We are grateful to an anonymous reviewer for pointing out this problem.

Table 2. Variables and correlation matrix

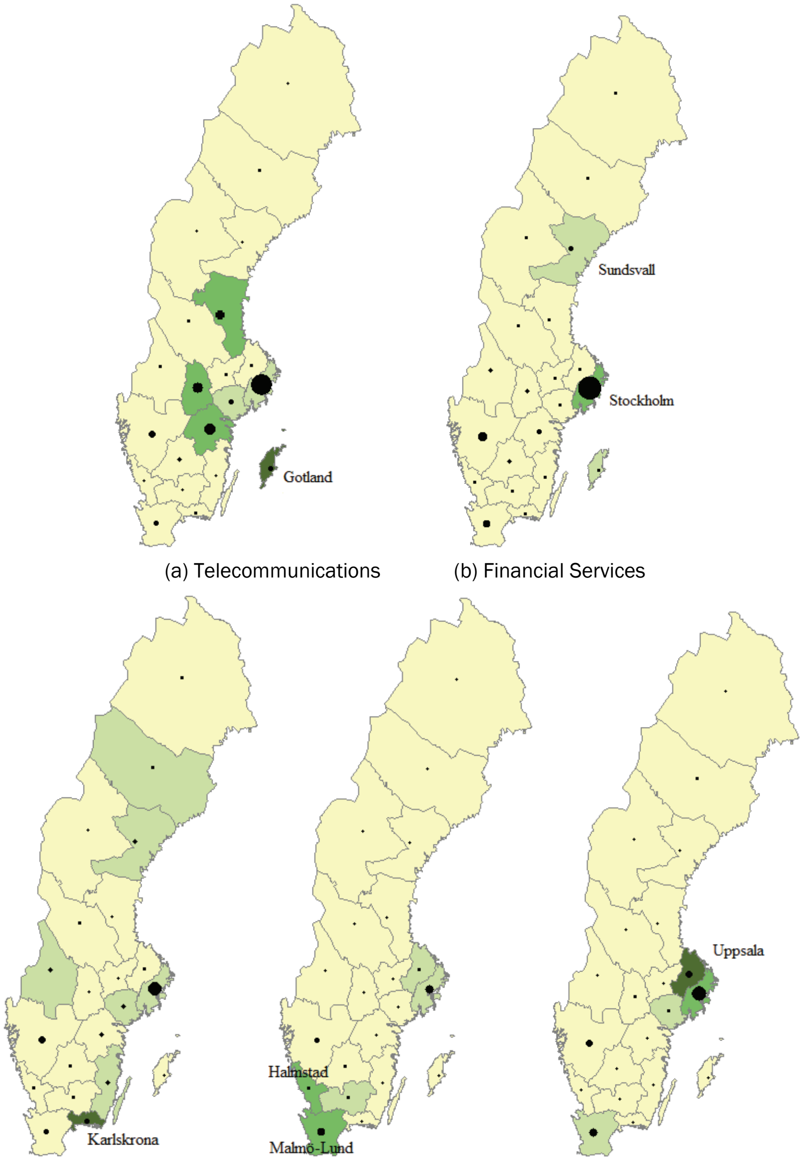
	Variable	*Mean*	*S.D.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	Survival	0.722	0.414													
2	Job Creation	5.199	107.240	.040												
3	VAT payments (log)	14.382	0.949	.059	.111											
4	Salary Payments (log)	11.976	0.504	.118	.027	.202										
5	Legal form	0.774	0.418	.524	.020	.263	.229									
6	Population density	43.007	90.731	.232	.070	.039	.039	−.014								
7	House price index (log)	1.371	2.138	.197	.062	−.119	−.091	.131	.743							
8	Region employment (log)	4.792	5.011	.231	.041	.028	.015	−.034	.410	.423						
9	Local universities	0.796	1.636	.345	.062	.033	.023	−.003	.896	.763	.419					
10	Employees (log)	0.983	0.721	.089	.259	.378	.087	.245	.120	.102	−.004	.123				
11	Human capital	0.401	0.093	.039	.508	.068	.028	.026	.083	.063	.067	.077	.235			
12	Special Human capital	0.089	0.388	.159	.340	.219	.111	.139	.217	.242	.270	.225	.580	.385		
13	Cluster employment (log)	2.144	2.363	.349	.048	.037	.017	−.015	.456	.461	.539	.228	.016	.070	.276	
14	Inverse Mills Ratio	0.129	0.446	.241	−.008	−.271	−.084	−.629	.300	.446	.412	.297	−.229	−.011	−.030	.410

Note: All correlations above ±0.02 significant at the 5 percent level. Survival and legal form variables represent yearly dummies.

Table 3. Correlation between different measures of agglomeration

			Quotients (cluster specialization)						*Counts (cluster size)*				
	Regional base:		*County*		*NUTS-2 region*		*Labor market region*		*County*		*NUTS-2 region*		*Lab. mkt. reg.*
		Aggl. measure:	*Empl*	*Plants*	*Empl*	*Plants*	*Empl*	*Plants*	*Empl*	*Plants*	*Empl*	*Plants*	*Empl*
Quotients (specialization)	*County*	*Plants*	.913										
	NUTS-2 region	*Employment*	.977	.922									
		Plants	.912	.994	.931								
	Lab. mkt. region	*Employment*	.674	.633	.660	.634							
		Plants	.752	.862	.760	.857	.555						
Counts (size)	*County*	*Employment*	.887	.756	.908	.769	.576	.595					
		Plants	.890	.799	.915	.813	.583	.634	.972				
	NUTS-2 region	*Employment*	.899	.789	.924	.802	.589	.628	.993	.966			
		Plants	.898	.841	.922	.855	.597	.677	.955	.989	.962		
	Lab. mkt. region	*Employment*	.875	.751	.897	.765	.592	.605	.974	.944	.975	.937	
		Plants	.877	.783	.901	.796	.597	.634	.947	.969	.948	.965	.972

Figure 1. Absolute and relative cluster strengths for five cluster categories in Sweden, 1997



(a) Telecommunications (b) Financial Services

(c) Information Technology (d) Medical Equipment (e) Pharmaceuticals

Notes: Black dots indicates absolute size of a cluster (number of employees). Shaded areas represented level of specialization in the region, a darker shade is a higher degree of specialization (location quotient of plants).

ample, model 1 indicates that each additional employee with a college degree in science or engineering (ordinal scaled variable) decreases the hazard of disbanding by 34 percent and being an incorporated firm (dummy variable) decreases the hazard of disbanding by 83 percent. The cluster variable in logarithmic form takes values from 0 to 10.2 and is therefore fairly easy to compare to other ordinal scaled variables. For instance, the hazard rate for a firm started in a region where own-cluster employment is 1.50 is 9 percent lower than in a region where own-cluster employment is 2.50. Since the standard deviation of own-cluster employment amounts to 2.36, a one standard deviation increase in cluster strength (i.e. being located in one of the top one-sixth clusters) increase the survival by 21 percent. This means that locating in an industrial cluster has a significant and meaningfully positive effect on firm survival.

We now investigate the effect of cluster strength on firm performance. 27 percent of the firms did not survive for two years from their formation. Since all predictor variables are lagged one year to avoid endogeneity, data from at least two periods is needed to assess the effect of cluster strength on subsequent performance. The firms that did not survive more than one year therefore had to be omitted in the performance analyses. However, if performance differs systematically between firms that survive compared to firms that do not, removing the non-survivors could induce a bias in our models. To control for this bias we used a Heckman-type selection model to create a variable that corrects for firms' attrition from the sample. Since the error term in the first stage of the equation (the attrition model) was not normally distributed, we used Lee's (1983) generalization of the Heckman procedure by estimating a logit model of attrition from the sample, using the same variables as in the model on firm survival. The logit model used to predict the likelihood of attrition from the sample should preferably include at least one variable that influences the probability of attrition from the samplethat is uncorrelated with the performance variables. For this purpose, we include the yearly regional unemployment rate which is likely to influence new firms' survival but not their general performance since many small firms are closed down during economic booms when the opportunity costs of entrepreneurship increases, regardless of economic performance (Gimeno et al., 1997). We then included the transformed logit predictions in the form of Inverse Mills Ratios as a selection variable in the performance models (Lee, 1983).

Table 4. Cluster effects on firm performance

	Model 1: Survival	*Model 2: Job Creation*	*Model 3: VAT Payments*	*Model 4: Salary Payments*
Constant	–	50.245	93.320 ***	10.104 ***
		(78.890)	(4.219)	(0.041)
Legal form = incorporation	0.170 ***	–	–	–
	0.011			
Population density	0.881 ***	−4.093	−0.125	−0.323
	(0.042)	(6.081)	(0.091)	(0.044)
House price index(log)	0.013	−6.112	0.095 *	0.203 **
	(2.259)	(12.066)	(0.047)	(0.030)
Other-sector employment (log)	1.032	0.000	0.002 ***	0.000
	(0.251)	(0.000)	(0.001)	(0.000)
Local universities	2.353	−2 .298	0.153 *	0.010
	(1.353)	(7.321)	(0.054)	(0.018)
Employees(log)	0.878 ***	7.434	18.212 ***	−25.983
	(0.061)	(2.024)	(3.042)	(3.813)
Human capital	0.920 **	8.241 **	8.970	43.990 ***
	(0.120)	(2.503)	(5.020)	(4.765)
Special Human capital	0.662 ***	33.003 ***	14.883 *	85.442 *
	(0.102)	(6.760)	(6.703)	(9.221)
Cluster employment (log)	0.902 ***	0.217 ***	0.143 **	0.122 ***
	(0.013)	(0.035)	(0.022)	(0.016)
Inverse Mills Ratio	–	−8.690	−0.472 **	−0.036
		(9.260)	(0.014)	(0.025)
Fixed firm effects:	No	Yes	Yes	Yes
Log-L. value / R^2:	−2449.23	0.084	0.140	0.091
Autocorrelation (AR1) control:	–	0.302	No	0.321
R^2 without autocorr. control.	–	0.186	–	0.176
Firm-year obs. / times at risk:	12,368	10,181	10,181	10,181
Firms:	3,799	3,208	3,208	3,208

Notes: Coefficients of Models 1 in hazard rate format, in models 2–4 in GLS format. Standard errors in parentheses. All models include dummy variables for cohort, age, and 5 cluster sectors. * p<05; ** p<0.01; *** p<.001; (two-tailed).

Model 2 shows the effect of cluster strength on firm job creation. Looking at the coefficient for own-cluster employment, we can see that cluster strength clearly has a positive effect on firms' ability to create new jobs, i.e. their net number of new employees hired. Is this an important finding? If one compares the coefficients to those of the other variables, the effects do not appear to be very large. However, we cannot judge the relative magnitude of the effect in a linear model based on the coefficients alone. To do that, we need to calculate the marginal effect, i.e. the derivate of the outcome variable (job creation) divided by the derivate of the predictor variable (own-cluster employment), holding all other variables constant. Using the logarithmic value of own-cluster employment as in the hazard model on survival, this procedure reveals a marginal effect of 0.120. In other words, a firm in region with own-cluster employment of 2.50 will have a rate of job creation 12 percent higher than a similar firm in region with own-cluster employment of 1.50. A one standard deviation increase in cluster strength thus increases the number of jobs created by a firm by 28 percent. This is indeed an indication that cluster strength has a strong impact on firm job creation. Looking at the foot of Table 4, we can see that model two is based on fixed effects for each firm and also includes a control for autocorrelation disturbance. The same model based on random effects estimation, or alternatively on fixed effects but without the autocorrelation control, indicates qualitatively similar results. However the explained variance is twice as high for a model without the autocorrelation control (0.19) and is more than three times as high (0.31) for a model based on random effects. The only other alterations in these alternative models are seemingly larger effects for cluster strength as well as the controls for employees and human capital without the autocorrelation control. This shows that our results are robust across different model specifications and, furthermore, indicates the existence of strong path-dependent factors that might confound the results of cluster models if one cannot properly control for such factors.

Model 3 shows the effect of cluster strength on firms' VAT payments. Similar to model 2, it is based on fixed effects estimation because the Hausman test indicated the non-stationarity of variance in the residual between time periods. The Drukker/Wooldridge test did not indicate that autocorrelation was a problem in this model, so no autocorrelation control is included. The results are seemingly similar to those of model two, although with somewhat higher explanatory power due to the omitted autocorrelation control. Also in this model, our cluster variable is significant, albeit at a somewhat lower level of significance ($p<0.01$) than in the model on job creation. However, the magnitude of effects is strikingly similar; holding all other variables constant at their means, the marginal effect of own-cluster employment (in log form) on firms' VAT payments amounts to 0.094. A firm in a region with own-cluster employment of 2.50 will make taxation payments that are 9.4 percent higher than a similar firm located in a region with own-cluster employment of 1.50, or 22 percent higher with a one standard deviation increase in cluster strength. Also these effects are qualitatively identical if we estimate the model based on random effects or no effects. The Inverse Mills ratio variable is significant, highlighting a selection effect for VAT payments – firms with a high likelihood of exit have lower turnover. Interestingly, the control variable for other-sector employment is now significant, suggesting that cluster congestion is not a problem (Beaudry & Swann, 2001). Finally, the control variable for local universities is weakly significant, suggesting that firms situated in urban areas with research institutions tend to pay higher taxes.

Our last model, model 4, shows the effect of cluster strength on the mean salary levels of newly created jobs. Similar to model 2 on job creation, model 4 is based on fixed effects and includes a control for autocorrelation. The effects of the control variables are also very close to those of model 2, with the exception of human capital. The human capital variable is now significant and strongly positive, which is quite logical if we consider that the educational level within a firm should be associated with the level of salaries paid to employees. Also the control variable for regional house prices is significant, indicating that firms in more affluent areas need to pay higher wages. Most importantly, in this model of mean salary payments, the own-cluster employment variable is strongly significant. Looking at the marginal effects we find that a firm in a region with own-cluster employment of 2.50 will make pay salaries that are 10 percent higher than a similar firm located in a region with own-cluster employment of 1.50, or 24 percent higher with a one standard deviation increase in cluster strength. The effects are robust to models estimated by random or no effects. Throughout our models, the control variable for local universities remains insignificant. This could be attributed to the fact that the variable does not gauge the intensity and quality of research (e.g.

Fritsch & Slavtchev, 2007) but simply count the presence of universities.

Finally, in unreported models we validated the analyses for all five cluster separately. With the exception of cluster four (medical equipment), which in Sweden is a quite small cluster, all findings were identical to reported models. Among the start-ups in medical equipment, same-cluster employees in the region contributed positively to survival ($p < 0.05$) but the positive effect on job creation is significant only at the 10% level. Further, for VAT payments and salary payments the effects are even weaker, although the coefficients are in the expected direction. Also the models estimated only for start-ups in the biotech/pharma cluster showed weaker results; however all cluster variables were still significant at the 5% level. That only the smaller clusters showed weaker results indicates this is a problem of sample size and not a problem of pooling divergent industries.

The effect of alternative cluster measures

It has been pointed out throughout this paper that the inconclusive evidence of prior research of clusters on entrepreneurship and economic development might partly be attributed to methodological diversity and also differences in the geographical granularity of data set used (Pe'er & Vertinsky, 2006; Rocha, 2004). Since there are several candidates in the empirical literature for the best way to identify and measure clusters, we chose the same-sector employment figure which we found was the most commonly used variable in prior studies, and which also is in line with most of the theoretical effects suggested in the literature by the works of Marshall, Krugman, and Porter. However, given that we had the choice to use other measures and also that we wanted to assess the findings on different geographical levels, we decided to assess the validity of our findings for competing measures of cluster and different geographical levels.

Table 5 summarizes the same four empirical models estimated as in Table 4, but with different measures of cluster and on different geographical levels. We show models based on counts (same-cluster number) of employees or plants, as well as models based on location quotients, i.e. the proportion of employees or plants in a specific industry in the region, relative to all employees/ plants in that region. We also alternated our base for geographical level, labor market area, with county and NUTS-2 region.

Table 5 reveals several interesting patterns. First, our findings are quite robust across different ways of measuring clusters and also on different regional levels. Second, the magnitude of effects differs between measures and regional levels. Specifically, it seems that basing our measure of cluster on a higher regional level such as counties (21 regions) or NUTS-2 regions (6 regions) indicate stronger effects than the base model showed for labor market region (87 regions).

To a certain extent, it is puzzling that measures based on location quotients of employees or plants reveals much weaker effects, sometimes not even statistically significant, compared to measures based on counts of employees or plants (but see Becchetti, Panizza & Oropallo, 2007, for similar findings). In unreported tables we estimated the same empirical models with location quotients as cluster measure using both random and fixed effects. This revealed that random effects estimation showed statistical significance but not fixed effects. There simply seems to be too little variation in quotients over time to be picked up by the fixed effects model. Since the Hausman test indicated that random effects based on location quotients are asymptotically inefficient, a tentative conclusion of Table 4 would be that, while location quotients are a good measures of identifying clusters, they are poorer measures for gauging the potential effect of vari-

Table 5. Marginal effect of alternative cluster measures on firm survival and performance

Agglomeration measure:	*Regional base:*	*Aggl. base:*	*Survival*	*Job Creation*	*Tax Payments*	*Salary Payments*
Counts (cluster size)	Labor market region	Empl	21.2%	28.3%	22.2%	23.8%
		Plants	23.2%	34.9%	34.5%	19.1%
	County	Empl	21.2%	26.3%	43.9%	36.9%
		Plants	5.2%	28.5%	42.7%	42.3%
	NUTS-2 region	Empl	17.4%	28.6%	31.4%	57.2%
		Plants	12.2%	33.6%	41.6%	68.2%
Quotients (specialization)	Labor market region	Empl	n/s	4.80%	n/s	n/s
		Plants	2.3%	n/s	12.30%	6.70%
	County	Empl	n/s	4.20%	2.20%	n/s
		Plants	5.0%	n/s	10.10%	16.50%
	NUTS-2 region	Empl	n/s	n/s	n/s	9.40%
		Plants	13.1%	n/s	22.20%	20.20%

ation in cluster strength on firm-level outcomes. Simply put, ten biotech firms in a small town may stand out more than fifteen firms in a big town, but the cluster benefits are nevertheless greater from fifteen than from ten. An alternative conclusion is that we have failed to control for urbanization effects not captured by the controls for population density, local universities and employment in other industries. This would then have biased our initial results for own-cluster employment. Yet, our control variables include the usual ways to measure urbanization effects and our review of the empirical literature did not suggest the potential omission of some significant urbanization variable.

