Department of Industrial Engineering and Management

Dynamics of ecological interdependences between European paper & pulp and printing & publishing industries, 1950-2005

Joonas Järvinen

Aalto University

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Dynamics of ecological interdependences between European paper & pulp and printing & publishing industries, 1950-2005

Joonas Järvinen

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Abstract

Earlier research on industry evolution has introduced a number of theoretical models of how industries evolve, and identified a number of factors driving this process. In general, however, much of the earlier topical research has focused on explaining the evolution of industries by the characteristics of the industry in question or the firms operating within it. One of the areas where little research exists is on the effects of other industries or organizational populations on the evolution of a particular industry.

Thus, responding to calls for this type of research, this study aims at extending the knowledge of inter-industry or inter-population interactions both theoretically and empirically. The study builds primarily on organizational and community ecology, the only research paradigm that has systematically studied evolutionary interdependences between different types of organizational populations.

Theoretically, the study introduces a novel theoretical framework of interdependences between organizational populations. In particular, the framework incorporates the view that a population niche is a multidimensional construct, and turns the basic level of analysis of interactions to the level of the niche dimension. A number of propositions are formulated of the effects of different types of niche dimension level interactions on vital rates of organizational populations.

Empirically, the study examines ecological interdependences in a novel research context: the paper & pulp and the printing & publishing industries in four European countries – Finland, Germany, Sweden, and the UK – during 1950-2005. On the basis of historical narratives of the evolution of the eight separate industries, descriptive analyses of the resource flows between the industries, and the theoretical framework, hypotheses of the interdependences between the industries are formulated. By employing life-history data of the evolution of paper and pulp firms in the four countries, the hypotheses are then statistically tested.

In general, the results show that paper & pulp and printing & publishing industries have affected positively on each other's vital rates. When it comes to the specific interactions between the industries in the four country setting, the results suggest that the interactions have been complex. For example, it is found that the interactions have not been bounded by geographic space, there have been differences in the strength of the interactions between the industries, and that the strength of the interactions has changed as a function of time.

Keywords Community ecology, industry evolution, industry coevolution, paper & pulp industry, printing & publishing industry

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Tiivistelmä

Aikaisempi toimialaevoluutiotutkimus on tunnistanut useita erilaisia toimialojen evoluutioon liittyviä teoreettisia malleja sekä suuren määrän evoluutioprosessiin vaikuttavia tekijöitä. Aikaisempi alueeseen liittyvä tutkimus on kuitenkin keskittynyt pääsääntöisesti selittämään toimialojen evoluutiota yritys- ja toimialatason tekijöiden kautta. Yksi tutkimussuunnista, johon liittyen aikaisempi tutkimus on ollut vähäistä, on toisten toimialojen tai organisaatiopopulaatioiden vaikutus tietyn toimialan evoluutioon. Tässä työssä pyritäänkin luomaan uutta sekä teoreettisesta että empiiristä tietoa toimialojen ja organisaatiopopulaatioiden välisistä vuorovaikutussuhteista. Tutkimuksen teoreettisen ja käsitteellisen pohjan muodostaa organisaatio- ja yhteisöekologia, joka ainoana toimialaevoluutiotutkimussuuntana on systemaattisesti analysoinut toimialojen välisiä vuorovaikutuksia.

Tutkimuksen teoreettisessa osassa kehitetään uusi viitekehys organisaatiopopulaatioiden välisistä vuorovaikutussuhteista. Viitekehys perustuu näkemykseen, että populaation ekologinen lokero (niche) on moniulotteinen ja vuorovaikutusten perusanalyysitaso on yksittäinen ekologisen lokeron ulottuvuus. Tähän perustuen työssä muodostetaan propositioita erityyppisten populaatioiden ekologisten lokerojen eri ulottuvuuksien välillä esiintyvien vuorovaikutusten vaikutuksista populaatioiden elinvoimaisuuteen.

Empiirisesti työssä tutkitaan ekologisia vuorovaikutuksia neljän Euroopan maan (Suomi, Ruotsi, Saksa, ja Iso-Britannia) paperiteollisuus- ja painotuotetoimialojen välillä vuosina 1950-2005. Pohjautuen tutkittavien toimialojen historiallisiin kuvauksiin, deskriptiivisiin analyyseihin resurssivirroista toimialojen välillä, sekä teoriaviitekehykseen, työssä muodostetaan hypoteesit toimialojen välisistä ekologisista vuorovaikutussuhteista. Lopuksi hypoteesit testataan tilastollisten menetelmien avulla.

Tulosten mukaan paperiteollisuus- ja painotuotetoimialojen välillä on tutkimusajanjakson aikana yleisesti vallinnut positiivinen (symbioottinen) ekologinen vuorovaikutussuhde. Tarkasteltaessa vuorovaikutussuhteita toimialojen välillä neljän maan muodostamassa systeemissä, tulokset osoittavat toimialojen olleen vuorovaikutuksessa keskenään melko monimutkaisin tavoin. Vuorovaikutukset eivät esimerkiksi rajoitu vain maantieteellisesti samalla alueella toimivien toimialojen välille. Lisäksi, vuorovaikutusten löydetään poikkeavan toisistaan voimakkuudeltaan ja vuorovaikutusten voimakkuuden havaitaan myös muuttuvan ajan funktiona.

Avainsanat Yhteisöekologia, toimialaevoluutio, yhteisevoluutio, paperiteollisuus, painotuotetoimiala

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1. Introduction

The research on industry evolution focuses on explaining the changes and dynamics in the structure of industries as a function of time. In general, earlier research in the area, originating from a number of scientific paradigms, has introduced several different types of theoretical models of industry evolution and identified a number of factors and antecedents driving this dynamic process.

As **Table 1-1** indicates, the main paradigms of this body of research comprise, first, business history, which includes a large amount of literature on the evolution of firms and industries in different types of settings (e.g. Hannah 1976; Chandler 1977; Mokyr 1990; Chandler 1994). These usually in-depth case studies of a particular firm or industry suggest a number of different types of antecedents driving the evolution of firms and industries. Considering the nature of this research, many of the antecedents are specific to the firm or industry in question. Second, evolutionary economics considers formal evolutionary models of economic growth, with industries in a central role (e.g. Nelson & Winter 1982; Silverberg, Dosi & Orsenigo 1988; see also, Nelson 1995). The driving force of the evolution of firms and industries in these models are new technologies, resulting in differences in the fitness of the firms within the industry and ultimately in changes in industry structure (either by changes in firms' routine portfolios or by firm entries and exits).

Table 1-1: Industry evolution research paradigms and how they consider inter-industry or inter-population interactions.

	Business history	**Evolutionary economics**	**Historical sociology**	**Industry life-cycle**	**Organizational ecology**
Key references	Landes (1969); Hannah (1976); Hannah & Kay (1977); Chandler (1977; 1994); Mokyr (1990)	Nelson & Winter (1982); Silverberg et al. (1988)	Hughes (1983); Tushman & Romanelli (1985); Nelson (1993); Rosenkopf & Tushman (1994)	Utterback & Abernathy (1975); Abernathy & Utterback (1978); Gort & Klepper (1982); Klepper (1996)	Hannan & Freeman (1977); Hannan & Freeman (1989); Carroll & Hannan (2000)
Focus	Firm evolution; Industries in a central role	Models of economic growth; Industries in a central role	Co-evolution of industries and different types of institutions	Industry evolution	Ecology of organizations, populations, and communities of populations
Key driving mechanisms of industry evolution	Explanations specific to the firm or industry in question	Technology	Institutions relevant to the industry	Technology	Organizational, population, and environmental characteristics
Allows industry/population interdependences	Yes	Yes	Yes	Yes	Yes
Considers competitive interdependences between horizontally/commensalistically- related industries/populations	Yes, if part of the explanation	No	No	No	Yes, interactions considered by community ecology
Considers mutualistic interdependences between horizontally/commensalistically- related industries/populations	Yes, if part of the explanation	No	No	No	Yes, interactions considered by community ecology
Considers interdependences between vertically/symbiotically related industries/populations	Yes, if part of the explanation. Otherwise, a basic assumption is that markets for products and necessary resources exist	Not directly; however, a basic assumption is that markets for products and necessary resources exist	Not directly; however, a basic assumption is that markets for products and necessary resources exist	Yes, some studies have considered co-evolution of vertically related industries. Otherwise, a basic assumption is that markets for products and necessary resources exist	Yes, interactions considered by community ecology. Otherwise, a basic assumption is that markets for products and necessary resources exist
Considers interdependences between industries/populations and institutions	Yes, if part of the explanation.	Yes, but not part of the core theory	Yes	Yes, but not part of the core theory	Yes, interactions considered by institutional ecology

In a related vein, the third research paradigm in the field is that of industry life-cycle theory (Utterback & Abernathy 1975; Abernathy 1978; Abernathy & Utterback 1978; Gort & Klepper 1982; Klepper 1996) (for reviews, see e.g. Nelson 1995; Klepper 1997; Peltoniemi 2009) argues that technological evolution (in the form of investments by firms in R&D) is the central driver of firm and industry structure. Fourth, research on organizational ecology has explored the long-time evolutionary dynamics of organizations, organizational populations and communities of organizational populations (Hannan & Freeman 1977; Hannan & Freeman 1989; Carroll & Hannan 2000). In particular, the theory of density-dependence and its extensions have focused on explaining the evolutionary dynamics of organizational populations (for reviews, see e.g. Singh & Lumsden 1990; Baum 1996; Lomi, Larsen & Freeman 2005; Mattsson 2008). The mechanisms driving the evolution of populations in these

theories include different organizational characteristics, such as organizational age and size, and environmental characteristics, such as other organizational populations, industry structure, or institutional or technological processes. Finally, the stream of historical sociology, with a focus on industry evolution, stresses that the industry itself strongly molds its own selection environment. In general, this research has focused on the co-evolution of different types of institutions and industries or organizational populations (for examples, see e.g. Hughes 1983; McGuire, Granovetter & Schwartz 1993; Nelson 1993).

As this short overview of earlier research and theories on industry evolution indicates, the factors driving the evolution of industry structures vary from managers and organizational characteristics to industry characteristics, and to a wider market and institutional environment, as well as technology and its evolution. Despite the large number of suggested drivers of industry evolution, much of the earlier research has focused on explaining the evolution of industries by the characteristics of the industry in question or the firms operating within it. One of the areas in which little research exists is the effects of other industries or organizational populations on the evolution of a particular industry.

As **Table 1-1** reveals, every major industry evolution paradigm, as such, would facilitate studying the role of inter-industry or inter-population interactions in the evolution of a particular industry or population. However, it has been only organizational ecology (and community ecology in particular) that has systematically studied the different types of interdependences and their effects on the evolution of industries and organizational populations. With regard to interactions between industries/populations that are linked by commensalistic/horizontal interdependences, it is only earlier community ecology research that has considered their effects on populations/industry evolution (for earlier reviews, see e.g. Baum 1996; Freeman & Audia 2006). The effects of symbiotically related populations or vertically related industries have been studied by industry life-cycle and community ecology research streams. In the industry life-cycle paradigm, the research has explored how the structure of vertically related industries are dependent upon each other (Bonaccorsi & Giuri 2001) and the market structures of vertically related industries (Cacciatori & Jacobides 2005; Argyres & Bigelow 2007; Wolter & Veloso 2008; Malerba, Nelson, Orsenigo et al. 2008b). In the community ecology stream, earlier research has considered how symbiotically linked populations affect each other's structure and evolution (Audia, Freeman & Davidson Reynolds 2006; de Figueiredo & Silverman 2010).

It is important to note that all the paradigms, at least implicitly, assume that there are markets for the products and different types of resources (e.g. labor and financing) with regard to the industry or population in question. The research on interdependences between vertically or symbiotically related industries or populations, however, goes beyond this assumption by considering the effects that vertically or symbiotically related industries or populations exert on each other's structure and evolution. Finally, earlier research on the different streams has explored the co-evolution of different types of institutions and industries or organizational populations (e.g. Nelson 1993; Baum 1996; Ingram & Inman 1996; Murmann 2003; Malerba, Nelson, Orsenigo et al. 2008a).

Thus, although the potential importance of inter-population interactions has been acknowledged in earlier research (e.g. Nelson 1995; Baum 1996; Bonaccorsi & Giuri 2001; Murmann 2003; Ruef 2004; Audia et al. 2006; Freeman & Audia 2006; Peltoniemi 2009; de Figueiredo & Silverman 2010), and recent research has called for research in the topical area (e.g. Murmann 2003; Freeman & Audia 2006; de Figueiredo & Silverman 2010), only the community ecology stream has explicitly focused on the area. But even in this stream, research has been rather rare. Considering this, the main objective of the present study is to extend the knowledge of the inter-industry or inter-population interactions both theoretically and empirically by building primarily upon earlier research on organizational and community ecology. In the following sections, I will elaborate both the theoretical and empirical motivation of the study further, and formulate the main research questions. The main findings, contributions, and structure of the study follow thereafter.

1.1. Theoretical motivation and research questions

In general, interdependences between organizational populations are central to ecological theories of the organization (Hannan & Freeman 1977). This is because populations develop relationships with other populations engaged in diverse activities that bind them to organizational communities (Hawley 1950; Astley 1985; Fombrun 1986). Eventually, when an evolving population interacts with other populations, the success and survival of its members become dependent on the nature and strength of its ecological interactions with organizations in other populations. Thus, because the fates of populations are commonly linked, it is generally difficult to understand the behavior of organizations in a single population in isolation

(Fombrun 1986; Baum 1996). These arguments about the importance of inter-population interactions on the evolution of organizational populations are supported by earlier, but rather rare, empirical research on the topical area: interdependences between organizational populations have important effects on the vital rates of organizational populations.