DISCUSSION

In this paper we have investigated the effects of clusters on the survival and performance of new entrepreneurial firms. Using detailed firm-level data, we assessed all Swedish firms started during a ten-year period in five different industry groups and found evidence that a high concentration of own-cluster employment (in same industry and related industries) was related to better chances of survival, higher employment, higher tax payments, and higher salary payments. These effects are consistent for absolute agglomeration measures (counts), but weaker and inconsistent for relative agglomeration measures (location quotients). The strength of the effects vary depending on which geographical aggregation is chosen for the agglomeration measure. Our study contributes to the literatures on entrepreneurship and economic growth and agglomeration in economic geography. To the best of our knowledge, the study is the first of its kind to measure these outcomes at the level of the individual firm and not as regional aggregates.

These findings support previous research indicating that clusters do provide economic benefits not only for firms in general but for newly started entrepreneurial firms in particular. Although this study does not identify which mechanisms are producing these benefits, it does confirm that new firms in stronger clusters not only have higher survival rates, but also have higher economic performance in ways that have a direct impact on the regional economy. Several factors augment the external and internal validity of these conclusions including the fact that 23 industries grouped in five different clusters were studied and the large and unbiased sample size of 4,397 firms started in the specified industries. The inclusion of fixed firm effects in our models effectively controls for many alternative factors that could have impacted our results. The findings of our study of five knowledge-intensive clusters can be contrasted to studies of other industries. Sorenson and Audia (2000) found in their study of the US footwear industry 1940-1989 that proximity to other footwear plants decreased the survival of footwear manufacturers. These divergent findings may indicate that clusters and agglomeration effects operate differently in knowledge-intensive versus capital-intensive industries. The fact that cluster effects were markedly weaker for start-ups in the smaller clusters (medical equipment and biotech/pharma) indicate that further research on larger clusters of this type is needed to substantiate the results for these industries.

The results from our analysis of different cluster measures echo those of Rosenthal and Strange (2001). They note that drivers behind agglomeration (such as knowledge spillovers and labor market effects) have different reach, some being strongest on the lower zip code levels while others are more pronounced on the higher state level. The difference they find in the geographic reach of agglomeration *drivers*, we find in terms of economic *benefits* of agglomeration: some economic benefits are most pronounced on the lower labor market area level, while others are strongest on the higher NUTS2 level.

There are, however, also limitations to this study, primarily the fact that it is based only on Swedish data. Sweden is a small country where the industrial structure combines a large public sector with a relatively small but highly international and productive private sector. The findings are therefore not necessarily generalizable to other countries. More research comparing regions, time periods and especially different measurements will improve upon our attempt to establish consistencies in cluster measurement. In particular, studies using agglomeration measures based on NUTS-2 regions in other parts of Europe are certainly needed. Further, our evidence is limited to characteristics of the region/cluster and that of the firm. Including characteristics of the founding entrepreneurs such as growth motivation or industry experience is likely to reveal additional evidence on the determinants of new firm performance.

Appendix

Cluster	*Industry*	*Start-ups*	*Employees*	*Plants*
Cluster 1: Telecom and consumer electronics	Manufacture of office machinery	25	1 379	53
	Manufacture of insulated wire and cable	41	4 804	81
	Manufacture of other electrical equipment	116	3 136	322
	Manufacture of television and radio	65	16 359	162
Cluster 2: Financial services	Other monetary intermediation	66	702	225
	Other credit granting	68	5 797	332
	Investment trust activities	79	1 213	237
	Unit trust activities	590	4 091	1721
	Unit link insurance	16	991	60
	Other life insurance	17	3 586	140
	Non-life insurance	47	14 463	488
	Administration of financial markets	9	474	23
	Security brokerage and fund management	646	2 741	1622
	Activities auxiliary to financial Insurance	331	2 516	708
	Management activities of holding companies	141	6 779	995
Cluster 3: Information technology	Manufacture of computers and IT equipment	172	2 271	349
	Manufacture of valves, tubes and electronics	176	6 018	410
	Publishing of software	1 291	13 233	2869
Cluster 4: Medical equipment	Manufacture of medical / surgical equipment	170	7 293	507
	Manufacture of artificial teeth, dentures, etc.	268	1 817	725
Cluster 5: Pharmaceuticals	Preparation of biotechnical products	14	602	19
	Manufacture of pharmaceutical preparations	49	18 182	119
	SUM:	4 397	118 447	12 167

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Study 5

Regions, innovation and economic prosperity: evidence from Europe

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Study 5

Regions, innovation and economic prosperity: evidence from Europe

ABSTRACT It is a general fact of economic life that regions differ markedly in their innovative capacity and economic prosperity. This is certainly true for nations across Europe, but is similarly true across regions within each nation. Successful regions have economic profiles different from those of less successful ones. This paper compares differences in both regional specialization giving rise to Marshallian (or MAR) externalities and urban diversity giving rise to Jacobian externalities. The analysis is based on a structural equation model with data from 211 regions in Europe. It shows that both types of externalities play important roles, but in different ways. First, our results show that MAR externalities are important for economic prosperity, but only indirectly through innovation. Specialized regions in Europe perform much better in terms of innovation input and output, which in turn leads to improved GDP/capita. Second, urbanization plays a direct positive role for economic prosperity. It also plays a role in explaining public R&D, but is not directly linked with business R&D or innovation output. Third, public R&D only leads to innovation output through business R&D, and thus the notion that more investments in public R&D should lead directly to more innovation does not agree with the empirical results for Europe.

Introduction

The modernization initiative known as the Lisbon Strategy is predicated upon the belief that Europe needs to improve its research and innovation environment in order to sustain a high and rising standard of living. There is evidence to suggest that both innovation and economic prosperity are geographically concentrated phenomena, and thus regional specialization, or clustering, should play a key role in building a more competitive Europe. But the processes of regional specialization, innovation, and economic growth remain something of a black box, in want of more empirical research. Do more diverse regions or more specialized regions perform better? Can diversity and specialization play complementary roles or are they mutually exclusive? Is innovation critical to economic prosperity? And how is innovation linked to the characteristics of different regions? This article offers a model built around these component issues—regional characteristics, innovation, and economic prosperity—and tested on a rich dataset covering 211 regions in Europe (EU-25).

The article is organized as follows: the remainder of this introduction presents an overview of the literature on regional specialization and clusters, and outlines four main arguments as to why innovation is strongly linked with local clusters. Local processes of knowledge accumulation and innovation involve continuous interaction and close relationships and networks involving firms, universities, non-profit organizations and other agents, and various other place-bound institutions. The next section reviews previous literature in the area and presents a model relating regional characteristics to innovation and to economic prosperity. The following section describes our econometric methodology and data sources, and reports the results. The final section concludes by interpreting the results and discussing implications.

Regional specialization

The first major type of regional economy that stems from agglomeration, or clustering, are specialization economies, so-called Marshall-Arrow-Romer (MAR) economies (Arrow, 1962; Marshall, 1920; Romer, 1986). These mechanisms operate within an industry. or within a cluster of related industries (Porter, 1990, , 1998), and are strongest when a region exhibits a high degree of industry specialization. Linkages among firms, institutions, and infrastructures within a geographic area give rise to economies of scale and scope; the development of general labor markets and pools of specialized skills; enhanced interaction between local suppliers and customers; shared infrastructure; and other localized externalities. In Scott's view (Scott, 1983; , 1988), the formation of regional agglomerations will be particularly intense where linkages tend to be small-scale, unstable, and unpredictable, and hence subject to high transaction costs.

Clusters are not just fixed flows of goods and services, but rather, are dynamic arrangements based on knowledge creation, increasing returns (Krugman, 1991), and innovation in a broad sense. In line with this view, more recent research has come to focus on the importance of innovation when trying to explain the emergence and sustainability of agglomerations. Thus, clusters are made up not only of physical flows of inputs and outputs, but also by the intense exchange of business information, know-how, and technological expertise, both in traded and untraded forms, locally and globally (Bathelt, Malmberg, & Maskell, 2004; Storper, 1997). Several studies have confirmed the importance of knowledge externalities in regional clusters (David B Audretsch & Feldman, 1996; Jaffe, Trajtenberg, & Henderson, 1993) as well as the importance of connecting regional clusters to extra-regional sources of knowledge (Gertler & Levitte, 2005).

The second type of regional economy includes urbanization economies, also known as Jacobian economies (Jacobs, 1969), which arise from the mix of industries in a region. Knowledge spillovers between industries, rather than within them, give rise to externalities due to the diversity of the industries. This process is most readily observable in and around cities, as industrial diversity is greatest in urban regions. In addition, cities are home to universities and other scientific institutions which play critical roles in the innovation process. Capital cities representing political power and markets for public projects are particularly attractive to corporate headquarter functions. Haig (1926) pointed to the need for daily, often unplanned contacts in larger cities where executives produce answers to unstandardized problems, problems that change frequently, radically and unpredictably. Jacobian economies are therefore strongest in highly urbanized regions with greater industrial diversity. Glaeser *et al.* (1992) showed that Jacobian economies are indeed important for employment growth, but that the Porterian cluster argument based on competition also holds true.

Urbanization economies relate to knowledge creation and creativity without any sectoral boundaries. Instead of specialization of related industries, emphasis is placed on the presence of a regional variety of skills and competencies, where the (often-unplanned) interaction among different actors leads to new and often unexpected ideas and new creative designs, products, services, and business concepts (Florida, 2002; Johannisson, 1987).

Innovation in clusters

Innovation output, often measured by patenting activity, tends to be highly skewed across regions, and both within and across nations. A large number of empirical studies demonstrating this point have been published in the last decade (Cheshire & Malecki, 2004; Crescenzi, Rodríguez-Pose, & Storper, 2007). There is widespread evidence of both MAR and broader urbanization externalities. Empirical evidence shows that the two types of externalities vary with type of industry (Henderson, 2003), level of technology (Feldman & Audretsch, 1999), and industry maturity (Henderson, Kuncoro, & Turner, 1995).

Innovation can be of a technological nature and/or related to improved business models. As we know from the writings of Rosenberg (1976; , 1992), the economic effects of technological breakthroughs are not really about the sophistication of a technology itself, but rather linked to the degree to which it is commercialized and diffused into society. In cases in which there has been a genuine technological invention behind incremental innovation, the subsequent adjustment of the business model and financial construction often becomes more important than the invention itself.

This is precisely the point at which regions and clusters come into the picture. Clusters offer a broad range of advantages, providing a zone in which frequent day-to-day and face-to-face interactions spark ideas, concepts, and beta versions that are tried over and over again, within a particular institutional setting, as personal networks and trust are built up over time (Malmberg, Sölvell, & Zander, 1996). These concepts of localized and culturally bound processes, based on trust, cooperation, continuous interaction, interpersonal and interorganizational networks—i.e., relational economic geography—has attracted much recent interest in the field (see Sunley, 2008, for a review and critique).

Localized innovation and knowledge creation are both built on the interaction of technologically related actors (buyer-supplier, industry-university etc.). We can identify four inter-related characteristics that are particularly important for understanding innovation processes within clusters.

- A process of *incremental reduction of technical and economic uncertainty* (Cristopher Freeman, 1982; Christopher Freeman, 1991), where new technologies typically undergo a number of modifications and business models are adjusted. New particular knowledge and skills develop over time. This often takes place in a process of Rosenbergian learning (Rosenberg, 1982), where unplanned problems are solved in unplanned meetings using technology in unplanned ways. Research, technology, and innovation are all involved simultaneously rather than sequentially.

- A process of *continuous interaction* across organizations, building thick ties, specialized language, and social capital within the region. This process of exchange and creation of new knowledge is enhanced by face-to-face contacts. Frequent interactions between buyers and suppliers, as well as the key role of users, have been emphasized by von Hippel (1998) and Lundvall (1992). These exchanges frequently involve sensitive information, and therefore require a high level of trust between the parties.

- A process of *transferring technology and tacit skills* through apprenticeship training, through specialized research and technology-transfer organizations, and through regional public-private organizations focusing on networking and diffusion of new technology, such as between universities and the private sector. Important linkages between the scientific community and firms engaged in innovation have been illustrated (Cristopher Freeman, 1982).

- A process where different resources are constantly rearranged, through mobility of skilled personnel, venture capital and business angle investment, IPOs and financial restructuring, cross-licensing, and the like. Various forms of cooperative solutions and M&A activity also lead to resource reshuffling. Many inventions and innovations do not take hold where and when they first emerge. Instead, it is often only after migration that they are able to find the right soil, so to speak, a process that is influenced by information distance and networks.

All of this can potentially take place at a global scale, but for reasons of both efficiency and openness, built on trust and social capital, these innovation processes seem overwhelmingly productive within proximate and networked environments, surrounded by a common set of institutions and particular historical and cultural norms. Common inter-firm linkages within clusters include joint R&D projects, joint product development, or the sharing of technology through licensing (involving fees, patent transfers, and so on). These ties develop both between similar types of organizations (firm – firm), and between different types of cluster actors (public research organization – firm, VC – firm, and so forth). For example, the Boston – Cambridge biotech cluster is built on two quite separate networks of thick ties, one centered around Harvard – Brigham & Women's Hospital – Genzyme, and the other centered around MIT – Mass General Hospital – Biogen (Powell, Owen-Smith, & Colyvas, 2007).

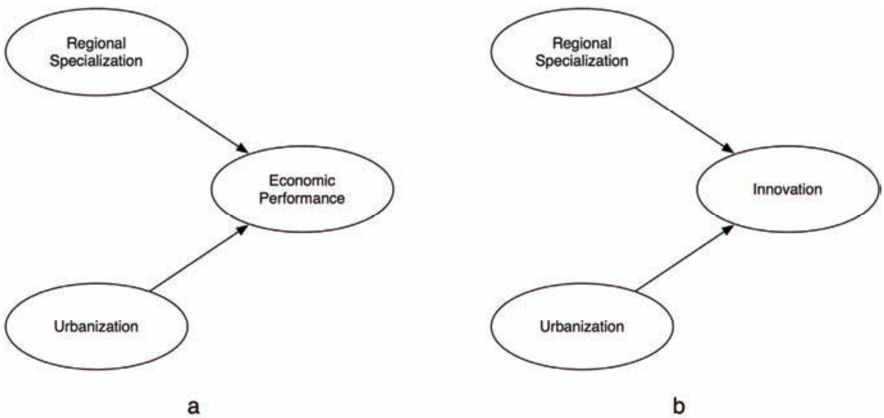
Face-to-face contacts appear to be of particular value for exchanging tacit knowledge, or when the exchange of knowledge requires the direct observation of products or production processes in use. This type of knowledge typically does not reside in blueprints and formulae, but is instead based on personal skills and operational procedures that do not lend themselves to be presented and defined in either language or writing (Polanyi, 1962; Winter, 1987). Some studies indicate that informal and oral information sources facilitate most of the key communications about market opportunities and technological possibilities that lead to innovation. According to Utterback (1974), it is these unanticipated, or unplanned, personal encounters that often turn out to be most valuable. It is in this context that the cluster configuration has substantial advantage over a globally dispersed configuration. The costs and time associated with the repeated exchange of knowledge and information will be lowered if the exchanges take place within clusters.

Theoretical model

Our theoretical model is built on three pillars: first, the regional characteristics giving rise to MAR and Jacobian externalities; second, the innovative activity within the region in terms of public and business R&D inputs and output; third, regional performance in terms of the level of economic prosperity.

Whether MAR externalities or Jacobian externalities are more important for a region's economy has been an issue for academic discussion, and a large number of empirical studies have compared the two types of effects. The effects have been studied on two different levels of outcome: the effect on economic performance, such as productivity or employment growth (see Figure 1, illustration a), and the effect on innovation, usually measured through patenting activity (see Figure 1, illustration b). In this paper, we contend that valuable insights can be gleaned from combining these two approaches in a single analysis.

Figure 1. Basic elements of the theoretical model



The first stream, focusing on economic performance, has provided mixed and somewhat contradictory findings, as is apparent from the following examples. Henderson *et al.* (1995) found evidence of MAR externalities in a study of US manufacturing industries between 1970 and 1987, but found evidence of Jacobian externalities only in the realm of high-tech manufacturing. Baptista and Swann (1999) examined the computer industry in 39 US states and 14 UK regions in 1988 and 1991 respectively. They found evidence of MAR but not of Jacobian economies. Similarly, Almeida (2005) studied the wage growth of manufacturing firms in 275 Portuguese regions between 1985 and 1994, and found support for the existence of MAR externalities but not for Jacobian externalities. Glaeser *et al.* (1992), on the other hand, found that employment growth between 1956 and 1987 in 170 US cities was positively linked to diversity but negatively correlated to specialization. Combes (2000) analyzed employment growth from 1984 to 1993 in 341 French regions, finding the effects of specialization to be generally negative, while determining that the effects of urbanization were positive for services and negative for manufacturing. Gao (2004) examined output growth in resource extraction and manufacturing from 1985 to 1993 in 28 Chinese provinces, and found both specialization and diversity to have had a negative or insignificant effect on output growth.

Based on these previous studies we hypothesize:

> **Hypothesis 1a:** Regional specialization is positively related to economic performance.

> **Hypothesis 1b:** Urbanization is positively related to economic performance.

The other stream of research has examined the effect of MAR and Jacobian externalities upon innovation rather than economic performance. The two streams are closely related through the assumption that the main source of long-term economic growth is “the ability to create, diffuse, and adopt new ideas and apply them to economic activities” (Montibbio, 2004:44). The importance of intentional investments in new technology for economic growth follows from two key features of knowledge: since knowledge is a nonrival good, it can be accumulated without bound; and due to knowledge spillovers it has incomplete excludability. These two features imply increasing returns to scale and make endogenous growth possible (Romer, 1990).

> **Hypothesis 2:** Innovation is positively related to economic performance.

A central concept in innovation research is the process of knowledge spillover (David B. Audretsch, 1998; Jaffe, 1989). This is of particular importance for innovation, since spillovers from outside the firm can provide novel knowledge in radically new arenas. In addition, universities have less reason to be protective of their ideas than firms, so university research tends to spill over into firms and generate business R&D and firm-level innovation (Jaffe, 1989).

There is, however, a geographical aspect to knowledge spillovers. Jacobs proposed that cross-sectoral knowledge spillovers occur more readily in urban settings. Marshall suggested that within a limited geographical region, knowledge spreads easily: "inventions and improvements in machinery, in processes and in the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas" (Marshall, 1920:225).