The research on interdependences in community ecology is guided by the notion that two organizational populations are interdependent insofar as one population affects the viability (i.e. vital rates) of another (Hannan & Freeman 1977). The current frameworks of research build on this, and generally suggest that interdependences between different types of populations may vary from negative (typically referred to as competitive interactions) to positive (typically referred to as mutual interactions) (see e.g. Barnett & Carroll 1987; Brittain & Wholey 1988; Aldrich & Ruef 2006). The frameworks also often see that it is the product market that creates the most important interaction between the considered populations. This is natural, taking into consideration that much of earlier ecological research considers population's product market to be equal to population niche (Baron 2004; Sorensen 2004). When considered more closely, however, the frameworks differ with regard to what kind of interactions may exist between different types of organizational populations (compare e.g. Barnett & Carroll 1987; Korn & Baum 1994; Aldrich & Ruef 2006).

In this study, I aim to complement earlier community ecology frameworks by relaxing the implicit assumption about the equality of product market and population niche. My argument is that since a population niche is inherently a multidimensional construct, it is possible that two populations have different types of interactions between their different niche dimensions (for example, a competitive (negative) interaction with one type of dimension and a highly cooperative (positive) interaction with another type). I see that studying interactions at the level of niche dimension may offer a richer view of the potential interactions between organizational populations than research that mainly operates at the level of niche and considers the main interdependence between the populations to be caused by the product market. For example, the niche dimensions related to labor, financing, or input resource may create as important interactions between populations as the product market.

Therefore, taking these issues with regard to earlier community ecology research into consideration, my main objective is to complement earlier theoretical frameworks of population interdependences by introducing a novel theoretical framework of population interactions. In particular, the framework incorporates the view that a population niche is a

multidimensional construct. From the theoretical point of view, then, the main research question of the study can be formulated as follows:

RQ1: *Given that a population niche is a multidimensional construct, what kind of ecological interdependences exists between populations of organizations?*

In order to answer the research question and achieve the main objective, I will start the theoretical part of the study by briefly reviewing earlier research on organizational ecology. Next, I will elaborately analyze the earlier research on community ecology with the focus on population interdependences with the aim of both identifying the problems and disagreements in this research, and the issues that much of this research agrees upon. Building on earlier community ecology research, different theories of organizational ecology (e.g. research and theory of population niche, see e.g. Hannan & Freeman 1977; Popielarz & Neal 2007), and Hawley's (1950; 1986) studies on human ecology, I will then introduce the main arguments or building blocks of the theoretical framework. Based on this, I will finally formulate propositions of the most typical interdependences between different niche dimensions and the main arguments of the framework.

1.2. Empirical motivation and research questions

Turning to the empirical motivation of the study, the earlier, rather limited research on community ecology has focused primarily on studying interdependences between populations that share an overlapping niche (or actually, have an overlapping product market). The research on evolutionary interactions between populations that earlier research refers to as symbiotic (i.e. interdependences between populations that do not share an overlapping niche, at least from the perspective of a product market) or vertically related (i.e. populations adjacent in the industry value chain) has been extremely rare.

In order to respond to the calls from earlier research on studies of evolutionary interactions between industries or organizational populations in general (e.g. Baum 1996; Audia et al. 2006; Freeman & Audia 2006; de Figueiredo & Silverman 2010), this study aims at offering new empirical evidence of ecological interdependences in the context of the paper & pulp, and the printing & publishing industries; interdependences which earlier

research would categorize as symbiotic. The research setting consists of the two industries in four European countries – Finland, Sweden, Germany, and the UK – during the time period 1950-2005. The characteristics of the studied industries make the research setting particularly interesting. First, the paper and pulp industries in the four countries have been the largest in Europe since the Second World War (except for the UK), and they currently account for some 56 percent of paper and board production in Europe.

Second, despite the size of the paper and pulp industries, the countries have very different sized printing and publishing industries. Due to the basic characteristics of the printing and publishing industry, the small countries, Finland and Sweden, have small-sized industries in comparison to Germany and the UK, which have the largest markets for printing and publishing products in Europe. Thus, as the printing and publishing industry has always been the major customer of the paper and pulp industry, the demand for printing and publishing products in Finland and Sweden would not have allowed the growth of the respective pulp and paper industries to their current size. Third, Germany and the UK have been the most important export countries for the Finnish and Swedish paper and pulp industries since the Second World War. For example, with regard to printing and writing papers, the share of Germany and the UK of the total exports of printing and writing papers of Finland and Sweden has been some 40 percent since the Second World War.

Finally, it should be emphasized that the empirical research setting of the study is particularly interesting from the point of view of the Finnish (but also the Swedish) paper and pulp industry. For example, the Finnish paper and pulp industry has been the most important export oriented manufacturing industry in the country for almost the whole of the considered research period and has contributed considerably to the growth of the Finnish economy (Lamberg, Näsi, Ojala et al. 2006). Although the role of the paper and pulp industry in Sweden has not been as important as it has been in Finland, the industry has still also been among the largest export industries in the country for the whole of the analysis period (Rydberg 1990). Thus, the results of the study are expected to be of particular interest when it comes to the evolution of the Finnish and Swedish paper and pulp industries.

Consequently, by building on the introduced theoretical framework, my main objective in the empirical part of the study is to examine the ecological interdependences between the two industries in the research context described above. The main research questions for the empirical part of the study can then be formulated as follows:

RQ2: *On the basis of the introduced framework, what kind of ecological interdependences have existed between the paper & pulp and the printing & publishing industries in Finland, Sweden, Germany, and the UK during 1950-2005?*

RQ3: *How have these interdependences affected the vital rates of the respective industries during 1950-2005?*

In order to answer the research questions and to achieve the stated objective, the empirical part of the study proceeds as follows. First, I will conduct a historical descriptive analysis of the evolution of the industries with the aim of identifying the main evolutionary trends affecting the evolution of the industries during the research period. The historical narratives based on industry histories are complemented by statistical time-series data of the evolution of the industries. Second, the historical narratives are followed by an analysis of the ecological interdependences between the industries, based on the theoretical framework and quantitative data of the resource flows between the studied industries. Third, I will formulate hypotheses related to the interdependences between the industries on the basis of the earlier analysis. Finally, I will test the hypotheses from the perspective of the pulp and paper industry by quantitative research methodology, using the growth of the paper and pulp firms in the four countries as a dependent variable. The analysis builds on the life-history databases of the paper and pulp firms operating in the four countries during 1949-2005, constructed for the purposes of the current study.

1.3. Main findings and contribution

The main findings of the study may be summarized as follows. With regard to the theoretical framework, it builds on the following principles. First, a population niche is considered as a multidimensional construct that is divisible into *N* number of dimensions based on different environmental conditions (Hutchinson 1957; Hannan & Carroll 1992). Second, the framework argues that interdependences originating from resources and identity (cf. Dobrev, Ozdemir & Teo 2006) are inherently different; thus the niche is divided to two main parts: one related to resources and the other

related to identity. Third, the framework suggests that two kinds of basic interactions may be present between two niche dimensions: (1) interdependences between two same or like niche dimensions (referred to as type 1 interdependences); and (2) interdependences between two different or unlike niche dimensions (referred to as type 2 interdependences). Fourth, the effects of the interdependences on the vital rates of the organizational populations may vary from fully positive to fully negative. Finally, the 'total' or aggregate ecological interaction between two organizational populations (at time *t*), is a function of all of the sub-interdependences between all possible niche dimensions.