Krugman (1991) proposed that of Marshall's three mechanisms, technological spillovers would be the least worthy of research attention because of the difficulty inherent in observing and measuring them. Nevertheless, later research found ample evidence of such spillovers. Jaffe *et al.* (1993) identified one channel for knowledge spillovers through patent citations, which were found to exhibit clearly localized patterns. Localization was also found to fade over time, suggesting that knowledge takes time to traverse geographical distances. Maureseth and Verspagen (2002) found, similarly, that patent citations within Europe occur more often between regions in geographical proximity to each other. Almeida and Kogut (1999) examined labor mobility and found that inter-firm mobility of engineers is another channel of local knowledge transfer, and further, that the flow of knowledge is embedded in regional labor networks.

The effect can be self-reinforcing when the presence of strong clusters begin attract additional firms to invest in the region. Almeida (1996) found that foreign subsidiaries tend to draw strongly on local patents, suggesting that knowledge-building is localized—and particularly so for foreign firms.

Several studies have aimed to distinguish the differences between MAR effects and Jacobian effects on innovation, and again the results have been mixed. Feldman and Audretsch (1999) examined the introduction of new manufacturing products in US cities and found a negative specialization effect (measured for a single 4-digit SIC level) but a positive diversity effect (within six groups of industries related by the same type of science input). They also found the same pattern for firm-level innovation. Paci and Usai (1999), in their study of patent applications in 784 Italian regions, found evidence of specialization externalities and, particularly for high-tech sectors and in metropolitan areas, diversification externalities. Massard and Riou (2002) analyzed patenting in 94 French regions, concluding that specialization (in terms of R&D investment) had a negative impact on innovation, while the effect of diversity was low or insignificant. Porter (2003) found a positive relationship between patenting rates in 172 US regions and regional specialization. Greunz' analysis (2004) of patenting in 153 European regions suggested that both specialization and diversity had a positive impact on innovation, and that diversity was particularly important within highly urbanized areas.

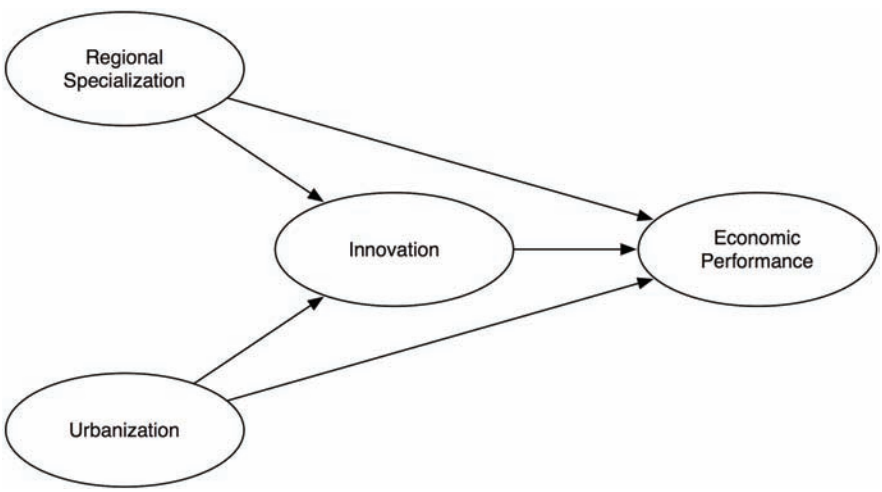
Empirical work has produced mixed results, but we hypothesize positive effects of both specialization and urbanization:

Hypothesis 3a: Specialization is positively related to innovation.

Hypothesis 3b: Urbanization is positively related to innovation.

If we now combine the results from these two streams of literature, the result is the intermediary model shown in Figure 2. However, we will extend this model one step further as we disentangle innovation by separating the input side (i.e., R&D activities) from the innovation output side.

Figure 2. Intermediary model



While there is widespread agreement that R&D activities are an important driver of innovation, it has also been found that the impact of business R&D differs from public sector R&D (universities and research institutes). Jaffe (1989) studied corporate patenting across 29

US states from 1972 to 1981, and found a stronger effect from industry R&D on patenting than from university R&D. The study also suggested an indirect effect from university R&D on industry R&D. Anselin et al. (1997) confirmed these findings, and also found evidence that university research influences industry R&D, but uncovered no evidence for the opposite. These results suggest that when the effect of specialization and diversity on innovation is studied, there is reason to distinguish between public R&D and business R&D, as these seem to have separate effects on innovation.

Hypothesis 4a: Business R&D is positively related to innovation.

Hypothesis 4b: Public R&D is positively related to innovation.

Hypothesis 4c: Public R&D is positively related business R&D.

This brings us to the ways in which specialization and urbanization affect R&D activity. Both MAR and Jacobian spillovers could result in increased company R&D. Clustering effects lead to intensified and more varied R&D approaches (Porter, 1998), and metropolitan centers not only house public research institutions, but also tend to attract corporate R&D centers (Lund, 1986).

Hypothesis 5a: Regional specialization is positively related to business R&D.

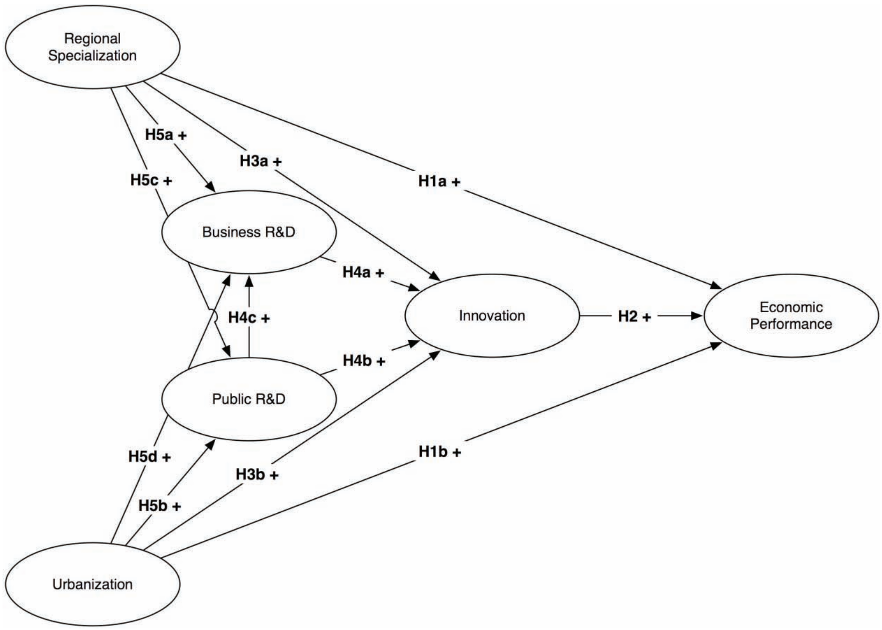
Hypothesis 5b: Urbanization is positively related to business R&D.

Hypothesis 5c: Regional specialization is positively related to public R&D.

Hypothesis 5d: Urbanization is positively related to public R&D.

The review above shows that there is a wealth of empirical evidence regarding the effects of specialization and urbanization on innovation and on economic performance. The patterns, however, are complex. While each of these research streams contributes separately to our understanding of the effects of agglomeration, much can be gained from a *combined* analysis that considers all of these effects simultaneously. In order to disentangle these complex relationships, we use a combined model with specialization and urbanization influencing economic performance, both directly and indirectly, through innovation, and with public and business R&D represented as two intermediary steps. The complete model and the signs of the hypotheses are shown in Figure 3.

Figure 3. Theoretical model



Model specification and results

The model we have specified for this study combines multiple interdependent relationships connecting regional specialization and urbanization to innovation and economic performance. In order to estimate such a model, we cannot use simple bivariate methods, as we cannot assume the independence of equations. Instead we employ a structural equation modelling technique, where a construct that is an independent variable in one bivariate relationship can be dependent in another.

Regional and industry aggregation

Geographically, the data analyzed is divided into 211 regions in within EU-25. The regional division follows EU's Nomenclature of Territorial Units for Statistics (NUTS), and most of the data is for the NUTS level 2. However, for four countries we have used the larger NUTS level 1: in Belgium and Netherlands due to very small geographical areas of the NUTS level 2 regions, in Greece due to a small population, and in Ireland due to data availability. With the exception of the Canary Islands, EU territories outside Europe were excluded (overseas possessions of France, African territories of Spain, and Atlantic islands of Portugal). Scotland and Sachsen-Anhalt were removed from analysis due to the changes in NUTS classification in 2006, breaking the data series. The Finnish isles of Åland were also excluded due to the very small size of the region. This left us with 211 regions covering virtually the entire surface of the European Union (see Table 1).

Applying Porter's methodology (2003), we aggregate data by industry in order to measure regional specialization. This entails applying a broad industry definition, referred to as 'cluster categories.' In short, the method focuses on industries that display agglomeration

Table 1. Number of regions per country

Country	*Number of regions*	*Country*	*Number of regions*
Austria	9	Latvia	1
Belgium	3	Lithuania	1
Cyprus	1	Luxembourg	1
Czech Republic	8	Malta	1
Denmark	1	Netherlands	4
Estonia	1	Poland	16
Finland	4	Portugal	5
France	22	Slovakia	4
Germany	37	Slovenia	1
Greece	4	Spain	17
Hungary	7	Sweden	8
Ireland	1	United Kingdom	33
Italy	21	Total	211

Table 2. Cluster categories

Cluster category	Examples of industries	Cluster category	Examples of industries
Aerospace	Aerospace industry, aerospace engines	Heavy Construction Services	Construction businesses, rental of construction machineries
Analytical Instruments	Measurement instruments, process control	Hospitality & Tourism	Hotels, taxies, amusement parks
Apparel	Clothes	Information Technology	Electronic components, computer manufacturing
Automotive	Motor vehicles, components	Jewellery & Precious Metals	Jewellery, cutleries
Building Fixtures, Equipment & Services	Kitchen furnishing, plaster	Leather Products	Bags, furs
Business Services	Management consultancy, rental of office machinery	Lighting & Electrical Equipment	Lamps, electricity distribution's equipment
Chemical Products	Chemicals, nuclear fuels, industrial gases	Construction Materials	Scrap, ceramic sanity fixtures
Communications Equipment	TVs, Cable, telephony equipment	Medical Devices	Medical equipment, wheelchairs
Processed Food	Beer, dairies, glass packages/wrapping	Metal Manufacturing	Rolling mills, casting, tools, screws
Agricultural Products	Sugar, agricultural services, alcoholic drinks	Oil & Gas Products and Services	Refineries
Distribution Services	Mail order, wholesale trading	Biopharmaceuticals	Pharmaceuticals
Education & Knowledge Creation	Universities, libraries	Plastics	Plastics, colours
Entertainment	Video- and music recording, sport events	Power Generation and Transmission	Generators, isolators
Heavy Machinery	Forest machinery, tractors, locomotives	Production Technology	Bearings, tanks, machine tools
Financial Services	Banks, insurance companies	Publishing & Printing	Publishing services, printing
Fishing & Fishing Products	Fishing, hunting	Sporting, Recreational & Children's Goods	Bicycles, toys
Footwear	Shoes	Textiles	Fabrics
Forest Products	Paper machines, pulp	Tobacco	Cigarettes, snuff
Furniture	Furniture, laminated boards	Transportation & Logistics	Inventories, air transports

patterns, thus eliminating local and natural-resource-driven industries, which together represent about 2/3 of European employment. The remaining industries are grouped according to co-location patterns. Of the resulting 41 categories identified by Porter (2003), we have eliminated three due to differences in industry classification systems. The remaining 38 cluster categories are listed in Table 2.

Variables and data sources

All constructs in this model are estimated as reflective based on our theoretical model, in order to diminish the effect of multicollinearity (Fornell and Bookstein, 1982).

Regional Specialization in our model is a unidimensional construct. We have collected employment from Eurostat and national statistics agencies and aggregated it into a matrix divided in terms of region by NUTS level 2 and in terms of industry by cluster categories. Using the latest available data, the analysis is based upon employment statistics mostly for 2004–2005. However, for some countries, 2006 data were used, and for Poland, 2001 data were used (Table 3).

The region-industry employment statistics are used to produce a specialization measure, referred to as "stars," which in turn is a composite of three agglomeration indicators. For every region-cluster category combination, one star can be awarded for each of these indicators.

The first indicator, referred to as "size," describes the region's share of total European employment in a cluster category. Size is calculated as

$$size_{rc} = E_{rc} \Big/ \sum_i E_{ic}$$

where E_{rc} is the number of employees in region r and cluster category c. If this value is among the top 10% of a particular cluster category, a star is awarded.

The second indicator is referred to as "focus," and it refers to the cluster category's share of the employment in a region. It is calculated similarly to size:

$$focus_{rc} = E_{rc} \Big/ \sum_j E_{rj}$$

If this value is among the top 10% of all cluster categories and all regions, a star is awarded.

The third indicator is called "specialization," and is identical to the location quotient. This indicator measures how over-represented a cluster category is in a region relative both to the total employment of the region and to the total employment of the cluster category.

Table 3. Employment data sources

Country	*Data source*	*Year*
Austria	Eurostat	2004
	Statistics Austria	2004
Belgium	National Office of Social Security	2004
Cyprus	Statistical Service of Cyprus	2005
Czech Republic	Eurostat	2005
Denmark	Statistics Denmark	2005
Estonia	Eurostat	2004
	Eurostat	2004
Finland	Statistic Finland	2004
France	INSEE	2005
Germany	SBA	2006
Greece	National Statistical Service	2006
Hungary	Eurostat	2005
Ireland	Central Statistics Office	2004
	Eurostat	2004
Italy	Eurostat	2005
Latvia	Central Statistical Bureau	2005
Lithuania	Statistics Lithuania	2004
Luxembourg	Eurostat	2005
Malta	Eurostat	2005
Netherlands	Eurostat	2005
Poland	Central Statistical Office	2001
Portugal	Statistics Portugal	2004
Slovakia	Eurostat	2005
Slovenia	Statistical Office	2006
Spain	Eurostat	2005
Sweden	Statistics Sweden	2005
UK, Britain	DETI, Northern Ireland	2005
UK, Northern Ireland	Office for National Statistics	2005

$$specialization_{rc} = \frac{E_{rc} \Big/ \sum_j E_{rj}}{\sum_i E_{ic} \Big/ \sum_i \sum_j E_{ij}}$$

If the specialization value (location quotient) is above 2, a star is awarded. This represents roughly the top 10% of all cluster categories and all regions.

With these three indicators, a region can be awarded 0, 1, 2, or 3 stars for each of the 38 cluster categories. However, to avoid overemphasizing relatively concentrated agglomerations that are small in absolute terms, an extra criterion is applied: none of the three possible stars is awarded if there are less than 1,000 employees in the cluster category in the region.

Finally, we sum up the region's total number of stars for all 38 cluster categories, which gives us the combined measure for *Regional Specialization*.

The *Degree of Urbanization* is a unidimensional construct, calculated as a ratio of the number of households in a region located in areas with at least 500 inhabitants/km^2 to the total number of households. The data has been supplied by Eurostat and represents the situation as of 2006.

The *Business Research and Development* construct illustrates the intensity of firm research activities in the region. The indicator we use is business R&D spending as the percentage of each region's GDP. Most of the data refer to 2003, but Austrian data are for 2002 and UK data are for 1999.

The *Public Research and Development* latent variable is represented by two manifest variables differing in terms of the source of funding: government and higher education R&D spending, respectively. These variables were measured, as was business R&D, as the share of the region's GDP.

Innovation Performance represents the innovative output of the region. Due to data availability, we measure this as the number of patent applications to EPO in 2004 per million labor force, as supplied by Eurostat. Patents are frequently used as an indicator of innovation output, but it has been pointed out that this measure has several potential deficiencies. Not all innovations are patentable; not all patentable innovations are patented; propensity to patent varies by industry; patent data reliability can be questioned; many patents lack economic value; many patents are of a purely defensive nature; and patent requirements vary over time and space (Desrochers, 1998). However, Acs *et al.* compared patents and innovation as model variables and found considerable similarities between the two variables, concluding "that the measure of patented innovations provide a fairly good, although not perfect, representation of innovative activity" (Acs, Anselin, & Varga, 2002:1080).

Finally, the *Economic Performance* construct consists of three variables most often used to reflect the welfare of a region: GDP per capita, gross value added, and wages. The first variable is directly available from Eurostat, while the latter two were computed as a ratio of, respectively, total GVA and employee compensation to the number of persons employed in a region.

Estimation procedure

The most common method of estimating structural equation models in social sciences is LISREL (Jöreskog & Sörbom, 1985). However, this approach suffers from a number of technical shortcomings, including the requirement of relatively large sample sizes (Fornell, 1982) or otherwise biased estimation of SEM parameters (Fornell & Bookstein, 1982). Instead, we estimated the model with the Partial Least Squares (PLS) technique, introduced by Wold (1980; , 1982), which has been shown to avoid those limitations while also relaxing the Gaussian assumption for distributional normality and absence of multicollinearity among manifest and latent variables (Cassel, Hackl, & Westlund, 1999; Hulland, 1999).

The method we used to assess the reliability of the estimates and test the theoretical hypotheses is based on the t-statistics derived from a Bootstrap procedure. We determine the structural model's overall goodness-of-fit and the explanatory power of the model through the R^2 values of the endogenous latent variable (Hulland, 1999).

Results

The PLS estimates of the measurement model together with associated t-statistic values are presented in Table 4. The factor loadings of each individual variable are a very good measure of single item reliability (Carmines & Zeller, 1979). As a rule, the variables with estimated loading above 0.7 should be kept in the model, as in this case, more than half of their variance goes into the construct. All variables are above this level.

Table 4. Measurement Model – Bootstrap estimate

		Loading			*Weight*		
Construct	*Variable*	*Entire Sample Estimate*	*Standard error*	*t-statistic*	*Entire Sample Estimate*	*Standard error*	*t-statistic*
Regional Specialization	Number of Stars	1.000	0.000	0.000	1.000	0.000	0.000
Urbanization	Urban Share	1.000	0.000	0.000	1.000	0.000	0.000
Business R&D	Business R&D	1.000	0.000	0.000	1.000	0.000	0.000
Public R&D	Governmental R&D	0.760**	0.079	9.640	0.545**	0.087	6.260
	Educational R&D	0.846**	0.043	19.856	0.703**	0.083	8.524
Innovation Performance	Patents	1.000	0.000	0.000	1.000	0.000	0.000
Economic Performance	GDP per Capita	0.965**	0.006	170.596	0.351**	0.007	48.250
	GVA per Capita	0.981**	0.004	232.891	0.321**	0.006	58.324
	Wages	0.978**	0.003	320.121	0.354**	0.006	55.514

** Significant at $\alpha = 0.01$

Internal consistency of the measurement model is assessed with the average variance extracted (AVE) indicator, as proposed by Fornell and Larker (1981). This indicator shows the portion of the variance of the latent variable explained by the manifest variables. Values of above 0.5 are considered acceptable, since more variance is explained by variables than by the error. As can be seen from Table 5, the AVE of all the constructs in our model are well above the threshold.

Table 5. Composite reliability and average variance extracted (AVE)

Construct	*Composite reliability*	*AVE*
Regional Specialization	1.000	1.000
Urbanization	1.000	1.000
Business R&D	1.000	1.000
Public R&D	0.785	0.647
Innovation Performance	1.000	1.000
Economic Performance	0.983	0.950

Another key measure is discriminant validity (Fornell & Larcker, 1981), which indicates whether the strength of the relationships within latent variables is greater than the relationships among them. As can be seen in Table 6, all diagonal elements are larger than any value in the respective row or column, which indicates that the constructs have been separated correctly.

Table 6. Discriminant validity

Construct	*Regional Specialization*	*Urbanization*	*Business R&D*	*Public R&D*	*Innovation Performance*	*Economic Performance*
Regional Specialization	1.000					
Urbanization	0.234	1.000				
Business R&D	0.204	0.223	1.000			
Public R&D	0.084	0.315	0.490	0.804		
Innovation Performance	0.368	0.169	0.728	0.356	1.000	
Economic Performance	0.106	0.380	0.503	0.331	0.621	0.975

Table 7 presents the Bootstrap estimates of the standardized regression coefficients of the model and the reliability of each estimate. Figure 4 shows the whole structural model with estimated coefficients and R^2 for all equations.

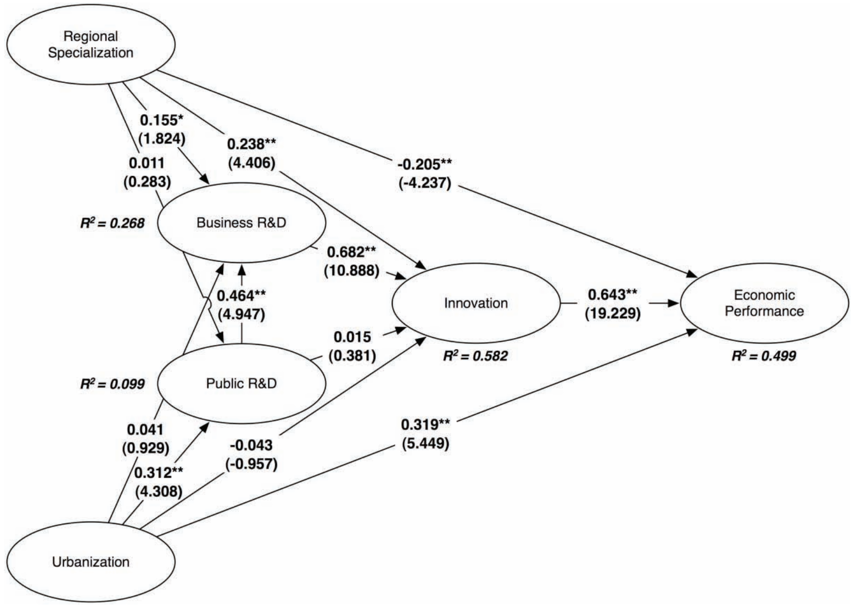
Urbanization is found to have a strong effect on *Economic Performance*, confirming Hypothesis 1b. The inclusion of *Innovation* is also confirmed, as the very strong connection between *Innovation* and *Economic Performance* confirms Hypothesis 2. With R^2 values for both

Table 7. Structural Model – Bootstrap estimate

Path	*Entire Sample Estimate*	*Standard error*	*t-statistic*
Reg Spec→Bus R&D	0.155*	0.0850	1.8236
Reg Spec→Pub R&D	0.011	0.0389	0.2831
Urban→Bus R&D	0.041	0.0441	0.9291
Urban→Pub R&D	0.312**	0.0724	4.3083
Reg Spec→Inno Perf	0.238**	0.0540	4.4058
Urban→Inno Perf	-0.043	0.0449	-0.9569
Pub R&D→Bus R&D	0.464**	0.0938	4.9466
Pub R&D→Inno Perf	0.015	0.0394	0.3805
Bus R&D→Inno Perf	0.682**	0.0626	10.888
Inno Perf →Econ Perf	0.643**	0.0334	19.2288
Reg Spec→Econ Perf	-0.205**	0.0484	-4.2367
Urban→Econ Perf	0.319**	0.0585	5.4491

* Significant at α = 0.05
** Significant at α = 0.01

Figure 4. Estimated model



* Significant at α = 0.05
** Significant at α = 0.01

Innovation and *Economic Performance* close to or above 0.5, the model explains half the variance in them using the indicators we have selected.

However, Hypothesis 1a is not confirmed. *Regional Specialization* is found to have negative direct effect on *Economic Performance*. One possible explanation is that there is a positive influence of specialization, but that it goes indirectly through R&D and innovation. To test this, we estimated another model with only the constructs *Regional Specialization* and *Economic Performance* to isolate the total effect of specialization. That model supported the explanation, as the relationship was then revealed to have a positive value of 0.127, significant on the 1% level.

Hypothesis 3a is confirmed, with *Regional Specialization* having a significant direct effect on *Innovation*. *Urbanization*, on the other hand, does not, leaving Hypothesis 3b without support.

Hypotheses 4a and 4c are both confirmed. We find significant relationships from *Public R&D* to *Business R&D* and from *Business R&D* to *Innovation*. However, we find no support for Hypothesis 4b, as there is no significant direct relationship between *Public R&D* and *Innovation*. The R^2 for *Business R&D* is satisfactory at 0.268, but R^2 for *Public R&D* is very low, suggesting that *Regional Specialization* and *Urbanization* together account only for a small fraction of the variation in *Public R&D*.

Finally, the remaining hypotheses display an interesting symmetry. *Regional Specialization* is found to be significantly related to *Business R&D* but not to *Public R&D*, while the opposite is true for *Urbanization*. Hypotheses 5a and 5d are thus supported, but 5b and 5c are not.

Conclusions

Europe has expressed its ambition to become the most competitive knowledge-driven region in the world. There are few signs that the gap between the U.S. and Europe is closing, in regards to both innovation and economic prosperity. Within Europe, some regions continue to perform better than others, and this study offers a model to test differences in economic prosperity across regions of Europe.

In this study, we have advanced the notion that MAR and Jacobian economies are not mutually exclusive, but instead play complementary roles in explaining regional economic performance. Previous research on these effects has produced inconsistent and somewhat contradictory results. We believe that one reason for this is that there is a complex set of relationships linking specialization and urbanization on one hand and economic performance on the other, with innovation playing a central intermediary role. Previously, these relationships have been studied independently or in parallel using traditional regression models. In this paper, we evaluate several layers of relationships in a single model, allowing us to examine how the effects interact with each other.

A first main conclusion is that regional specialization, associated with MAR externalities, plays a critical role. This role, however, is not tied directly to prosperity, but instead is channeled through the innovative activities taking place within the region. That many studies have failed to find evidence that specialization leads to economic prosperity or growth (Glaeser, Kallal, Scheinkman, & Shleifer, 1992) may be explained by the fact that the intervening variable of innovation was not included in previous models.

The crucial role of innovation is an interesting result, as it suggests that, contrary to Krugman's (1991) view, innovation may be the *most* important effect to study, not the *least*. Krugman pointed out that industrial agglomeration occurs not only in "high-tech" industries, but also in industries such as financial services and carpets. However, our study is based on *all* agglomerated industries and suggests that innovation, far from being a minor and isolated effect, is a key link between a region's characteristics and its economic performance.

A second main conclusion is that urbanization, connected to Jacobian externalities, is positively associated with economic performance as expected; however, unlike Marshallian externalities, urbanization has no direct effect on innovative output. In Europe, it seems as if urbanization has an effect on innovation that is mostly indirect, channeled through the ability of university R&D to promote business R&D.

A third conclusion is that more public R&D is not directly associated with more innovative output. This is in line with the results of Malerba (1993), which showed that the national R&D system is less linked to innovative activity. Similar to previous studies (Anselin, Varga, & Acs, 1997; Jaffe, 1989), we find that business R&D is more important than public R&D for patenting, but further, we find that the effect of public R&D on innovation in Europe is even more indirect than was found to be the case in the US. For Europe, it appears that the entire positive effect of public R&D is found in its ability to promote business R&D. This may reflect the lower propensity of European universities to patent their results.

The main policy implications from our study are twofold. First, the EU agenda to increase R&D spending through large public programs will not necessarily lead to more innovation or increased economic prosperity. This finding is particularly salient, as political agendas within the EU often build on a logic that assumes more public R&D will necessarily lead to more innovative output. Based on our results, it appears that in order to be effective, future policy measures must also include incentives for increased business R&D to achieve desired innovative outcomes.

Second, Europe must face the fact that the US economy as a unified entity – with one language, one basic set of rules and regulations, one currency, etc. – has been growing for over 200 years, whereas Europe really only started to integrate into a single market during the last 50 years. On the other hand, an array of fragmenting and compartmentalizing barriers still prevail throughout the European economy. One clear example of this can be seen in the case of IPR regulation. The US patent system was devised in the late 18th century, whereas a unified European patent system is yet to be established. In order to foster larger and more innovative clusters within Europe, the internal market agenda must be advanced, with special emphasis afforded to the service sectors, in which fragmenting forces are the most detrimental. Within a more open single market, citizens, investors, corporations, etc., can migrate and capital and corporate resources can be reshuffled to find the most attractive regions, reinforcing patterns of geographical concentration across the European space. Increased homogenization will eventually lead to more specialized regions; however, as our results have shown, each region must also focus attention on the innovative environment, where increased economic prosperity will only come as a result of increased innovative input and output. Regional specialization within a few clusters is not in itself a sufficient condition for economic prosperity.

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Study 6

Cluster organisations: activities and performance

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Study 6

Cluster organisations: activities and performance

ABSTRACT This paper examines cluster policy from the perspective of cluster organisations. Cluster organisations are dedicated to enhancing the growth and competitiveness of selected clusters, and do so by engaging in a wide range of activities. Using survey data from a large number of cluster organisations in many different countries, these activities are shown to fall into seven distinct groups. The effect of each upon self-reported performance is assessed and found to vary between activity groups. In addition, the performance effect of cluster organisations initiated by government or undertaken in collaboration with other cluster organisations is tested, but no evidence is found to support the assumption that these factors have an effect in general.

Introduction

Since the 1990s, the cluster concept has been a prominent basis for economic policy in both advanced and transitional economies, and to a lesser degree in developing economies. A wide range of policy actions are deployed with the objective of stimulating innovation and economic growth. (European Commission, 2002, 2003; OECD, 1999, 2001, 2007; Raines, 2002)

One frequent component of cluster policy consists of targeted activities aimed at particular industry sectors in particular regions in the form of public-private partnerships. Such actions, which we can label *cluster initiatives*, are sometimes conducted by government agencies at the local or regional level, but they can also be directed from the national level. Cluster initiatives can also be initiated by non-government parties, such as individual firms, industry association, universities, or, as is often the case in developing economies, donor organisations. However, regardless of who the initiator is, cluster initiatives typically lead to the establishment of a *cluster organisation*, which is an organisation dedicated specifically to improving the growth and competitiveness of a cluster. Since the 1990s, thousands of these organisations have been initiated across the globe. (Ketels, Lindqvist, & Sölvell, 2006; Sölvell, Lindqvist, & Ketels, 2003).

There is a substantial and dynamic body of literature addressing cluster policies, their benefits and shortcomings, and their rationales and effects. Critics argue that in the absence of distinct definitions and proven impact, policymakers should avoid an over-reliance on the cluster concept (e.g., R. Martin & Sunley, 2003). Proponents argue that the multifaceted character of clusters make clear-cut quantification of cluster impacts difficult to attain, and that a lack of specific empirical evidence should not eliminate the application of this key concept in policy and business practice (e.g., Jacobs & de Man, 1996).

The lively literature on cluster policies has produced a number of practitioner-oriented handbooks for cluster initiatives (e.g., DTI, 2003; Ffowcs-Williams, 2001; Rosenfeld, 2002; USAID, 2003; World Bank Group, 2005). These manuals are based on the practical experience of the authors (many of whom have taken part in large numbers of cluster initiatives) or are based upon the conclusions drawn from a series of case studies. Similarly, academic writings on cluster initiatives have been based on case studies (e.g., Hallencreutz & Lundequist, 2003; Waits, 2000), theoretical considerations (e.g., Newlands, 2003; Porter, 2000), or a combination of the two (e.g., Fromhold-Eisebith & Eisebith, 2005).

Considering the varying theoretical approaches that are associated with clusters and the diversity of regional and political conditions where cluster initiatives have been put into place, it is not surprising that the literature has produced rather disparate views of what cluster organisations actually do and which factors are important for their performance. Rather than moving towards a converging consensus on the subject, the literature has offered up a lengthy and ever-evolving list of factors that could be crucial for the success of cluster initiatives. However, this outcome is in no way an indication of poor research quality. To the contrary, it demonstrates the breadth of perspectives that have been applied, and the richness of the sample from which case studies have been drawn. Case studies have proven to be well-suited to this kind of exploratory research, allowing researchers to produce hypotheses and form the bases for exploratory examinations of the cluster initiative phenomenon.

What is absent from the literature, however, is a substantial body of quantitative studies based on data from large numbers of cluster initiatives. This approach could help address what is a fundamental problem in cluster policy research, namely, determining how best to distinguish broadly applicable effects from those that are influential in the individual case. This has proven to be problematic because there has been a marked tendency among policymakers towards comparing and benchmarking regional cluster initiatives in a way that may not take regional contingencies into account (Hospers & Beugelsdijk, 2002). Porter shares this concern, and calls for "an integrated approach that frames clusters generally rather than homing in on special cases." (Porter, 2000, p. 32)

The aim of this paper is to contribute to the cluster policy literature by applying quantitative methods on a large-scale survey material for cluster organisations. This paper addresses three main questions. First, it provides a typology of activities in which cluster organisations engage. Second, it attempts to make a tentative connection between activities and the overall performance of the cluster organisations. The word "tentative" is an important caveat, because this assessment is based on self-reported performance perception rather than objective performance measures. Third, a number of the basic assumptions about the key drivers behind cluster organisation performance are tested.

The purpose of this paper is not to identify or confirm contingencies that can influence the outcome of a cluster initiative. Although this objective, too, could be achieved by using large-scale quantitative methods, the aim of this paper is rather to identify the more general effects that cut across a large sample drawn from a wide range of industries and regions. While contingencies are certainly important, this paper will focus on general effects.

The remainder of this paper is organised as follows. First, a brief literature overview of cluster policy research and some previous findings about the activities and performance of cluster organisations will be presented. Next, the data collection, which consists of an international survey with replies from 377 cluster organisations located in advanced economies, is described. The following section describes how activities and performance measures are grouped, as well as presenting the results of a regression model for cluster organisation performance. A discussion of the results and their implications for policy and practice concludes the paper.

Cluster organisations: activities and performance

Cluster organisations have not been extensively studied. They have occasionally been described in cluster characterisation exercises, where the existence of a cluster organisation can be considered to be a property of a cluster (Enright, 2000). The vast majority of cluster policy research does not directly address cluster organisations at all, but instead deals with cluster policy on a more general level (Boekholt & Thuriaux, 1999; Jacobs & de Man, 1996; Raines, 2001; Swann, 2006). For example, Jacobs & de Man (1996) propose two main areas of policy activities, which in practice often overlap: i) policies aimed at intensifying the use of knowledge in existing clusters, and ii) policies aimed at creating new networks of constructive cooperation in clusters. The first area includes measures like vocational training and centres of excellence. The latter includes efforts by (semi-)public brokers who work to enhance networking, which would fall close to our definition of cluster organisations. However, most authors have not specified further what activities such organisations might carry out.

Some past policy studies have highlighted an activity which has important implications for cluster organisations, namely, how best to select the industry sectors to target with cluster policies (Learmonth, Munro, & Swales, 2003; Peters & Hood, 2000). Many cluster organisations have been formed after just such a selection process. In general, however, cluster organisations are not usually treated as research targets in and of themselves, but figure rather only as a secondary aspect of cluster policies.

In this paper, I derive the definition of cluster organisations from a definition of cluster initiatives:[1]

[1] This corresponds to the term *cluster promotion* proposed by Fromhold-Esiebith and Eisebith (2005, p. 1252): ”any set of measures, in whatever constellation and style of implementation, that supports the development of a regional industrial aggomeration towards ideal features of a cluster in terms of a specialized, competitive, collaborative and collectively innovative set of sector related industries, research/education and other organizations”.

> Cluster initiatives are organised efforts to increase the growth and competitiveness of clusters within a region, involving cluster firms, government and/or the research community. (Sölvell, Lindqvist, & Ketels, 2003, p. 15)

A *cluster organisation,* then, is the organisational entity of such an initiative. It may have been set up specifically to carry out the cluster initiative, or, more rarely, it may be an existing organisation that has been converted to this purpose. In either case, the definition implies that a cluster organisation is a partnership between private firms and a public institution or research organisation, such as a university. In practice, private-university partnerships without government involvement are very rare, so cluster organisations are in virtually every case public-private partnerships.

It is important to note that the terms 'cluster initiative' and 'cluster organisation' do not overlap completely. The activities of a cluster organisation can be a subset of the activities conducted within a cluster initiative. In other words, a cluster initiative can be conceptualised as a *framework* within which some actions are carried out by a dedicated cluster organisation, while other actions may be carried out independently by existing policy bodies. This paper is limited to the study of the activities and impacts of cluster organisations.

Cluster organisation activities

What do cluster organisations do? As mentioned earlier, previous research has not focused extensively on cluster organisations, but there are some more general studies of cluster initiatives that provide a good starting point for exploring this question. Case-based studies have shown that cluster initiatives include a wide range of activities that could also apply to cluster organisations. Several different methods of categorising these activities have been proposed in the literature, a few of the more notable of which will be outlined here.