The results of the empirical part of the study suggest that the main interdependence between the paper & pulp and the printing & publishing industries is a type 2 interdependence between the product market dimension of the paper and pulp industry and the input resource niche dimension of the printing and publishing industry related to paper. In general, the interactions are suggested to have positive effects on the vital rates of the studied industries. In the four countries studied, the industries are interdependent on each other in complex ways. Based on the descriptive analysis of the resource flows between the industries, it appears that the Finnish pulp and paper industry has been even more dependent on the German and UK printing and publishing industries than on the Finnish printing and publishing industry during the research period. The Swedish pulp and paper industry has been similarly dependent on the Swedish, German, and UK industries. The German paper and pulp industry, in contrast, has been only dependent on the German printing and publishing industry, and the strength of this dependence has decreased as a function of time. Finally, the UK paper and pulp industry has been only dependent on the UK printing and publishing industry.

These interdependences are also verified by a quantitative analysis of the growth of the paper and pulp firms in the four countries. I employ four variables to measure the interdependence between the industries: the actual paper resource flows, the total consumption of printing and writing papers by the printing and publishing industries, the output of the industries, and the total employment of the industries. The estimated effects of the variables on firm growth, except for the total employment variables, are generally in line with the hypothesized interdependences.

Although I do not test the interactions statistically from the perspective of the printing and publishing industry, the descriptive analyses of the paper resource flows between the industries suggest that the Finnish and Swedish printing and publishing industries have been only dependent on the respective paper and pulp industries during the period of study that is

under examination. The German printing and publishing industry has been mainly dependent on the German paper and publishing industry. However, the strength of the dependence has decreased as a function of time, and at the same time, the industry has become more dependent on the Finnish and Swedish paper and pulp industries. Finally, the main supplier of the UK printing and publishing industry has been the UK paper and pulp industry, but particularly from early 1970s onward, the role of the Finnish and Swedish paper and pulp industries has become almost as important as the UK paper and pulp industry.

The study makes several contributions to earlier research. First, the introduced framework is an important contribution with regard to earlier research on the topical area, but also with regard to further research on interactions between organizational populations. By relaxing the assumption in much of the earlier ecological research about the equality of population niche and product market of the population, the framework turns the basic level of analysis of interactions to the level of the niche dimension. The formulated propositions of the effects of different types of ecological interactions between different dimensions of population niche on the vital rates of the organizational populations, then, offer a coherent ground for further research on the topical area.

The introduced framework and its main arguments also offer several insights with regard to earlier research. First, in addition to product markets, other niche dimensions may also function as a source of important interactions between organizational populations. Two organizational populations may also have several different types of interactions between their different niche dimensions, all contributing to the total interaction. Thus, although in some cases it may be possible that the product market is the main source of the interdependence, interactions in other niche dimensions may also play an important role (see e.g. Sorensen 2004; Dobrev et al. 2006). As a second insight, the proposed framework offers one explanation for why it has sometimes been difficult to identify statistically significant relationships between density variables of one organizational population, and the rate of organizational founding or mortality of the other population. Because the total interaction may consist of different sub-interactions with opposite effects, in some cases the density may be far too "crude" a measure of population interaction, and therefore unable to take into account all possible sub-interactions potentially present between different niche dimensions. The third insight is that the framework is also able to shed light on the inconsistencies of results found in earlier research with regard to interdependences between organizational populations: since the research has not considered the possible sub-interdependences between

the different dimensions of the niches of the populations, and has focused on aggregate interaction, it may have missed some potentially important interactions between the populations.

The main contributions of the empirical part of the study are as follows. First, the research context of the study, as such, is novel. The paper & pulp and the printing & publishing industries have thus far not been studied from the perspective of organizational ecology. Second, the results of the study increase the understanding of the interdependences between symbiotically or vertically related organizational populations and how these types of interactions may affect the structure and evolution of industries and organizational populations, which have been rarely studied in earlier research. Third, principally with regard to organizational ecology, but also other research areas of industry evolution, the results of the study show how type 2 interdependences, originating from resource dependencies, do not always occur between industries or organizational populations in the same geographic space, as earlier research often implicitly assumes or suggests (e.g. Audia et al. 2006). As shown in the study, the Finnish and Swedish paper and pulp industries have actually been more dependent on the German and UK printing and publishing industries than the Finnish and Swedish printing and publishing industries, respectively. In general, the printing and publishing industries in Finland and Sweden would not have enabled the growth of the Finnish and Swedish paper and pulp firms and industries to their current size.

Fourth, the results also offer evidence of the complexity of interdependences and how they may change in time. Even in the current context of two industries and four countries, the interdependences between the industries can be rather complex. Additionally, for example, the results of the analysis in the case of the German paper and pulp industry suggest how the strength of the interdependences between the industries may change as a function of time. Fifth, the evolutionary descriptions of the eight industries also add knowledge with regard to how the industries have evolved during 1950-2005 in particular, but also before that period. Although detailed histories of many of the industries exist, the large volume of time-series quantitative data and the systematic nature of the narratives make the descriptions rather unique. Sixth, with regard to more methodological contributions, the study introduces new measures of population interdependence, such as the actual resource flow between the industries (see also Audia et al. 2006). The actual resource flows between the industries can be considered a more accurate measure of interdependence between the organizational populations than population

density, as it is based on the real material flow between the studied populations.

1.4. Structure of the study

The structure of the study is as follows. After this introductory chapter, Chapter 2 introduces the theoretical background of the study: it offers an overview of earlier research on organizational ecology, presents definitions for some of the main terms, and analyzes earlier research on population interactions. Chapter 3 then introduces the theoretical framework of the study. Chapter 4 starts the empirical part of the study and introduces the research design of the study, the research context, and the data. Chapter 5 provides evolutionary narratives of the dynamics of the eight industries during the research period of the study, a descriptive analysis of the interdependences between the studied industries, and testable hypotheses of the interdependences. Chapter 6 presents a quantitative study of the interdependences between the industries. Finally, Chapter 7 presents a summary and discussion of the main results of the study.

2. Theoretical Background

As organizational ecology, and community ecology in particular has been chosen as the main conceptual and methodological basis of the study, this chapter contains an overview of this research. I will start with an introduction to the field of organizational ecology and present its main assumptions and theories. Following this, I will elaborate on two important ecological concepts with regard to the study as a whole and the theoretical framework introduced in the next chapter: organizational population and form, and population niche. A thorough analysis of earlier research on community ecology with focus on population interactions follows thereafter. My aim is to not only identify the problems and disagreements in this research stream, but also the issues upon which much of this research agrees. A summary and conclusions of the state of the art of this research stream follows at the end the chapter.