Boekholt and Thuriaux (1999) derive appropriate cluster policy actions from the types of policy rationales that motivate intervention. The narrower market imperfection rationale for science and technology policy has with the application of the cluster concept been extended to a broader rationale that "fully incorporates the interactive element of innovation as well as the market-oriented approach" (ibid., p. 385). Six such rationales and corresponding actions are identified: i) identification and public marketing of clusters; ii) identifying and removing regulatory bottlenecks; iii) encouraging inter-firm networking and collaborative tenders; iv) retrieving and spreading strategic knowledge; v) promoting collaborative R&D actions and R&D facilities; and vi) attracting inward investment and supporting start-ups.

Porter (2000) stresses the importance of letting market forces rather than government determine which clusters will succeed or fail. However, government can play a role in cluster upgrading, which entails i) removing obstacles, ii) relaxing constraints, and iii) eliminating inefficiencies. He specifically mentions human resources, infrastructure, and regulatory constraints as possible targets for government intervention.

Raines (2002) summarises the results of seven regional case studies in Europe, suggesting that cluster policy intervention can be classified into three types: i) measures focused on specific linkages and projects, which involve different types of networking between cluster agents; ii) measures improving common resources, such as public goods, special information, and infrastructure; and iii) measures to promote community building and to encourage cluster agents to act as a cluster and promote their shared identity.

A report from OECD (2007) summarises an evaluation of national cluster policies in 14 countries. Again, the focus here is placed on national cluster policy, rather than the individual cluster organisations. The “instruments” they identify are categorised into three distinct types with different goals: i) engaging actors, which includes cluster identification (cluster mapping studies), and network support (conferences, support for networking organisations, performance benchmarking); ii) collective services and business linkages, with the sub-goals of supplier improvement, FDI and export promotion, and labour force development; and iii) collaborative R&D and commercialisation, which can be divided into promotion of firm-academia links, commercialisation of research, and spin-off financing. These are all activities that cluster organisations have been found frequently to engage in.

This overview of the literature reveals that cluster initiative activities have been seen as diverse components of cluster policies, rather than as integrated activities conducted by cluster organisations. Cluster organisations, although numerous in practice, have generally not been studied as a phenomenon in their own right. Activities are typically categorised into few groups formulated at a high level of abstraction. The notable exception is Boekholt & Thuriaux (1999), who propose as many as six action categories and offer concrete examples for each one.

Cluster organization performance

We now turn to the task of identifying the kind of activities that are suggested to impact and improve the performance of cluster organizations.

Promoting changes in government regulations and policy is highlighted by Porter (2000) as a characteristic activity of successful cluster initiatives. Left unchecked, some types of government regulation might increase inefficiencies by inflicting costs without bestowing any compensating social value.

Brand building has been presented a prerequisite for strengthening the competitiveness of a cluster (Lundequist & Power, 2002). Brand building has three primary functions. First, it serves as an attractor for inflows of investments, capital, skilled labour, and new entrants. Second, a cluster brand helps to unite actors around a shared purpose and identity. Third, brand building activities support marketing efforts for the products of the cluster, both for individual firms and in joint marketing efforts.

Upgrading the cluster through *training and education* programmes has been proposed as another key determinant for successful cluster initiatives. Rosenfeld (1997) stresses the importance of technical training, while Lundequist and Power (2002) point out that marketing and management are also important areas in which the cluster can benefit from enhanced levels of competence.

In addition to these activities, it has also been suggested that cluster organizations benefit from *cooperating with other cluster organisations*. Collaboration and knowledge exchange with similar clusters in the same region or in other regions offer an important source of added value for the firms involved (Lundequist & Power, 2002) and encourage the cross-fertilisation of new ideas across clusters (Rosenfeld, 1997).

Another aspect of cluster organisation performance concerns the role of government in cluster initiatives. While there is universal agreement that cluster initiatives should engage both public and private actors, views diverge significantly as to which way the balance between public and private influence should fall. Porter (2000) points out that government has an important role to play, but contends that business-led cluster initiatives have a better chance of success, since businesses generally are in a better position to identify and respond to market obstacles and opportunities. As such, Porter suggests that the cluster organisation should ideally be independent from government control. Fromhold-Eisebith and Eisebith (2005) stake out a middle-ground position on the issue, concluding that government-driven initiatives are neither inherently superior to nor inherently worse than privately initiated ones.[2] However, they suggest that government-initiated cluster initiatives may be more successful in terms of improving infrastructure and labour qualifications, as well as attracting and fostering new firms. Conversely, privately initiated cluster initiatives are suggested to be more successful in enhancing innovativeness and firm performance. Lundequist and Power (2002) tend to lean more towards favouring government involvement than does Porter. In a country such as Sweden, for example, they suggest that a positive public cluster vision can play a crucial role, and the Porterian preference for business-led initiatives may be unfounded.

The proposed categorisations of activities and performance drivers summarised above represent a series of testable hypotheses. We now turn to just such a test, using survey data drawn from a large sample of cluster organisations.

Method

About 1400 cluster organizations were identified worldwide, using internet searches, cluster-related reports, information requests from donors and contractors, and practitioners networks (such as The Competitiveness Institute) as sources for respondent identification. Self-identified respondents were also able to register for participation on the survey's website.

In the process of identifying potential respondents, the formal name of the organization was not considered to be a factor. Specifically, it was deemed to be unimportant whether the organization referred to itself using a term that included the word "cluster", such as "cluster initiative" or "cluster organisation". Depending on local conditions, cluster organisations can operate under widely varying

[2] Fromhold-Eisebith and Eisebith (2005) use the term ”top-down” for government-initiated cluster initiatives and ”bottom-up” for those initiated by the private sector.

names, and the reliance upon the cluster concept may not be explicit (Fromhold-Eisebith & Eisebith, 2005). Instead, the primary identification criterion applied was the one provided by the definition of cluster initiatives: organisations engaging in efforts to increase the growth and competitiveness of clusters within a region, involving cluster firms, government and/or the research community.

Data were then collected using an online questionnaire written in English and Spanish, the link to which was sent in an e-mail addressed to the cluster facilitator responsible for each cluster organization, most of whom had been contacted in advance with information about the upcoming survey. The questionnaire included 23 pages and 71 questions, of which several had sub-questions. 713 respondents started filling in the questionnaire, 551 of which were located in advanced economies according to IMF's definition (IMF, 2008). 450 respondents reached the last page of the survey (349 in advanced economies), taking on average of 51 minutes to do so. The survey was open from February to March 2005.

The main respondent countries were Germany (75), Sweden (60), United States (55), New Zealand (43), United Kingdom (42), and Canada (37); taken together, these countries represented 56% of the responses. 22 other advanced economies represented the remaining 44% of responses. The industry sectors most frequently represented were biotechnology and pharmaceuticals (41), information and communication technology (41), and automotive (16), which together accounted for 18% of respondents.

On a seven-step scale ranging from "not done" to "main activity", respondents were asked to indicate which of 25 listed activities they had engaged in during the most recent 12-month period. The activities are listed in Table 1. In the questionnaire, the activities were listed in a random order, which differed for each respondent.

Table 1. Activity questions included in the questionnaire

Activity	*Mean*	*SD*
Efforts to make companies (and others) aware of each other	5.49	1.631
Promote joint R&D projects	4.42	2.145
Analysis of underlying cluster	4.20	1.962
Collect market intelligence	4.20	1.912
Conduct joint branding of region	4.18	2.095
Analyze and inform about technical trends	4.12	1.966
Attract people and talent	3.93	1.975
Improve education system	3.87	1.992
Facilitate joint promotion in foreign markets	3.74	2.162
Lobby government for infrastructure investments	3.68	1.994
Promote subsidies to cluster	3.50	2.071
Promote supply-chain development within cluster	3.46	1.969
Provide technical training	3.38	2.027
Conduct joint branding of products/services	3.33	1.966
Promote joint or bundled production of products or services	3.26	2.048
Promote production process improvement	3.18	2.051
Promote changes in government regulations and policy	3.17	1.911
Promote spin-off formation	3.15	1.982
Provide incubator services	3.01	2.117
Provide management training	2.98	1.894
Promote business services (accounting, legal, etc.)	2.60	1.732
Promote joint purchasing	2.39	1.758
Improve FDI (foreign direct investment) incentives	2.21	1.665
Promote joint logistics (transport, warehousing)	2.19	1.649
Establish technical standards for industry	2.19	1.602

N = 377. Sorted by descending mean. Order in questionnaire was randomised.

Measuring the performance of a cluster organization can be a particularly difficult task. The challenge of distinguishing causality presents one significant problem.

> When looking at the actual development of promoted clusters, no matter which institutional model forms the base, it is extremely difficult to tell whether certain achievements can be attributed to the promotion strategy or to numerous other factors that affect corporate and regional economic dynamics, including influential external ones. (Fromhold-Eisebith & Eisebith, 2005, p. 1263)

An equally problematic issue is determining how best to collect reliable, objective performance data for the cluster organization. Many cluster organisations collect performance data on an annual, semi-annual, or quarterly basis, but the type of data collected can vary considerably. According to the survey, the most frequently collected type of data is the number of companies in the cluster (70% of respondents in advanced economies evaluated this measure at least yearly), employment data (54%), innovation data (46%) and government funding/subsidies data (46%). The least frequently collected figures include production cost data (15%) and import data (13%). For firms belonging to a group of cluster organizations in the same programme using the same data collection method, this kind of data can be used for evaluating performance (see P. Martin, Mayer, & Mayneris, 2008 for a study of French cluster organisations). However, because of the significant disparities seen in performance data collection procedures, using secondary data from the cluster organizations across different programmes would present large data gaps and severe comparability problems.

An alternative is to collect primary data at the firm level. This method has been used by Fromhold-Eisebith and Eisebith (2005) and by Ohler et al. (2001). However, these studies covered only two and six cluster organisations, respectively. Undertaking this type of data collection for hundreds of cluster organizations would be a task well outside the scope of the present study.

Instead, the method applied in this study has been to request that respondents (most of whom are managers responsible for overseeing organisational operations) assess their own organisation's performance. Because the study relies on self-reported performance, there is a risk of introducing common methods bias (CMB), i.e., the risk that correlations between measures are inflated by the fact that they are collected using the same method. This is considered a particularly resonant concern when self-reporting is used as a primary data collection method. Although CMB remains a concern in this study, it is also important to note that past analyses have concluded that common methods bias is not often a significant problem. Meade et al. (2007) find that although common methods variance (inflated error variance due to common methods) is frequent, the effect on correlations is often minor in magnitude. Methods that have been suggested to mitigate the problem include the use of negatively worded items, randomized item order, and multiple methods and raters, all of which have been applied in this study.

Since cluster organizations are usually not intended to produce short-term results, it was considered impractical to assess any performance for recently initiated organizations. Questions relating to performance were therefore only presented to respondent organisations that were initiated in or before 2002 (i.e., organisations that at the time of the survey had been in operation for more than two years).

Two sets of questions were used to assess performance. The first set refers to the impact on the cluster and was rated on a seven-step scale from "has had a strong negative impact" (coded as −3) via "has had no noticeable impact" (0) to "has had a strong positive impact" (+3). The other set refers to the performance of the organization itself, as measured through factors such as meeting deadlines or living up to expectations. These items were rated on a seven-step Likert scale from "disagree completely" (1) to "agree completely" (7). The questions are summarized in Table 2.

Results

A long list of activities that cluster organisations perform in practice and their relative importance is provided above in Table 1. However, one chief purpose of this study has been to identify groups of activities and develop a typology based on actual patterns seen among organisations. To do this, a principal component factor analysis was applied to the 25 activities to determine which activities tend to be performed together. For this number of variables, the latent root criterion with an eigenvalue cut-off value of 1 is recommended (Hair, Anderson, Tatham, & Black, 1998, p. 103).

In order to create factors that are as distinct as possible, an orthogonal VARIMAX rotation can be used. This is recommended for prediction testing, which is one of the purposes of this analysis. However, since factors can arguably be correlated, an oblique Direct OBLIMIN rotation could also be motivated, as this might more accurately reflect the categorisation of activities. I have therefore chosen to base the analysis on the orthogonal rotation (presented in Table 3), but have also verified the results with the oblique rotations. The oblique rotation produced the same factors with the same main

Table 2. Impact and organizational performance questions included in the questionnaire

Performance measure	*Mean*	*SD*
Impact (N = 236, range −3 to 3)		
Has the CI contributed to…		
increasing innovativeness	1.57	1.015
improving the business environment	1.49	.920
acquiring funds from government or international organizations	1.35	1.254
commercializing academic research	1.07	1.079
increasing employment in cluster	.93	1.043
attracting firms and investment	.89	.939
developing supply chains	.82	.925
increasing the value-added of the production	.81	.986
Increasing exports	.56	1.007
reducing production costs	.42	.894
reducing competition between companies in cluster	.40	1.077
promoting import-substitution	.04	.811
Organisational performance (N = 239, range 1 to 7)		
The CI is well known to its participants and potential participants.	5.40	1.305
The CI has been able to meet its goals.	5.17	1.359
The CI has lived up to expectations.	5.04	1.488
The CI has *not* met deadlines.	2.78	1.639
The CI has been mostly talk and has *not* generated much action.	2.25	1.541
The CI has been disappointing, and has *not* led to any changes.	1.83	1.199

variables as the orthogonal rotation, thus confirming its validity. With a sample size of 377, load factors as low as 0.3 can be considered statistically significant (Hair et al., p.112), and thus are also included in the table.

As an initial factor analysis indicated that two activities (analysis of the underlying cluster and establishing technical standards) had low extraction commonalities (< 0.4), they were subsequently dropped from the analysis.

Of the 23 remaining activities, three have commonalities above 0.7, another 13 above 0.6, and all of the remaining above 0.5. All variables have a measure of sampling adequacy (MSA) above 0.8, with the exception of one at 0.79. These seven factors capture 63% of total variance. The Kaiser-Meyer-Olkin (KMO) MSA for the analysis is 0.875, which is interpreted as “meritorious” (Hair et al., p. 99).

The factor analysis (Table 3) resulted in a list of seven factors, which appear to form distinct groups. *Joint production* includes supply chain, purchasing, logistics, bundled production, and production process improvement. It also includes, less distinctly, subsidy promotion. *Human resource upgrading* covers technical and management training, education improvement, and efforts to recruit and retain skilled workers. *Branding* includes both branding activities and brand awareness activities. It also includes foreign sales activities, albeit to a lesser degree, but this activity is also fairly strongly associated with the Joint production and Intelligence categories. The *Firm formation* group includes incubator and spin-off activities, supported by the business service provision. *Business environment* activities include infrastructure, regulation and, somewhat more ambiguously, FDI incentives. *Intelligence* includes market and technical intelligence collection, while *Joint R&D* constitutes a group of its own. For each of these groups, a factor score was calculated using the Anderson-Rubin method, which produces orthogonal (uncorrelated) factor estimates with a mean of 0 and a standard deviation of 1.

The seven activity groups have also been tested against sample splits along five dimensions (Table 4). First, cluster organisations *initiated by government* (national, regional, or local) are compared to those with non-government initiators. There is a significant difference in terms of Joint Production activities, where government-initiated organisations score higher than did their non-government counterparts, but lower for rates of firm formation. In terms of *age*, those founded in 2003 or later scored lower on Intelligence, HR upgrading, and Firm formation activities than those launched before 1999. Those organisations that *cooperated with other cluster organisations* (in either the same or another region) engaged to a lesser degree in Branding, Joint R&D, HR upgrading, and Firm formation than the few who did not. Organisations with a *dedicated office* conducted more Joint R&D, Intelligence, and Firm formation activities than those without. Finally, organisations with more than 50 *participating companies* were more likely to engage in Joint production, Intelligence, and Firm formation than those with 20 or fewer.

Table 3. Activity factor analysis: rotated components

	Component						
	1	*2*	*3*	*4*	*5*	*6*	*7*
	Joint production	*HR upgrading*	*Branding*	*Firm formation*	*Business environment*	*Intelligence*	*Joint R&D*
Promote joint purchasing	.754						
Promote joint logistics	.705						
Promote joint or bundled production of products or services	.654		.326				
Promote supply–chain development within cluster	.622						
Promote production process improvement	.490	.394					
Promote subsidies to cluster	.470			.367			
Provide technical training		.792					
Improve education system		.655			.315		
Provide management training	.310	.573		.387			
Attract people and talent		.515	.453				
Conduct joint branding of region			.772				
Conduct joint branding of products/services			.621				
Efforts to make companies (and others) aware of each other			.541				.365
Facilitate joint promotion in foreign markets	.326		.530			.462	
Provide incubator services				.826			
Promote spin-off formation				.686			
Promote business services				.533		.317	−.331
Lobby government for infrastructure investments					.763		
Promote changes in government regulations and policy					.759		
Improve FDI incentives			.359		.426		
Collect market intelligence						.750	
Analyze and inform about technical trends		.371				.617	.402
Promote joint R&D projects							.729

Principal component analysis. Orthogonal VARIMAX rotation with Kaiser normalisation.

Table 4. Five sample splits: difference of means

	Initiator			*Launch year*			*Cooperation with other cluster organisations*			*Dedicated office*			*No. of participating companies*		
	gov.	*non-gov.*		*-1999*	*2003-2005*		*yes*	*no*		*yes*	*no*		*1-20*	*51-*	
n	*185*	*190*	*t*	*117*	*115*	*t*	*351*	*26*	*t*	*282*	*95*	*t*	*105*	*167*	*t*
Joint production	.108	−.111	−2.13*	−.001	−.070	−.54	−.09	.01	.43	.01	−.02	−.23	−.28	.29	−4.86***
Branding	.035	−.024	−.57	.040	−.060	−.76	−.68	.05	3.48**	.04	−.12	−1.32	−.21	.09	−2.50*
Joint R&D	−.025	.027	.50	.053	−.109	−1.26	−.52	.04	3.48**	.08	−.22	−2.80**	−.08	.09	−1.39
Intelligence	.060	−.055	−1.11	.195	−.108	−2.26*	.09	−.01	−.49	.07	−.22	−2.55*	−.18	.19	−3.04**
HR upgrading	−.059	.066	1.21	.208	−.180	−2.95**	−.40	.03	1.93†	.03	−.10	−1.12	.01	.03	−.13
Business environment	−.040	.039	.76	.022	−.117	−1.06	−.07	.01	.33	.00	−.01	−.13	−.11	.03	−1.14
Firm formation	.097	−.097	−1.88†	.077	−.163	−1.83†	−.51	.04	3.22**	.07	−.20	−2.23*	−.17	.20	−3.02**

T-test for equality of means, equal variances not assumed.
† $p < 0.1$, * $p < 0.5$, ** $p < 0.01$, *** $p < 0.001$

For performance, two factor analyses have been undertaken. First, a number of impact variables were assessed using the same method as was employed for activities. The resulting list included three factors (Table 5), respectively labelled *Innovation and investment*, *Production*, and *Trade*. The MSA values for all variables rate above 0.7, except Import substitution at 0.68 and Commercialising academic research at 0.63. All extraction communalities are above 0.5, except Increasing employment at 0.48, which was nevertheless retained. 61% of total variance is explained, and the KMO value is 0.78 ("middling"). Factor scores were again estimated using the Anderson-Rubin method. Second, organisational performance was estimated, resulting in a factor analysis that produced a single factor only. Commonalities for four of the variables were found to be above 0.5, with findings of only 0.26 for Deadlines and 0.40 for Awareness. MSA for all variables rates above 0.8. The KMO value is 0.84 ("meritorious") and extracted variance is 53%.

Table 5. Impact factor analysis: rotated components

	Component		
	1	*2*	*3*
	Innovation and investment	*Production*	*Trade*
Commercialising academic research	.806		
Attracting firms and investment	.710		
Increasing innovativeness	.699	.305	
Increasing employment in cluster	.565		
Reducing production costs		.837	
Developing supply chains		.636	
Increasing value-added of production		.622	.405
Improving business environment	.501	.567	
Promoting import-substitution			.869
Increasing exports		.304	.776

Principal component analysis. Orthogonal VARIMAX rotation with Kaiser normalisation.

Table 6. Organisational performance factor analysis: components

	Component
	Organisational performance
Met goals	.827
Lived up to expectations	.812
Mostly talk, no action	−.771
Disappointment, not led to changes	−.743
Awareness of CI	.636
Not met deadlines	−.507

Next, the impact of activities on performance has been estimated using a linear regression model. Apart from the seven activity group scores, five control variables are added. A dummy for *government initiation* is given the value 1 for organisations where government (national, regional or local) was reported to have been most influential in initiating it, and 0 otherwise. Similarly, a dummy for *cooperation with other cluster organisations* (in the same or another region) is given the value 1 if such cooperation was reported to have occurred, and 0 otherwise. The *age* (years since initiation) was reported with an accuracy of half-years, which has been logged. The size of the organisation (in terms of number of participating firms) was reported as firm counts, and is also logged. One regression was performed for each performance measure: the three impact scores and the organisational performance score. The regression models have the following form:

$$PERF_i = \mathrm{a_i} + \sum_{j=1}^{7} b_{ij}\, ACT_j + b_{\mathrm{i}8} GOV + b_{\mathrm{i}9} COOP + b_{\mathrm{i}10} OFF + b_{\mathrm{i}11} AGE + b_{\mathrm{i}12} SIZE + e_i$$

where $PERF_i$ are the four performance scores and ACT_j are the seven activity scores. The regression results are given in Table 7. Three of the models show moderate but significant fits, while the Trade performance model is shown to be clearly insignificant.

Table 7. Linear regression models for cluster organisation performance

	Model 1 *Production performance*	*Model 2* *Trade performance*	*Model 3* *Innovation and investment performance*	*Model 4* *Organisational performance*
Independent variables				
Joint production	.542***	.149*	−.055	.086
Branding	−.037	−.013	.202***	.199**
Joint R&D	−.060	−.036	.366***	.206**
Intelligence	.162**	.118	−.015	.099
HR upgrading	.134*	−.033	.150**	.173**
Business environment	−.070	.013	.164**	−.005
Firm formation	−.084	−.105	.286***	−.016
Government initiated	−.011	−.077	.068	−.028
Cooperation	.067	.038	.043	.027
Office	.029	−.107	.138*	.152*
Age (log)	−.031	−.007	.139*	.067
Size (log)	.070	.045	.052	.108
Model fit				
R^2	.373	.054	.400	.198
F-value	9.675***	.933	10.818***	4.062***
N	207	207	207	210

† $p < 0.1$, * $p < 0.5$, ** $p < 0.01$, *** $p < 0.001$
Coefficients are standardised β values. Constant not reported in table.

Discussion

In the cluster policy literature, activity groups are presented as distinct categories with little or no comment on the degree or significance of variation within those groups. However, the present study shows that the 25 individual activities included in the survey vary considerably in frequency (Table 1). Awareness creation stands out as the most frequently performed activity, having been ranked as a main activity or at the next proximate frequency level by as many as 62% of respondents. Joint R&D projects, cluster analysis, market intelligence, and region branding are also ranked as frequent activities. Conversely, FDI attraction, joint logistics and technical standards are ranked as a main activity or at the level below by 6–7% of the respondents. As such, when cluster activities are categorised, we should keep in mind the fact that these groups are highly inhomogeneous: they are constituted of both frequent and rare activities.

The present study also suggests that three broad activity groups used in most of the cluster policy literature cannot adequately capture the full variety of activities undertaken by cluster organisations. In fact, it is the earliest of the categorisations reviewed (which also happens to be the most theoretical), namely, the grouping proposed by Boekholt and Thuriaux (1999) that comes closest to the categorisation arrived at by our factor analysis. Five of their six policy action groups conform fairly well to this schema of Branding, Business environment, Intelligence, Joint R&D, and Firm formation.

Interestingly, branding activities were found to be related to awareness building activities. This group also includes, although not unambiguously, the activity of joint foreign market promotion. This finding partially supports Lundequist and Power's (2002) suggestion that brand building serves the dual purpose of internal identity building and external promotion. In addition, they suggest that brand-building activities also work to attract investments, venture capital, firms and labour. However, the current study does not provide evidence of these additional functions.

The performance regressions suggest that activity groups exert different impacts on the cluster. Joint production is, not surprisingly, the activity most associated with production performance impact. Conversely, Joint R&D, Firm formation, Branding, and Business environment are primarily associated with Innovation and Investment performance. HR upgrading is associated with both impact types.

In terms of organisational performance, Joint R&D, Branding, and HR upgrading are significantly associated with the perception that the organisation has been successful in its efforts.

The present study does not provide any support for either side in the persistent government vs. private sector debate. There is no indication that effects differ between business initiated ("bottom-up") and government-initiated ("top-down") cluster promotion, as Fromhold-Eisebith and Eisebith suggest. Government initiation was found to have no significant effect in any of the performance models. It appears that for large numbers of cluster organisations across many countries, no *general* effect of government initiation can be distinguished. If it has any discernable impact whatsoever, it appears to be subject to specific contingencies.

One key strength of the present study is the unusually large and diverse sample of cluster organisations that have been surveyed. To the best of my knowledge, no previous study has included as many cluster organisations. The sheer diversity in terms of countries and industry sectors covered allows us to draw broader and more general conclusions than has been possible with earlier studies circumscribed by a narrower scope.

There is, however, reason to treat the conclusions drawn here with a degree of caution, as the study has several limitations that must be considered. The problems with self-reported performance measures have already been mentioned. Although the common methods bias is often of minor importance, we cannot be certain that it has not biased the results in this case. Also, cross-sectional studies have a potential risk of survivor bias. Organisations that were terminated before the time of the survey are not included in the sample, and as such, we do not know which activities and initiatives they engaged in. Nevertheless, even with these potential limitations, the present study provides tentative indicators for issues that previous small-scale studies have not been able to address.

Conclusions

The purpose of this paper has been to provide an empirically based typology of activities in which cluster organisations engage, to establish tentative connections between such activities, and to assess some previous claims about performance drivers.

The results suggest that different activities vary considerably in popularity. The findings also show that activities can be grouped into seven general activity groups, which I have labelled Joint production, HR upgrading, Branding, Firm formation, Business environment, Intelligence, and Joint R&D. Joint production is primarily associated with impact on self-reported production performance, while Joint R&D, Firm formation, Branding, and Business environment are primarily associated with self-reported Innovation and investment performance. HR upgrading is associated with both types of performance. In terms of organisational performance (the organisation living up to expectations, meeting goals and deadlines, etc.), Joint R&D, Branding, and HR upgrading show the greatest positive effect.

There is no support for the hypothesis that government-initiated cluster organisations in general would perform any better or worse than other cluster organisations. Nor is there any support that cooperation with other cluster organisations is generally associated with better performance. Having dedicated resources in the form of an office or having been in operation for a longer time are both associated with better performance in innovation and investment, but the size of cluster organisations (in terms of the number of participating companies) has no general effect on performance.

Much of the cluster policy literature has been focused on delineating the ways in which the cluster concept has been applied at the policy level and identifying the broad range of policy actions that it has informed and inspired. From this perspective, the cluster concept is a framework for a diverse set of actions carried out by a wide range of actors. However, cluster policy, as well as private-sector initiatives, has also given rise to a large number of organisations dedicated specifically to the enhancement of the growth and competitiveness of selected clusters. In contrast to the diverse and dispersed nature of cluster policy, these initiatives represent concentrated, coherent efforts in organisations with well-defined activities and participants. Our understanding of the ways in which the cluster concept has been applied to promote economic growth in practice has much to gain from further study of such organisations. This study has aimed to provide some insights that can be applied toward that objective.

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Study 7

Seeing eye-to-eye: how do public and private sector views of a biotech cluster and its cluster initiative differ?

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Study 7

Seeing eye-to-eye: how do public and private sector views of a biotech cluster and its cluster initiative differ?

ABSTRACT As clusters have developed from an analytical concept into a key policy tool, numerous cluster initiatives, or collaborative organizations designed to enhance the competitiveness of clusters, have been implemented across the globe. However, while research on clusters is abundant, research specifically focusing on these emerging organizations is scant to date. This paper analyzes one such cluster initiative and its cluster, and in particular examines to what degree the public and private sectors 1) have the same understanding of the cluster's competitiveness and underlying strengths and weaknesses and 2) what activities the cluster initiative should conduct.

Introduction

Since its introduction in 1990 by Michael Porter, the concept of clusters has rapidly attracted attention from academics, consultants, and policymakers. Many governments and industry organizations across the globe have turned to this concept in recent years as a means to stimulate urban and regional economic growth. As a result, a large number of cluster initiatives were started during the 1990s, and the trend continues as evidenced by the 2005 Global Cluster Initiative Survey funded by USAID in which more than 1400 such cluster initiatives across the globe were identified (Ketels, Lindqvist, & Sölvell, 2006).

More specifically, cluster initiatives are a particular form of public-private partnership and are *organized collaborations between public and private sector actors,* such as firms, government agencies, and academic institutions, with the purpose of enhancing the growth and competitiveness of clusters. Cluster initiatives are generally engaged in a broad range of activities designed to support the cluster, such as joint marketing, training, developing technical standards, coordinating joint R&D projects, promoting commercialization of academic research, supply chain development, improving the regulatory environment, and lobbying for better infrastructure or FDI incentives (Sölvell, Lindqvist, & Ketels, 2003).

Before proceeding, it is important to stress a few distinctions regarding cluster initiatives. First, a *cluster initiative* is not a *cluster* in the Porterian sense; rather it is an organization set up to serve the cluster. Second, cluster initiatives are neither exclusively government organizations nor industry organizations. They are, by definition, a collaboration involving *both* public and private actors.

Despite the growing interest and increasing resources invested in cluster initiatives, a literature review revealed that although a considerable body of literature focuses on areas such as the spatial qualities, characteristics, and dynamics of clusters (e.g., Isaksen, 2004; Liebovitz, 2004) and the dynamics of a sub-group of cluster actors such as the cluster's firms (e.g., Bagchi-Sen & Scully, 2004), surprisingly little empirical research has investigated *the cluster initiative organizations themselves*. Thus, the goal of this research is not to contribute directly to the ongoing debates in the cluster field, such as the value of a cluster approach and underlying theories of agglomeration or path dependency, but to developing an understanding of these emerging collaborative organizations designed to increase the competitiveness of a cluster.

To achieve this, we draw upon the organizational literature on decision-making groups comprising diverse members (e.g., Maznevski, 1994) and the alliance literature, (e.g., Lerpold, 2003) as well as the growing body of public-private partnership literature (e.g., Klijn & Teisman, 2003). Briefly, the first literature has found that decision-making groups with members who represent diverse organizations generally do not have a shared social reality or shared views and values while research in the second area indicates that the member organizations of inter-organizational decision-making tend to have divergent motives and objectives for what they expect to achieve in the collaboration. While these findings are echoed in the public-private partnership literature, this literature is still in a somewhat early stage and researchers have paid scant attention to the particular case of cluster initiatives. With the rapid implementation of cluster initiatives and high expectations for competitiveness improvements by their participants, however, it is important to understand just how the views and objectives of the primary groups of cluster actors compare. This understanding demands attention especially in light of the findings on diverse groups and alliances that such organizations often suffer from ineffective communication leading to obstacles to effective performance and in the case of alliances, frequent failure. Thus, the purpose of our study is to examine the degree to which the public and private sectors differ in their views regarding the cluster's competitiveness since this lies as the foundation for competitiveness improvement efforts as well as how they differ in their objectives for the cluster initiative. This leads us then to our two research questions:

- *Research Question 1:* To what degree do the public and private sectors have the same perception of a cluster's competitiveness and its underlying strengths and weaknesses?
- *Research Question 2:* To what degree do the public and private sectors agree on the activities the cluster initiative should conduct to improve the cluster's competitiveness?

We investigate these questions through a case study of one cluster in Sweden, the Uppsala biotech cluster, and its cluster initiative, Uppsala BIO. Through an online questionnaire of public and private sector respondents in the Uppsala biotech cluster, we find that these two groups do have significant differences in both the above areas. To anticipate the results, we find that the public sector consistently has a more positive view than the private sector of the cluster's competitiveness as well as higher expectations as to what the cluster initiative will be able to achieve. However, the public sector has less ability to differentiate in terms of the activities the cluster initiative should conduct. After presenting these results, we discuss our findings in light of the patterns of interaction that these two sectors have with other actors both within the cluster as well as internationally. The article then concludes with a discussion of the implications for the governance of cluster initiatives.

Previous research on clusters, cluster initiatives, and public-private partnerships

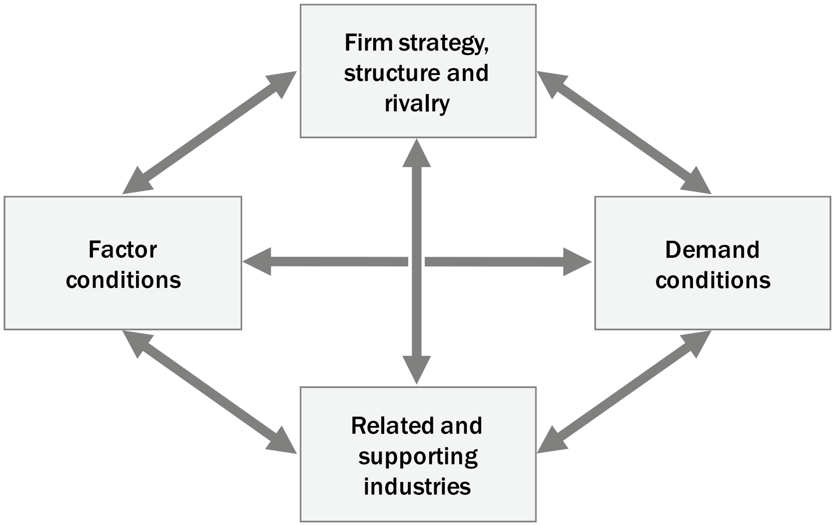
Cluster research

In 1990 Michael Porter introduced the cluster concept in his book, *The Competitive Advantage of Nations,* later defining clusters as "geographical concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies and trade associations) in particular fields that compete but also cooperate" (Porter, 1998, p. 197). Since then, the cluster concept has become widely circulated and used in both academic as well as in policy circles (Benneworth, Danson, Raines, & Whittam, 2003; Martin & Sunley, 2003; Simmie, 2004).

In his earlier work, Porter (1990) developed a model identifying the specific sources of competitiveness (see Figure 1). Essentially, the model proposes that competitiveness stem from four interrelated influences relating to 1) factor input conditions, 2) demand conditions, 3) related and supporting industries, and 4) the context for firm strategy and rivalry. The geographical concentration that occurs in clusters among actors enhances the processes of interaction between these four factors. While the diamond model is well-known to cluster researchers, we feel it is important to briefly present the model here as it forms the basis for our first research question.

Regarding the first factor of factor input conditions, the model stresses the importance of specialized inputs as opposed to the more generic classical notion of availability and cost for capital, labor, and land. Such specialized factors develop to fit the needs of a particular economic activity, such as the availability of specially trained labor or a research infrastructure that is specifically oriented to the cluster's needs. These conditions are important as factors of location since they are difficult to move and difficult to imitate in other regions. As for the second factor, while the sheer size of the local market can strongly influence local competitiveness, demand conditions are seen primarily as a qualitative factor in the context of an industrial system. Thus, the diamond stresses that sophisticated and demanding local buyers contribute to a cluster's competitiveness. In terms of related and supporting industries, the diamond model points to the fact that innovation and competitiveness tend to spill over across firms

Figure1. The diamond model



Source: Porter (1990)

and industries locally. In other words, the presence of a set of world-leading suppliers in a region may positively impact the upgrading of other firms in the local system by not only helping to streamline production and reduce transportation costs, but by also further enhancing competitiveness through fostering innovation in joint developments. Additionally, the local presence or absence of other industries with activities that are either related or complementary to the cluster's activities can profoundly affect the cluster's competitiveness. Finally, the model underlines the importance of local rivalry. The idea is that local rivalry adds intensity and an emotional dimension to the competition that most firms perceive in the global market. Firms in a local environment tend to develop relations of rivalry, where the firm down the road is often seen as the "prime enemy". Benchmarking in relation to neighbors is more direct, partly for reasons of local prestige and partly, presumably, because direct comparison is simplified (cf. Malmberg & Maskell, 2002).

Alongside Porter's work, other strands of research have continued to develop and have provided some interesting insights, e.g., economic geographers investigating innovation and learning processes in cities and regions and economists focusing on the relationships between agglomeration, specialization, and trade. As a result, the level of attention and number of studies focused on clusters continues to grow. For example, one recent issue of *Urban Studies* (May 2004) was dedicated to clusters in urban and regional development and presented a series of papers focused on three themes: 1) conceptualizing clusters from a theoretical standpoint through primarily addressing the spatial elasticity of the term, e.g., Martin & Sunley (2003), 2) the importance of knowledge and knowledge flows for a cluster's innovation ability and competitiveness, e.g., Power & Lundmark's (2004) study of labor movements in an ICT cluster, and 3) the main influences on cluster development and how the key linkages between firms and institutions actually operate throughout different stages of cluster development, e.g., Cooke's (2004b) paper on relatively new dynamic biotechnology clusters vs. Tödtling & Trippl's (2004) paper on mature clusters in an old industrial region. In addition to the above issues, researchers are investigating the issue of path dependence and to what degree successful cluster dynamics can be seeded, particularly through the actions of public-sector agencies, defined as federal, state/provincial/regional, and local governments as well as public research and higher education institutes (Wolfe & Gertler, 2004).