2.1. Organizational ecology

In their seminal paper, Hannan & Freeman (1977) introduce the perspective of population / organizational ecology to explore the question of why there are so many (or few) types of organizations or organizational forms. Thus, the focus of the research stream is on organizational diversity; on understanding how social conditions affect the rates at which new organizations and new organizational forms arise, the rates at which organizations change forms; the rates at which organizations and organizational forms die; and the dynamics that take place within organizational populations. Ecologists assume that the most important processes to study are population demographics, or what Carroll & Hannan

(2000) call vital events: patterns of organizational foundings, transformations, and disbandings.

Organizational ecology has its origins in the natural selection theories in biology with the work of Charles Darwin (Darwin 1859). In particular, organizational ecology approximates the Malthusian-Darwinian position on the nature of change in organizational populations over time (Hannan & Freeman 1989). The more recent intellectual roots of the perspective are in the neoclassical theory of human ecology, formulated by Hawley (1950; 1968), and in Stinchombe's (1965) research on change in the world of organizations. Ecology can be also considered to have its roots in and be related to a general evolutionary framework of variation, selection, and retention (VSR-framework, see Campbell 1969; Aldrich 1999; Aldrich & Ruef 2006).

Organizational ecology is also closely related in particular to the perspectives of resource dependence (Pfeffer & Salancik 1978) and neo-institutional theory (Meyer & Rowan 1977; DiMaggio & Powell 1983), classified as open-natural system theories of organizations (Scott 2003). Emerging in the 1970s, the three perspectives emphasize the importance of the environment in affecting the structure, behavior, and life chances of organizations, and challenge the assumption of organizations behaving as rational systems.

The basic assumption of organizational ecology, which differentiates it from the other open-natural system theories described above, is that organizations are relatively inert to change. In particular, organizational ecology assumes that it is the core properties of organizations – stated goals, forms of authority, core technology, and marketing strategy – that are difficult to change. This is because organizational structures are usually subject to high inertial forces that are both internal (such as an organization's investments on different types of assets, constraints on information, or organizational history) and external (such as legal and fiscal barriers to entry and exit, or legitimacy constraints) to organizations. This assumption about the high level of structural inertia does not, however, mean that organizations never change. Rather, it means that organizations respond relatively slowly to changes in their environments and, on average, the speed of reorganization is much lower than the rate at which environmental conditions change.

Thus, in contrast to the predominance of theories on organizational adaptation, ecology assumes that large-scale organizational change in organizational populations or communities is driven by evolutionary selection rather than organization-level adaptation (Hannan & Freeman 1977; Hannan & Freeman 1984). Similarly, most of the variability in the

core structures of organizations comes about through the creation of new organizations and organizational forms, and the demise of old ones. In the long run, this means that organizational populations emerge, change, and even die, not because the existing members of populations would flexibly transform their core properties and thus promptly adapt to environmental change, but because external selection processes introduce new organizations and even populations to replace existing ones over time (Hannan & Freeman 1977; Hannan & Freeman 1989; Carroll & Hannan 2000).

Given the assumption of organizational structural inertia described above, and because not all population-level processes are reducible to the level of organizations, the basic unit of analysis in much of the ecological research has been the organizational population. Accordingly, the second major assumption in organizational ecology is that populations of organizations can be considered to have a unitary character. A further assumption is that populations can be identified in a meaningful way on the basis of information about the structures of organizations and social boundaries.

A population is generally defined as a spatial-temporal instantiation of an organizational form (Hannan & Freeman 1977). In other words, all organizations within a population share the same organizational form, and are thus considered as fundamentally similar. An organizational form generally refers to "those characteristics of an organization that identify it as a distinct entity and, at the same time, classify it as a member of a group of similar organizations" (Romanelli 1991). Organizations sharing the same form have similar core structures (e.g. the product market served, stated goals, forms of authority, and core technology (Hannan & Freeman 1984), and occupy the same niche of resources within their environments (Freeman & Hannan 1983).

The population niche has been one of the main ways of defining organizational forms. In general, a niche can be defined as the "social, economic, and political conditions that can sustain the functioning of organizations that embody a particular form" (Hannan & Carroll 1995: 34), and its structure can be summarized by the fitness function, which is a rule relating the levels of environmental conditions to growth rates of populations. The use of niche in defining organizational forms is based on the fundamental duality that exists between organizational forms and niches: niches define forms and forms define niches. Because the population niche has in much of the earlier ecological research been mainly associated with the product market of the population studied, the reliance on using niche in defining the organizational form has resulted in the use of a product market to define both form and niche (Baron 2004; Sorensen

2004). Partly because of this, but also due to other difficulties in defining organizational form, much controversy still exists regarding the theoretical underpinnings of the concept of organizational form, and an unifying definition has yet to fully emerge (cf. Romanelli 1991; McKendrick, Jaffee, Carroll et al. 2003; Hannan, Polos & Carroll 2007).

As mentioned above, organizational ecology emphasizes the role of environment in affecting the structure and behavior of organizations. Organizations, thus, have many different types of dependencies with their environments, which consist mainly of other organizations, organizational populations, and organizational communities (Hannan & Freeman 1989), but also of other natural actors, political actors, technologies, and physical environments. Carroll & Hannan (2000) divide environments into exogenous and endogenous forms. An endogenous environment consists of all the effects imposed by other members within the organizational population in question, and exogenous of all the other effects.

Figure 2-1 presents a general framework of the structure of explanation in ecological research (in particular, demographical ecological research) (Carroll & Hannan 2000: 31). It shows the four general components of the argument used in ecological research: the social structure to be explained; decomposition of the entire set of organizations in the system into constituent organizational populations; estimation of population-specific vital rates; and specification of the environmental conditions affecting the rates. In the long run, it is also possible to detect exogenous feedback effects from the outcomes related to social structure to environmental conditions, and endogenous feedback effects from populations to population-specific rates.

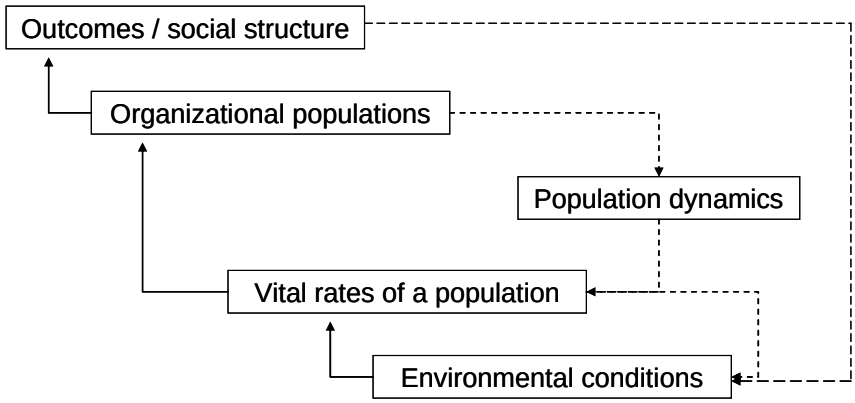

Figure 2-1: The structure of ecological explanations. Adapted from Carroll & Hannan (2001: 31).

With the structure of the ecological explanation in mind, organizational ecology, in terms of the levels of analysis used, distinguishes between the organizational demography, population ecology, and community ecology of organizations (Hannan and Freeman 1977; 1989). First, organizational demography considers variations in vital rates of organizational populations, both over time and between populations, and seeks to identify basic regularities in these rates. Additionally, it tries to relate variations in the rates to the pattern of change in the environments. Second, population ecology research focuses on interactions between localized sets of populations. Instead of considering each organizational population as an autonomous unit facing its environment, population ecology models describe how founding and mortality rates are affected by the presence and density of other organizational populations. The third level, community ecology, is interested in studying the evolution of a set of interacting populations. In particular, community ecology considers how the links between and among populations affect the likelihood and persistence of the community as a whole.

Table 2-1 presents an overview of earlier ecological research related to the three levels of analysis (for elaborate reviews of the empirical research carried out in different analysis levels, see e.g. Singh & Lumsden 1990; Amburgey & Rao 1996; Carroll & Hannan 2000; Lomi et al. 2005; Mattsson 2008). Before reviewing this research, it is important to note that, with reference to the three levels of analysis, most of the earlier ecological research has been conducted at the first level of analysis, namely organizational demography. This also includes most of the research categorized as population processes. Only the research on population interdependences may be considered as population ecology type research. However, much of this research may also be categorized as community ecology research, as has been often the case in earlier reviews and research (e.g. Baum 1996). The only pure type of community ecology research is that categorized as community processes. The basic unit of analysis in this research is an organizational community, and the research considers evolution and interdependences among organizational communities. In general, research on population interdependences and in particular on community evolution has been rare (e.g. Baum 1996; Sorensen 2004; Freeman & Audia 2006).

With regard to the focus of this thesis on industry evolution and interdependences among organizational populations, the research on population-level evolutionary processes and population interdependences can be considered as the most relevant. In general, this research builds strongly on the theory of density dependence (Hannan 1986; Hannan &

Carroll 1992), perhaps the most powerful and widely accepted model of organizational evolution. The main idea of the theory is that density can be used as a proxy for two main processes driving population evolution: legitimation and competition. In the early years of population evolution, an increasing density increases the legitimacy of the population, increasing the rate of founding and lowering the rate of mortality of organizations (more specifically, increases in density increase the population legitimation at a decreasing rate). Further increases in density, however, bring the population towards its environmental carrying capacity with regard to scarce resources and produce competition among the organizations, suppressing the rate of founding and increasing the rate of failure of organizations (more specifically, increases in density increase competition at an increasing rate).

Several extensions and modifications to the basic theory have also been introduced. These include, first, extensions to explain the typical population/industry life-cycle pattern, according to which the population density follows the shape of an inverted U[1]. As such, the basic density-dependence model is not able to produce this type of a pattern. Extensions to consider the declining density include density delay (Carroll & Hannan 1989; Hannan & Carroll 1992), mass dependence (Barnett & Amburgey 1990), temporal heterogeneity and interactions of density and population time (Baum 1995; Hannan 1997; Cattani, Pennings & Wezel 2003; Wezel 2005), dynamic selection pressure (Barron 1999), competitive intensity (Barnett 1997), and dynamic resource constraints (Lomi et al. 2005). In addition, several studies have also identified that the basic assumption of homogenous populations is too simplistic, and propose modifications to the basic model to account for e.g. the spatial heterogeneity of populations (Carroll & Wade 1991; Swaminathan & Wiedenmayer 1991; Hannan & Carroll 1995; Lomi ; Hannan 1997; Lomi 2000; Sorenson 2000; Swaminathan 2001; Greve 2002; Cattani et al. 2003; Wezel 2005). The most recent additions to the basic model include fuzzy density and revised models of legitimation (e.g. Bogaert, Boone & Carroll 2006; Hannan et al. 2007; Kuilman & Li 2009; Hannan 2010).

[1] Or other typical population evolution patterns, like resurgence after decline.

Table 2-1: Key ecological theories and processes.

Theories and processes	Description and predictions	Key concepts and variables	Key references
Organizational processes			
Age dependence	Different processes and theories of how organizational age affects survival chances of organizations. Processes include liability of newness, obsolescence, adolescence, and senescence	Organizational age; liability of newness, obsolescence, adolescence, and senescence; endowments; imprinting and structural inertia	(Freeman, Carroll & Hannan 1983; Brüderl & Schüssler 1990; Fichman & D.A. 1991; Barron, West & Hannan 1994; Henderson 1999; Hannan et al. 2007)
Size dependence	Different processes and theories of how organizational size affects the survival chances of organizations. In particular, liability of smallness, suggesting that failure rates decline with size, which buffers organizations from threats to survival	Organizational size; liability of smallness; capacity; scale of operations	(Freeman & Hannan 1983; Baum & Mezias 1992; Barnett, Greve & Park 1994; Edwards & Marullo 1995; Carroll, Bigelow, Seidel et al. 1996; Ranger-Moore 1997)
Population processes			
Niche-width dynamics	Specialist and generalist strategies. Effect of niche width on organizational mortality	Specialist strategy; Generalist strategy; Niche width	(Freeman & Hannan 1983; Carroll 1985; Dobrev, Kim & Hannan 2001; Dobrev, Kim & Carroll 2002)
Density dependence and its extensions	Legitimation and competition are two key mechanisms driving population evolution. Initial increases in density increase the legitimacy of a population, increasing foundings and lowering failures, but further increases produce competition, suppressing foundings and increasing failures. Extensions include:	Population density; legitimation; competition	(Hannan 1986; Hannan & Freeman 1987; Hannan & Freeman 1988; Hannan & Freeman 1989; Hannan & Carroll 1992)
	Density delay		(Carroll & Hannan 1989)
	Mass dependence		(Barnett & Amburgey 1990)
	Competitive intensity		(Barnett 1997)
	Temporal heterogeneity		(Hannan 1997)
	Dynamic selection pressure		(Barron 1999)
	Dynamic resource constraints		(Lomi et al. 2005)
Resource partitioning	As a population matures, the strongest competition for resources gets concentrated between a small number of generalist organizations positioned in the market centre. This crowding may free up uncontested resource niches in the market periphery for specialist organizations. This results in a late resurgence (decline) in entry (exit) rates for specialist organizations.	Specialist and generalist strategies; concentration; market centre vs. periphery	(Carroll 1985; Boone, Brocheler & Carroll 2000; Carroll & Swaminathan 2000; Carroll, Dobrev & Swaminathan 2002)

Table 2-1 (continues): Key ecological theories and processes.