However, despite the further development of alternative models and the inconclusive findings relating to the impact of cluster efforts on competitiveness, Porter's work on clusters continues to exert the most direct influence on policymakers at all levels (Cumbers & MacKinnon, 2004). Policymakers have been quick to adapt the cluster concept as an overarching framework and guide to promoting economic development (Wolfe & Gertler, 2004), and they are currently making efforts to develop or strengthen clusters across the globe within all kinds of industrial sectors through such means as infrastructure improvements, tax incentives, and research funding programs. As mentioned above, another frequently used vehicle for improving cluster competitiveness worldwide is the implementation of a cluster initiative, which we turn to next.

Cluster initiatives and public-private partnerships

Cluster initiatives are *organized collaborations between public and private sector actors,* such as firms, government agencies, and academic institutions, with the purpose of enhancing the growth and competitiveness of clusters (Sölvell, Lindqvist, & Ketels, 2003). As such, they are public-private partnerships (cf. Klijn & Teisman, 2003) in the wider sense of the term. While the literature on public-private partnerships has grown considerably in the past two decades, much of it focuses on joint-ventures between government and private businesses as an alternative to privatization that emerged during the 1990s (Linder, 1999). This literature also tends to focus on collaborations in areas such as improving public health (Widdus, 2005), education (Woods & Woods, 2005), and construction and infrastructure (Tranfield et al., 2005). There is, however, less research devoted to public-private partnerships in the form of cluster initiatives. One example is Samii et. al. (2002), which deals with cluster initiatives conducted by United Nations Industrial Development Organization (UNIDO) in India. In terms of quantitative research on cluster initiatives, we are aware of only two studies, namely the Global Cluster Initiative Survey (GCIS) 2003 (Sölvell, Lindqvist, & Ketels, 2003) and GCIS 2005 (Ketels, Lindqvist, & Sölvell, 2006). Below we provide some of the findings from these surveys.

First, these surveys clearly indicate a rapid growth in the number of cluster initiatives. The 2005 survey identified more than 1400 cluster initiatives across the globe, compared to about 500 two years earlier, and 37% of the respondents were initiated in 2003 or later. Second, they vary greatly in their organizational forms, in terms of size and resources as well as legal status. Some are huge organizations with extensive resources in the form of personnel, offices, and websites while others are modest projects involving just a few companies and a local government agency. Third, in terms of governance, these surveys found that cluster initiatives were usually managed by some kind of board or steering group with representatives from industry, government, and/or a relevant university in addition to a part-time or full-time "facilitator" or manager responsible for the day-to-day activities. These organizations also tended to be generally membership-based, receiving their financial support from sources such as government funding, membership fees from companies, and/or sales of services. Finally, with regard to the cluster initiatives' objectives and activities, they were found to engage in a variety of activities, e.g., supply-chain development, market intelligence, incubator services, FDI attraction, management training, joint R&D projects, and setting technical standards. While the variation in activities is great between cluster initiatives, it was also found that many individual cluster initiatives engage in a wide range of activities.

Beyond the two above-mentioned surveys, as noted above, we found unfortunately little in our review of the cluster and public-private partnership literatures that provided a deeper insight into these organizations. Perhaps we should not be too surprised given the relatively recent development of such organizations; however, with such a high level of resources being invested globally in cluster initiatives, these organizations do deserve attention from researchers as well. Thus, the purpose of the next section is to develop two overarching research questions related to these organizations.

Development of research questions

An organization is a vehicle for cooperative endeavor, one in which the purpose is to coordinate the various activities of its members in order to accomplish a goal that could not be achieved by any of its members individually. Organizations can be characterized by the diversity of their members along various dimensions, and several have been suggested, e.g., role-related vs. personally inherent (Maznevski, 1994) or observable vs. non-observable (Milliken & Martins, 1996). In the former distinction, role-related refers to characteristics such as occupation, organizational position, specialized knowledge and skills while personally inherent diversity refers to age, gender, nationality, personality, etc. (Maznevski, 1994). This diversity is generally associated with underlying differences in the behaviors, values, and attitudes of members. Moreover, research has found that people in different roles not only notice different information, but that they perceive the same information differently (Maznevski, 1994). As a result, diverse organizations tend to lack a shared social reality with members and their organizations failing to have a common "here-and-now" and perspective (Blakar, 1984).

As discussed above, cluster initiatives are composed of members who represent various public and private sector actors, thus cluster initiatives have a high level of role diversity. Since it is the firms or the private sector that actually determines the viability and competitiveness of a cluster (Wolfe & Gertler, 2004) while it is the public sector or government and academic institutions that indirectly support this competitiveness, we would expect these two types of organizations to develop different perceptions of the competitiveness of the cluster, i.e., divergent social realities. This leads us to our first research question:

- *Research Question 1:* To what degree do the public and private sectors have the same perception of a cluster's competitiveness and its underlying strengths and weaknesses?

While the majority of the above research has focused on intra-organizational groups, research within the alliance literature has focused on temporary organizations created by two or more partners agreeing to cooperate for a limited time, regardless of how long this proves to be. These alliance organizations combine individuals from different corporations, individuals who as a result have unique organizational identities and different corporate loyalties. Furthermore, as a case study of the BP-Statoil alliance revealed, these individuals and their organizations may even have differing motives for entering an alliance and that these motives may change over time (Lerpold, 2000, , 2003). These findings are echoed in the public-private partnership literature that has found that this form of collaboration is generally characterized by members with multiple, simultaneous, conflicting interests. On the one hand, the public sector has the goal of creating jobs and increasing public services while on the other, the private sector is dedicated to maximizing the value for its firms. From the perspective of organization and business strategy, however, a collaboration structured for the benefit of the private sector can have negative feedback effects on the goals of the private sector (Teisman & Klijn, 2002) and vice versa.

In the case of cluster initiatives, we would also expect to find multiple, conflicting goals. While the public and private sector organizations have a common overarching goal of improving the cluster's competitiveness, we would expect that the public sector would be more interested in cluster initiative activities focusing on improving the cluster as a whole such as creating more jobs, improving the quality of the labor force, and attracting foreign investment to increase the tax base. However, the private sector would be more interested in creating "short-term" financial returns for the individual firm's shareholders through activities focusing on either increasing revenues or decreasing costs, e.g., obtaining marketing partnerships, reducing time-to-market, etc. The above thus leads us to our second research question:

- *Research Question 2:* To what degree do the public and private sectors agree on the activities the cluster initiative should conduct to improve the cluster's competitiveness?

Study design and data collection

This study explores the two research questions through a quantitative case study, and biotechnology clusters are particularly interesting for such a study. As noted above, the number of cluster initiatives has grown rapidly in recent years, and regions in more advanced economies have tended to focus on developing and strengthening "high-technology" clusters. In particular, biotechnology clusters are seen as an essential component of regional economic development primarily due to their association with the "knowledge-based economy" (Liebovitz, 2004). In many respects biotechnology clusters characterize the local-global aspects of highly knowledge-intensive clusters, i.e., highly networked both regionally and globally. On the one hand *knowledge production and early exploitation* is rather strongly regionalized due to the necessary presence of a research base in university and research institute laboratories in addition to a significant number of dedicated biotechnology firms while on the other hand the subsequent *knowledge development and distribution and marketing* is highly globalized through connections with multinational pharmaceutical companies (Cooke, 2004b).

Numerous regions across Asia, Europe, and the US are attempting to establish or strengthen their biotechnology presence through emulating the biotech clusters that are revered to be centers of excellence, such as those centered around San Diego, Silicon Valley, and Boston in the US and around Cambridge, Oxford, the Dundee-Edinburgh-Glasgow triangle, Stockholm-Uppsala, and Munich in Europe (Cooke, 2004a, , 2004b). Based on this growing interest in biotechnology clusters, we chose to focus on one of these "centers of excellence" – the Uppsala biotech cluster. While the objective in the future is to broaden the investigation to other clusters, due to the exploratory nature of this research it makes sense to begin in a single case and then to re-evaluate on the basis of the findings from this study.

The Uppsala biotech cluster

Uppsala is just to the north of Stockholm, and similar to other biotechnology intensive regions across the globe, Uppsala exhibits a close historical relationship between industry and academia. Uppsala has an international reputation as "the city of methods" due to its traditional focus on the development and production of biotechnology methods, instruments, and research tools. In brief, at the time of this study in 2003, the Uppsala region employed approximately 4000 individuals in around 50 active biotech companies of which 34 were founded after 1995. Moreover, approximately 8% of the total Uppsala workforce is directly involved in biotech related activities through working in industry, academia, or government organizations. In terms of the research environment, Uppsala University and the agricultural university, SLU, encompass more than 900 researchers and graduate 900 students each year in biotechnology-related areas. An academic hospital as well as several research centers serves as customers, suppliers, and knowledge resources for Uppsala's biotech companies. Additionally, the universities have created business centers and holding companies that work specifically with the commercialization of research results, while there are a number of related national government authorities, e.g., the National Veterinary Institute, the Medical Products Agency, and the National Food Administration, employing together around 1200 individuals. Recently, Uppsala has seen the growth of an extensive sector of specialized services firms, such as patenting, legal advice, business development, recruiting, auditing and marketing. Finally, a number of local organizations have as an explicit objective to stimulate the development of the region, e.g., the Foundation for Collaboration between Uppsala's Universities, the Business Community, and Society (STUNS), Uppsvenska Chamber of Commerce, Invest in Uppsala. These organizations act as meeting points for representatives from industry, academia, and local and regional authorities (Waxell, 2005).[1]

Uppsala BIO – the Life Science Initiative

While Uppsala BIO – the Life Science Initiative was initiated in 2003 to improve the region's competitiveness, this initiative dates back to a

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[1] For an in-depth history and description of the Uppsala Biotech Cluster, see Waxell (2005).

pilot project in 2001 that observed that collaboration between industry, academia, and government needed to be increased to promote the region's long-term growth in biotechnology. In June 2003, Vinnova, the Swedish Agency for Innovation Systems, selected Uppsala BIO as one of three grant recipients of the national Vinnväxt program, thus leading to the kickoff of the Uppsala BIO project in the fall of 2003. Through Vinnväxt, Uppsala BIO is to receive a package of financial support for a period of ten years (up to 10 million SEK per year for up to 10 years to be matched by an equal amount from regional sources yearly).

Uppsala BIO is organized not as a legal entity but rather as a project under STUNS. As such, it does not have a board, but rather a steering committee. This steering committee combines individuals from both the private sector, e.g., CEOs and top executives of Uppsala's leading biotech companies, and the public sector, e.g., top county officials and influential individuals within Uppsala's universities.[2] There are four from each sector for a total of eight members, thus this mix of organizations represented in the steering committee reflects the initiative's and the region's commitment to increasing collaboration between academia, industry, and government. In addition to the steering committee, three part-time to full-time project leaders or facilitators run the day-to-day activities.[3]

Method

There is no generally established method for determining the boundaries of a biotech cluster, with different studies applying different definitions of biotechnology firms, e.g., Estades & Ramani (1998); Prevezer (1998); Shohet (1998). We chose to follow Waxell (Waxell, 2005) who in a study of the Uppsala biotech cluster combined the above definitions and defined the biotech industry as all companies with applications in drug development (including drug discovery, drug delivery, and vaccines), diagnostics and medical technology (including clinical/contract research organizations), biomaterials, biotech supplies (including bioinformatics and chromatography), health food (including health products, functional food/feed, etc.), agricul-

[2] Universities in Sweden are generally public organizations.

[3] More information on Uppsala BIO can be found at www.uppsalabio.com or in Teigland et.al. (2005).

tural biotechnology, environmental biotechnology; and other miscellaneous (e.g., biotechnical activities in dentistry, energy, cosmetology).

Based on this definition, we built our pool of survey respondents from two sources of data. First, a comprehensive study involving interviews and an analysis of secondary material such as predefined lists of biotech firms and articles and job announcements in the media from 2000 to 2003 provided a list of biotech and supporting firms (Waxell, 2005). This list of 141 organizations was then complemented with a list of 222 individuals from across a wide range of organizations that was provided by Uppsala BIO. The basis for Uppsala BIO's list was that these individuals had expressed an interest in biotechnology and in keeping up-to-date with the activities of Uppsala BIO and the Uppsala Chamber of Commerce. After deleting duplicates, the final number of survey respondents was 249, of which 106 completed the entire questionnaire for a response rate of 43%. Below is the breakdown of respondents between the public and private sectors:

Private sector. We received a total of 75 private sector responses: 40 from "core" companies comprising biotech product and research companies, i.e., companies whose operations primarily focus on some aspect of biotechnology, and 35 from "support" companies combining financial institutions, e.g., banks, venture capital firms, and specialized services companies, e.g., patent bureaus, law firms, recruiting and staffing firms, management consultants.

Public sector. We received a total of 26 public sector responses from government organizations such as Uppsala Municipality, the National Food Administration, etc. and educational, academic, research or healthcare institutions, e.g., Uppsala University, the Swedish University of Agricultural Sciences (SLU).

The survey was divided into two different sections of questions, one representing each research question. We based the first section investigating the degree that the public and private sectors have the same perception of the cluster's competitiveness and its underlying strengths and weaknesses on Porter's diamond model. To develop the appropriate questions, we consulted with the Clusters and Competitiveness Foundation, an independent foundation resulting from the collaboration between Michael E. Porter and the Catalonian government. We then adapted their questions to the Uppsala biotech cluster based on three interviews with individuals from Uppsala BIO.

In order to investigate the second research question, to what degree do the public and private sectors agree on the activities the cluster initiative should conduct to improve the cluster's competitiveness, we adapted questions from the Clusters and Competitiveness Foundation as well as questions from the Global Cluster Initiative Survey (Sölvell, Lindqvist, & Ketels, 2003). We then completed this set of questions based on discussions with Uppsala BIO.

We administered the questionnaire using an internet-based survey tool. First, we sent each respondent an invitation by email to complete the survey. In this email, we included an explanation of why the survey was being conducted as well as a hyperlink directing them to each respondent's individual online survey form. Additionally, the survey was created in a manner such that respondents could exit the survey to return at a later time without losing any previously entered data. The invitation emails were sent December 18-25, 2003. Reminder emails were then sent on December 26, January 8, and January 14, with the last available date for replying specified in the last reminder email as January 16, 2004.

Analysis and results

Perceptions of the cluster's competitiveness and underlying strengths and weaknesses

As discussed above, we used the diamond model to structure our investigation of the first research question on perceptions of the underlying strengths and weaknesses in the cluster's competitiveness. More specifically, individuals were asked to answer 43 questions focusing on the sections of the model: a) factor (input) conditions (18 questions), b) demand conditions (5 questions), c) related and supporting industries (3 questions), and d) context for firm strategy and rivalry (17 questions). Replies were given on a seven-point Likert scale (1 indicating poor competitiveness conditions to 7 indicating excellent competitiveness conditions). A complete list of all 43 variables and means is provided in Table 1.

To identify differences between the public and private sectors, we used Mann-Whitney's U test, a non-parametric test suitable when normality can not be assumed. For 17 of the 43 variables or 39%, we found significant differences between the two groups, and statistics for these variables are provided in Table 2.

First, it is notable that the differences between the two groups are highly consistent. The public sector respondents consistently rated the cluster's competitiveness variables higher than the private sector respondents, giving higher ratings to all 17 of the significantly different variables. In addition, it is worth mentioning that although not significant, 21 of the remaining 26 variables were assigned a higher perception of competitiveness by the public sector, and only 5 or 12% of the total number show lower perceptions by the public sector. Second, the significant differences are distributed across three of the four diamond model sections: all except related and supporting industries. Third, the public sector's positive perception of competitiveness was particularly evident for the variables related directly to the performance of the public sector itself. For example, differences for factor conditions were pronounced regarding the effectiveness of local and national government, the physical infrastructure, which is the responsibility of the public sector, and the quality of the training provided by universities, which are public. For demand conditions, public sector respondents find the regulatory system to be particularly effective. However, differences are not limited to conditions only under the control of the public domain. For example, in the section on context for firm rivalry and strategy, public sector respondents perceived the level of competition between cluster companies as well as the level of cooperation of cluster companies with academia and with regional government to be higher than the private sector respondents perceived it to be.

In addition to Porter's diamond model, we also asked questions on the overall perception of the competitive position of the Uppsala biotech cluster. More specifically, individuals were asked four questions on the overall competitiveness position of Uppsala as well as six questions on the level of innovation of the cluster in specific biotechnology areas, e.g., methods and tools for discovery, health food. This set of questions was also based on a seven-step Likert scale (1, "strongly disagree", to 7, "strongly agree"), and differences were again tested with Mann-Whitney's U test.