Theories and processes	Description and predictions	Key concepts and variables	Key references
Size-localized competition	Organizations with similar size have similar strategies and thus mainly compete with organizations with similar size. This typically leads to bimodal size distributions, where relatively small and very large organizations may coexist within a population.	Competition; organizational size distributions	(Hannan & Freeman 1977; Hannan & Ranger-Moore 1990; Baum & Mezias 1992; Ranger-Moore, Breckenridge & Jones 1995)
Population interdependences	Examines cross-population density effects. Interdependences among populations vary from competitive to mutual.	Population density; population interdependences; competition; mutualism; symbiosis	(Hannan & Freeman 1977); For empirical research, see Table 2-3
Community processes			
Community structure and evolution	Examines the evolution of and interdependences among organizational communities	Organizational community; Community density	(Wade 1995; 1996; Zhang, Li & Schoonhoven 2009)
Environmental processes			
Institutional processes	Examines the effects of political turmoil, government regulation, and institutional linkages among others on the evolution (rates of organizational founding and mortality) of organizational populations	Institutions; political turmoil; government regulation; institutional linkages	(Carroll & Delacroix 1982; Delacroix & Carroll 1983; Carroll & Huo 1986; Singh, Tucker & House 1986; Tucker, Singh & Meinhard 1990; Baum & Oliver 1991; 1992; Barnett & Carroll 1993; Baum & Oliver 1996; Ingram & Inman 1996; Haveman & Rao 1997; Ingram & Clay 2000; Rao, Monin & Durand 2003; 2005)
Technological processes	Examines how technology cycles affect the patterns of founding and failure by, for example, changing the relative importance of various resources, creating opportunities to establish new competitive positions, and rendering the competencies of existing organizations obsolete	Technology cycles	(Tushman & Anderson 1986; Anderson & Tushman 1990)

The research on population interdependences concerns ecological interactions among organizational populations, the main theme of this study. This research often builds on the community ecology model introduced by Hannan & Freeman (1977), or the theory of density-dependence. I will review this research comprehensively in the following sections. Prior to this, however, I will discuss two key concepts for the remainder of the theoretical part of the study, namely organizational population and population niche.

2.1.1. On the concept of organizational population

Based on the assumptions about organizational populations discussed above, namely that (1) populations can be considered to have unitary characteristics (i.e. members of populations are sufficiently homogeneous) and (2) populations can be identified in a meaningful way on the basis of information about the structures of organizations and social boundaries, ecological research has commonly defined organizational populations as spatial-temporal instantiations of organizational forms (Hannan & Freeman 1977; 1989). Thus, every organizational population has to, first, be bounded in time. Second, it also has to be bounded and defined geographically. Third, the organizations in the population must share the same organizational form. In particular, this last characteristic has received a considerable amount of criticism due to the fact that no coherent and generally accepted definition of the concept of organizational form has yet emerged (Romanelli 1991; Hsu & Hannan 2005).

However, scholars usually tend to agree on the functional purpose of the concept of organizational form in ecological research: the concept is generally used to refer to "those characteristics of an organization that identify it as a distinct entity and, at the same time, classify it as a member of a group of similar organizations" (Romanelli 1991). Furthermore, it is generally agreed that the forms are socially constructed and are used in identifying organizations that are ecologically similar (Aldrich & Ruef 2006). Thus, in general, the purpose of the concept of organizational form is to identify classes of organizations that are similar in relation to some core elements (e.g. strategy, product markets, or external identity), but are simultaneously different and unique in terms of peripheral or less core features (Mattsson 2008).

Earlier research has defined organizational forms in various ways. First, in their seminal article, Hannan & Freeman (1977: 935) defined an organizational form as a "blueprint for organizational action, for transforming inputs into outputs". Such "blueprints" are essentially defined

by characteristics such as "formal structure, patterns of activity, and forms of authority (Hannan & Freeman 1977). Second, a few years later, Freeman & Hannan (1983) made the definition somewhat more specific by suggesting that organizations sharing the same form have similar core structures and occupy the same niche of resources within their environments. Such core structures can be (1) the organization's stated goals, (2) forms of authority, (3) core technology, and (4) customer base, among others (Hannan & Freeman 1984).

Third, researchers of organizational taxonomy and classification (e.g. McKelvey 1982; McKelvey & Aldrich 1983) have suggested that the problem of classifying organizational forms is analogous to classifying biotic species, and tracing flows of "comps" (organizational analogy for genes) between organizations allows family trees and classification of forms based on considerations of organizational genetics to be specified. As such, this and the two earlier definitions of forms belong to a class of definitions that Carroll & Hannan (2000: 60) label as "trait-based". Such definitions see organizational forms as clusters of features, some of which are core and others peripheral.

Fourth, another class of definitions approaches the concept of organizational form through the concept of social boundaries (Hannan & Carroll 2000). In this vein, organizations are also seen as clusters of features, but the existence and location of socially identifiable boundaries between different forms matters more than the clustered features per se (Hannan & Freeman 1986). The processes that create and maintain such boundaries include social network ties, flows of personnel between the organizations in a population, technological discontinuities, social movements, and simply geographical boundaries. Fifth, network ties have also been used in defining organizational forms. In other words, if two organizations have similar kinds of relationships with key actors and resources in their environments, they can be considered as structurally equivalent (Carroll & Hannan, 2000). Sixth, because the concept of niche is fundamentally related to organizational forms, the population niche structure has also been used in defining forms. For example, the fitness functions of organizational populations can be used to infer differences between forms.

Finally, recent research on the identities of organizations and organizational populations (Hsu & Hannan 2005; Hannan et al. 2007) has started to explain organizational forms through socially recognizable organizational identities. The identity-based approach is a promising endeavor for defining organizational forms. Without going deeper into this new theorizing, following logic similar to the social boundaries view, the

identity-based approach sees organizational forms as cultural objects. An organizational form presents an externally enforced, collective organizational identity. More specifically, an organizational form is a codified category to which an audience attaches a label and a collective identity in terms of codes regarding what is and is not acceptable for the members of the category (Hannan et al. 2007).

Despite the theoretical interest on the concept of organizational form, a majority of the extensive empirical research on organizational ecology has not explicitly applied the concept in defining organizational populations (cf. McKendrick & Carroll 2001). As already noted, earlier ecological research has often defined the populations following industry or product-market categories. Even the latest empirical ecological research building on the identity-based approach (e.g. Dobrev et al. 2006) still seems to follow earlier conventions.

As a conclusion, this study follows Hannan & Freeman's (1977) definition of organizational population as a spatial-temporal instantiation of an organizational form. With regard to the concept of organizational form, I do not aim at offering an exhaustive definition (since even voluminous earlier research has not been able to do this). What is, however, important for the purposes of the theory created in this study, is the fundamental duality that earlier research sees to be present between forms and niches (cf. Popielarz & Neal 2007): niches define forms and forms define niches. Thus, when considering an organizational population (with a specific form), it can be seen to occupy a specific niche that differentiates it, at least in some respects, from other organizational forms and populations.