Table 1. Perceptions of cluster's strengths and weaknesses: means, standard deviations (SD), rank differences, and Z-values for Mann-Whitney's U Test of difference between respondent groups

		Private			*Public*		*Rank*	
Variable	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*diff.*[1]	*Z-value*
Factor (input) conditions								
1. Geographic location advantage	5,460	1,228	87	5,517	1,353	29	+	-0,493
2. Cost of doing business	3,816	0,934	87	3,607	0,916	28	−	-0,890
3. General physical infrastructure	4,364	1,136	88	4,897	0,939	29	+	-2,499**
4. Swedish capital availability for SMEs	3,220	1,397	82	2,880	1,424	25	−	-1,184
5. Foreign capital availability for SMEs	2,772	1,250	79	2,760	1,012	25	−	-0,079
6. Quality of local/regional government	3,116	1,332	86	4,115	1,532	26	+	-2,870***
7. Government subsidy frequency	2,699	1,197	83	2,960	1,338	25	+	-0,741
8. Ease of recruiting skills from Uppsala	5,434	1,191	83	5,808	0,801	26	+	-1,229
9. Ease of recruiting skills from rest of Sweden	4,639	1,312	83	4,731	1,002	26	+	-0,386
10. Ease of recruiting skills from outside of Sweden	2,974	1,395	78	3,000	1,058	26	+	-0,427
11. Quality of recruitment from Uppsala universities	5,543	1,225	81	6,036	0,793	28	+	-1,805*
12. Quality of recruitment from Stockholm universities	5,407	1,181	81	5,929	1,052	28	+	-2,158**
13. Quality of recruitment from other Swedish universities	4,738	1,260	80	5,143	1,268	28	+	-1,641
14. Quality of recruitment from Uppsala high schools	3,513	1,475	80	3,808	1,625	26	+	-0,720
15. Investment encouragement from taxes and regulations	2,974	1,235	77	3,550	1,356	20	+	-1,564
16. Effective government R&D incentives	2,041	0,985	74	2,500	1,147	20	+	-1,617
17. Effective local government	3,104	1,283	77	4,136	1,390	22	+	-2,930***
18. Effective national government	3,449	1,213	78	4,619	1,071	21	+	-3,859***
Demand conditions								
19. Advantage of Sweden's market size	2,513	1,384	78	2,800	1,414	25	+	-0,981
20. Swedish demand for new features	3,027	1,394	74	3,762	1,411	21	+	-2,244**
21. Demanding Swedish regulatory standards	3,870	1,550	77	4,750	1,032	24	+	-2,507**
22. Demanding European regulatory standards	4,584	1,472	77	5,217	1,166	23	+	-1,833*

	Private			Public			Rank	
(cont.)	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*diff.*[1]	*Z-value*
23. Demanding non-European regulatory standards	4,584	1,550	77	4,864	1,390	22	+	-0,691
Related and supporting industries								
24. Competitive local suppliers of components and materials	3,949	1,431	79	4,095	1,480	21	+	-0,048
25. Competitive local suppliers of machinery and equipment	3,859	1,307	78	4,095	1,480	21	+	-0,424
26. Competitive local suppliers of specialized services	4,545	1,382	77	4,762	1,179	21	+	-0,557
Context for firm strategy and rivalry								
27. High number of local/regional competitors	2,782	1,383	78	3,625	1,245	24	+	-2,559**
28. Fierce local/regional competition in the cluster	2,688	1,195	77	3,304	1,146	23	+	-2,067**
29. Strict competition laws	3,795	1,236	73	3,600	1,046	20	–	-0,859
30. Ease of domestic start-up establishment[2]	-3,347	1,438	75	-2,696	1,105	23	+	-1,797*
31. Ease of foreign establishment[2]	-3,595	1,498	74	-3,130	1,180	23	+	-0,967
32. Cooperation among companies	4,308	1,282	78	4,636	1,002	22	+	-0,991
33. Cooperation companies with academia/healthcare	5,103	1,373	78	5,739	0,752	23	+	-1,926*
34. Cooperation companies with regional government	3,833	1,343	78	4,417	1,213	24	+	-1,915*
35. Cooperation companies with regional financial institutions	3,671	1,408	76	4,565	1,161	23	+	-2,679***
36. Cooperation companies with IFCs	4,278	1,503	72	5,000	1,206	23	+	-2,083**
37. Cooperation companies with specialized service firms	4,581	1,385	74	5,091	1,019	22	+	-1,476
38. Level of cross-disciplinary research	4,613	1,532	75	4,750	1,567	24	+	-0,427
39. Level of labor mobility between cluster companies	4,671	1,482	73	5,136	1,082	22	+	-1,248
40. Degree of openness about ideas[2]	-3,986	1,255	74	-4,227	0,813	22	–	-0,919
41. Effective local IFCs	4,149	1,459	74	4,818	1,053	22	+	-1,940*
42. Effective national IFCs	3,767	1,253	73	4,286	1,189	21	+	-1,644
43. Effective intellectual property protection	4,566	1,427	76	5,050	0,999	20	+	-1,484

[1] + indicates public sector responses were higher than private sector responses; – indicates public sector responses were lower than private sector

[2] Reverse coded

* p<0.1; ** p<0.5; *** p<0.01

Table 2. Significant differences in perceptions of cluster's strengths and weaknesses: rank differences, means, and Z-values for Mann-Whitney's U Test of difference

Variable	*Rank diff.*[1]	*Z-value*	*N Private*	*N Public*
Factor conditions				
Effective national government	+	–3.859***	78	21
Effective local government	+	–2.930***	77	22
Advantage of local/regional government	+	–2.870***	86	26
General physical infrastructure	+	–2.499**	88	29
Quality of recruitment from Stockholm universities	+	–2.158**	81	28
Quality of recruitment from Uppsala universities	+	–1.805*	81	28
Demand conditions				
Demanding Swedish regulatory standards	+	–2.507**	77	24
Swedish demand for new features	+	–2.244**	74	21
Demanding European regulatory standards	+	–1.833*	77	23
Context for firm strategy and rivalry				
Cooperation - companies with regional financial institutions	+	–2.679***	76	23
High number of local/regional competitors	+	–2.559**	78	24
Cooperation - companies with IFCs	+	–2.083**	72	23
Fierce local/regional competition in the cluster	+	–2.067**	77	23
Effective local IFCs	+	–1.940*	74	22
Cooperation - companies with academia/healthcare	+	–1.926*	78	23
Cooperation - companies with regional government	+	–1.915*	78	24
Ease of domestic start-up establishment[2]	+	–1.797*	75	23

[1] + indicates public sector responses were higher than private sector responses; – indicates public sector responses were lower than private sector responses

[2] Reverse coded

* p<0.1; ** p<0.5; *** p<0.01

As seen in Table 3, again we find that the public sector consistently has a more positive outlook with five of the ten questions receiving a significantly different score. The public sector has a higher appreciation of the competitiveness both of the local cluster as well as of the competitiveness of the combined biotech activities in the wider region. Furthermore, they perceive the Uppsala cluster as significantly distinct from the neighboring clusters. However, with regard to the cluster's economic impact in terms of local employment, the difference is not significant.

Table 3. Perception of cluster's competitive position: means, standard deviations (SD) and Z-values for Mann-Whitney's U Test of difference between respondent groups

	Private			*Public*			
	Mean	*SD*	*N*	*Mean*	*SD*	*N*	*Z-value*
Cluster's competitive position							
Competitiveness of the Uppsala cluster	4.077	1.215	78	5.000	0.571	22	–3.497***
Uppsala-Stockholm region's world leadership	4.141	2.980	78	4.875	2.810	24	–1.969**
Uppsala's cluster distinct from Stockholm's	3.804	2.599	92	4.519	2.798	27	–1.856*
Uppsala's cluster's share of regional employment	4.325	1.038	77	4.217	0.905	23	–0.500
Cluster's level of innovation							
Methods and tools for discovery	5.611	1.593	72	6.217	1.087	23	–2.116**
Diagnostics	5.268	1.370	71	5.783	0.996	23	–1.893*
Life science in general	4.781	1.507	73	5.174	1.787	23	–1.399
Drug discovery and development	4.333	1.972	72	4.652	1.510	23	–0.827
Health food	3.829	1.999	70	4.174	1.787	23	–1.009
Stem cell research	3.217	2.026	69	3.478	1.988	23	–0.674

* $p<0.1$; ** $p<0.5$; *** $p<0.01$

With Uppsala's strong reputation in developing methods and tools for discovery, it is not surprising that both respondent groups ranked this field as the strongest, followed by diagnostics. Stem cell research was ranked the least innovative field in Uppsala. However, while both groups ranked the six fields in the same order, the public sector consistently rated each field as having a higher level of innovation than the private sector. Furthermore, as shown in the lower part of Table 3, the differences between respondent groups were larger for the strongest fields. For the weaker fields, differences between groups were not significant.

Agreement on cluster initiative activities

The second survey section dealt with the recently initiated cluster initiative, Uppsala BIO. Respondents were asked one seven-point scale question on how they expected Uppsala BIO to influence the competitiveness of the cluster (1, "strongly reduce", to 7, "strongly improve") as well as one question on whether they felt Uppsala BIO had a explicitly formulated vision (1, "completely disagree", to 7, "completely agree").

Second, respondents were asked to rate on a seven-point scale the importance (1, "not important", to 7, "key purpose") of six main groups of activities that Uppsala BIO could conduct. Additionally, we calculated for each respondent the average importance of all six activity areas as well as the individual's variance in replies. Thus, respondents with a small individual variance in importance of activities have rated all six activities roughly equal (be it high or low). Again we tested for differences between the public and private sector using Mann-Whitney's U test, and results are provided in Table 4.

In general, we found most of the differences between the two respondent groups to be significant. First, we found that public sector respondents have higher expectations of the effect of the cluster initiative on the cluster's competitiveness, and they found the vision of the cluster initiative more clearly formulated. Second, on average the public sector rates the importance of potential cluster initiative activities more highly than private sector respondents. On a scale from 1 to 7, the public sector's mean activity ratings range from 5.4 to 6.3 while the private sector's mean activity ratings range from 3.8 to 5.8. There are even significant differences for individual activities. The public sector rates the promotion of innovation and research and technical/management training significantly more highly. Furthermore, the non-significant activity differences all show a positive tendency for the public sector. Finally, we find that the variance is smaller in the public sector than in the private sector when looking at the variances across all activities for each *individual* respondent. In other words, the public sector respondents tended to give more similar ratings to all activities than private sector respondents and had difficulty in prioritizing among the activities.

Discussion

This case study suggests that consistent differences in both the perception of cluster competitiveness as well as the activities that the cluster initiative should conduct to improve competitiveness do indeed exist between the public and private sectors. First, our results indicate that the public sector has a more positive view of the dia-

Table 4. Expectations and importance of cluster initiative activities: means, standard deviations (SD) and Z-values for Mann-Whitney's U Test of difference between respondent groups

	Private			*Public*			
	Mean	*SD*	*N*	*Mean*	*SD*	*N*	*Z-value*
Expectations on the cluster initiative	5.657	1.136	67	6.478	0.665	23	–3.276***
Cluster initiative has an explicit vision	5.145	1.671	55	6.368	0.597	10	–2.862***
Importance of activities							
Promote cluster expansion, e.g., spin-offs, firm attraction	5.885	1.309	78	6.238	1.136	21	–1.277
Lobby government authorities to improve cluster conditions	5.346	1.689	78	5.619	1.161	21	–0.207
Promote biotech innovation and research in cluster	5.338	1.501	77	6.318	1.211	22	–3.031***
Promote cooperation with other biotech cluster	5.273	1.553	77	5.762	0.768	21	–0.907
Promote research about cluster and build networks	5.247	1.763	77	5.714	1.271	21	–0.785
Provide technical and/or management training for cluster	3.870	1.780	77	5.429	1.121	21	–3.665***
Individual's average importance of activities	5.135	0.981	74	5.857	0.561	21	–3.408***
Individual's variance in importance of activities	2.288	1.889	79	1.216	1.205	21	–2.477**

* $p<0.1$; ** $p<0.5$; *** $p<0.01$

mond model conditions of the cluster, the cluster's overall competitive position relative to other clusters, and the level of the cluster's innovation. As noted above, research has found that individuals with different roles not only notice different information, but that they perceive the same information differently thus leading to a lack of a shared reality (Maznevski, 1994). Our results indicate a similar finding - a low level of shared reality between the public and private sectors with the public sector having a higher opinion of the competitiveness of the cluster's firms in addition to its own performance in supporting these firms.

We may then ask why the public sector is consistently more positive than the private and not vice versa. Is there some reason for the public sector to be more optimistic and overestimate the strength of the cluster? Or does the private sector underestimate its potential? The present study is not designed to answer these questions, but we could tentatively proffer a rationale for each position. On the one hand, the private sector may have reason to have a more sober view. A cluster's competitiveness is simply a joint product of the competitive positions of the firms in the cluster, and it is a relative concept such that any one cluster's competitiveness is defined in terms of the competitiveness of firms and clusters elsewhere in the world. The private sector may have a more balanced worldwide view since they may be more aware of the relative competitive situation due to their own direct experience from competing on the international market – something that is especially prevalent within biotechnology clusters (Cooke, 2004b). Thus, they can take a more skeptic stance than the public sector towards the sector's "official success story" through balancing it with their impressions of companies in other clusters. Conversely, one could argue that the public sector has the ability to "see the bigger picture" locally, thus going beyond the individual firms and taking a more holistic, long-term perspective of the cluster. While companies in the cluster only interact with perhaps a few other local companies, the public sector has opportunities to appreciate the extent of the cluster more thoroughly due to its interaction with a greater set of local actors, be they firms or other types of organizations.

We were interested in investigating this question further, thus we analyzed a series of additional survey questions looking at the level of interaction with biotech companies both nationally and internationally. Respondents were asked to assess how often their organization interacted with biotech companies nationally on the one hand and internationally on the other hand. This question was adapted from a study by Teigland (2003) and was again on a seven-step scale (1, “not at all”, to 7, “to a great extent”). The results are presented in Table 5.

Table 5. The level of interaction by the respondent’s organization’s with biotech companies either nationally or internationally: means, standard deviations (SD), and Z-values for Mann-Whitney’s U Test of difference between respondent groups

	Private			*Public*			
	Mean	*SD*	*N*	*Mean*	*SD*	*N*	*Z-value*
Level of national interaction	3.758	1.733	66	4.447	1.353	19	–1.754*
Level of international interaction	3.955	2.003	66	3.389	1.685	18	–1.063
Difference between national and international interaction	0.197	2.454	66	–1.167	1.237	18	–2.463**

* p<0.1; ** p<0.5

We found that the public sector organizations interact significantly more with biotech companies on a *national* level than the private sector companies. Conversely, the private sector interacts more often with biotech companies on an *international* level slightly more often, but not significantly, than public sector organizations. Further, for each respondent we calculated the difference between national and international interaction. This value is on average positive for private sector organizations, indicating that international interaction outweighs national interaction, whereas it is negative on average for public sector organizations. This difference is significant and suggests that the public sector has a nationally dominated view of the cluster, while the private sector’s input is more international. Thus, these results do not present any conclusive evidence one way or the other since they lend tentative support for both the above hypotheses.

The second set of findings from this study revealed that the public sector has higher expectations on the impact of this cluster initiative and views that cluster initiative activities are in general more important than the private sector. As noted above, the public sector rated two activities, “promoting research and innovation” and “providing technical/management training", significantly more important than the private sector, with the latter showing the greatest difference. This provides very tentative evidence that cluster initiatives are similar to other public-private partnerships in that the partner organizations have multiple, conflicting goals (Tranfield et al., 2005). In the case of Uppsala BIO, the public sector appears to be more interested than the private sector in improving the long-term conditions of the cluster through improving the labor force quality as well as the underlying research base. However, the private sector may feel that these activities do not contribute to creating "short-term" financial returns for the individual firm's shareholders.

Our findings have several implications for cluster initiatives and public-private partnerships. Researchers of diverse organizations have consistently found that while diversity may serve to increase the number of potential solutions developed, this same diversity more often than not results in decreased group performance (e.g., Levine & Moreland, 1990; Wanous & Youtz, 1986). One of the primary reasons for this is that effective communication is difficult to achieve due to the differing underlying values and social realities (Maznevski, 1994). This challenge is further increased in inter-organizational organizations such as alliances due to the differing objectives and goals of the alliance members for the collaboration, and in many cases, these differences lead to failure of the alliance (Lerpold, 2003).

The above may provide an explanation for a finding from the GCIS 2003 survey (Lindqvist, 2005) that many cluster initiative managers, or "facilitators", mentioned that a key barrier to success was the difficulty in getting commitment from either the public sector actors or the industry actors. The current study suggests, however, that while lack of enthusiasm or commitment may reflect doubts about the potential benefits of the cluster initiative, these doubts may be grounded in differences in the more fundamental perceptions of the cluster's competitive position and hence the specific needs for action.

However, it is important to note that collaboration between diverse members is not only associated with problems to be overcome. Diversity can be managed productively. Research has found that groups that are able to integrate their diverse members such that they are able to understand each other and combine and build on each others' ideas are able to work productively and even have a higher level of performance than more homogeneous groups (Lerpold, 2000; Maznevski, 1994). This productivity can be further enhanced through the development of performance-oriented goals that are understood by all and to which all members are committed in addition to the development of an appropriate task strategy with a clear set of rules suitable to the task (Maznevski, 1994). This suggests that cluster initiatives require the *active* participation and collaboration of both the public and private stakeholders in order to be productive. Members should focus on developing an understanding of each other's views of the cluster's competitiveness through systematically evaluating the drivers and barriers to the specific cluster's competitiveness. In addition, they should focus on making explicit the goals and objectives of the various members. As we found in our study, the public sector had more difficulty in prioritizing among the activities that the cluster initiative should conduct in addition to different views regarding the importance of different activities. Thus, cluster initiatives should work towards developing a consensus around the activities that the cluster initiative should undertake in order to avoid falling victim to "alliance failure".

Limitations and further areas for research

First we would like to note that there is no one right way to identify respondents of a cluster, and we created our list of respondents based on an "objective" list (Waxell, 2005) and a "subjective" list (from Uppsala BIO). Thus, our results may be somewhat biased and should be treated with caution when interpreting them. Moreover, we are not able to generalize our findings across all types of cluster initiatives based on our conclusions from this single case study. As mentioned earlier, cluster initiatives can take many forms, and they can be located in clusters in industrial sectors ranging from baskets to biotechnology as well as in developing to advanced economies. Thus, additional research focusing on comparing various types of cluster initiatives is necessary.

Second, our analysis has focused on the differences between the public and the private sectors, and each of these sectors has been studied as a unit. However, this approach does not take into account any differences between groupings *within* each of these sectors, or indeed between individual organizations. Studying such differences on a more detailed level, as well as how perceptions change over time, are thus areas for further research.

Finally, while not the purpose of this study, we would like to comment on the Uppsala biotech cluster's competitiveness compared to other biotech clusters. We realize that we may be sticking our heads out since our survey provides no information about the perceptions of people from outside the Uppsala region. However, we feel a cautious analysis could be interesting. Looking at both sets of respondents, we find that they perceive that the cluster fulfils the diamond model's conditions for a high level of worldwide cluster competitiveness to a medium degree. Observed relative cluster weaknesses based on the respondents' replies are the following: 1) local and foreign capital is somewhat difficult to obtain, 2) foreign labor with special skills is somewhat difficult to recruit, 3) local demand is neither very large nor sophisticated, 4) local suppliers are considered to be on average competitive compared to competing locations, 5) rivalry is modest despite the somewhat low barriers to entry, and 6) government organizations and policies are not considered to be very effective in furthering the cluster's competitiveness. Thus, one interesting area for further research could be to focus on systematically comparing competitiveness across various types of clusters to better understand the underlying drivers.

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