2.1.2. On the concept of population niche

The concept of niche has a long history in the context of sociological research. **Figure 2-2** tracks the development path of the concept in sociological research from its biological origins to its current uses. Currently, the concept is used in two somewhat different types of meanings; in the research on organizational ecology, and social structure. As this study follows the ecological research tradition, I define niche based on organizational ecology and do not consider the definition used in social structure type research (e.g. McPherson 1983; McPherson & Ranger-Moore 1991; McPherson, Popielarz & Drobnic 1992; McPherson & Rotolo 1996; McPherson 2004).

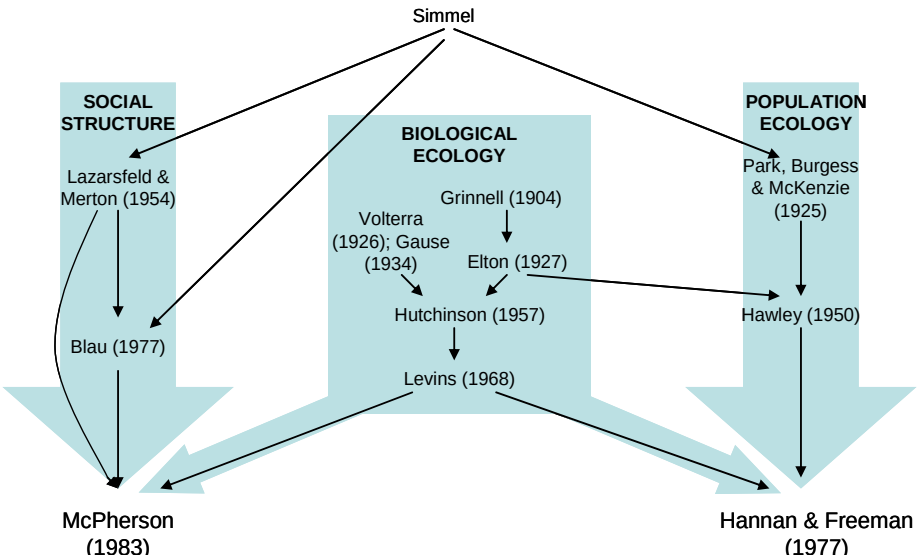

Figure 2-2: Schematic representation of the development of niche from its origins in biology to its use as a theoretical tool in two principal sociological traditions[2].

The concept of niche, as used in ecological research, has its roots in biological ecology, and in particular, in a general definition formulated by Hutchinson (1957): The niche of a species is the set of environmental states in which it thrives. So, geometrically, a niche can be considered a multidimensional space, in which each relevant aspect of the environment specifies a spatial dimension. For example, for an analysis that considers only two environmental factors, the space is a two-dimensional Euclidean plane. The niche of a species could then be represented by a rectangle in this plane that encloses all the points corresponding to the environmental states within which the species thrives (see Popielarz & Neal 2007).

An important extension to this definition, a possibility that an optimal part of the niche for the species in question may also exist, was introduced by Levins (1968) in a form of a fitness function, allowing for a variable level of fitness at different positions within a niche. The fitness function defines a niche, on a single environmental factor, as a probability density function where the x-axis indicates the different environmental states and the y-axis indicates the corresponding fitness or probability of survival. The maximum of the fitness function, therefore, indicates the environmental state where the species is fittest. Because the area under a probability density function is a unity, a fitness function that is taller must also be narrower, whereas a wider fitness function is flatter. Therefore, a species with a narrow niche is

[2]The dates refer to papers or books that were either the first or most seminal at each point in this development. The arrows indicate actual working relationships, citations, and/or intellectual affinities. Adapted from Popielarz & Neal (2007).

very fit, but only under a small range of environmental states – referred to as a specialist – and a species with a wider niche is relatively less fit, but under a great range of environmental states – referred to as a generalist.

By building on these concepts and Hawley's (1950) principle of competitive isomorphism, according to which the diversity of organizational forms reflects the diversity of environments, Hannan & Freeman (1977) suggest that within a given location and time period, any collection of organizations that share the same form constitutes a population, and each population occupies an identifiable niche in that systems' environment. More formally, Hannan & Freeman (1977) define a (fundamental) population niche as that area in constraint space (the space whose dimensions are levels of resources etc.) in which the population's growth rate is nonnegative. Thus, the fundamental niche of an organizational population consist of those social, political, and economical resources and conditions that can sustain the functioning of organizations that embody the form (Hannan & Carroll, 1992).

With regard to earlier ecological research, two theories have explicitly addressed the concept of the niche. In general, these theories, however, focus on realized niches of organizational populations or individual organizations. First, niche-width theory examines how dynamic environments affect organizational populations (Freeman & Hannan, 1983). The fundamental concern is how environmental dynamics determine a population's niche width, or the range of environmental conditions for which the population's fitness function is positive. In this type of research, niche width is typically treated as a dichotomy: generalists occupy wide niches and specialists occupy narrower ones. Second, the theory of resource partitioning starts from the question of why markets for products and services often appear to be partitioned into two noncompeting subpopulations of market-center generalists and peripheral specialists (see also **Table 2-1**). The main hypothesis is that an increasing market concentration among generalist organizations leaves room for a specialist at the edges of the market, although this process may reflect several different mechanisms (Carroll et al. 2002). In general, empirical research on resource partitioning examines how the founding and failure rates of specialists and generalists respond to increasing concentration among generalists (see e.g., Carroll & Swaminathan 2000; Mezias & Mezias 2000; Swaminathan 2001; Boone, van Witteloostuijn & Carroll 2002).

Furthermore, recent ecological research has also aimed at integrating the theories of niche-width, resource-partitioning, and density dependence to form a more comprehensive organizational ecology (Dobrev et al. 2001; Dobrev et al. 2002; Dobrev, Kim & Carroll 2003). When resource-

partitioning theory explains how market concentration drives the vital rates of specialists and generalists, the three studies aiming at integrating the three ecological theories focus on how concentration may also induce organizations to change either the niche width or the niche position. Dobrev and colleagues address the effects of niche change both directly (Dobrev et al. 2001) and indirectly with changing market concentration (Dobrev et al. 2002).

Although the basic definition of a population niche treats it as a multidimensional construct (in a sense that a population's resource environment is multidimensional), later ecological research has often considered it to be only one-dimensional. In particular, in much of earlier ecological research, a population niche has been considered to be more or less the same thing as the product market (Baron 2004; Sorensen 2004). Some research has, however, emphasized the multidimensional characteristic of the niche, at least implicitly (e.g. Podolny, Stuart & Hannan 1996; Barnett & Woywode 2004; Simons & Ingram 2004; Dobrev et al. 2006; Sorenson, McEvily, Ren et al. 2006; Audia & Rider 2010; Mattsson & Järvinen 2010). For example, Podolny et al. (1996) argue in their study that organizations compete in multiple domains and hence occupy multiple niche domains. In the context of the semiconductor industry, they consider the two main dimensions on which the firms compete to be product market and technology. The results of their empirical research suggest that at least during a period of rapid growth in market demand, the characteristics of a firm's technological niche matter more for the firm's growth than the sales growth of the firm's technological competitors. Barnett & Woywode (2004) and Simons & Ingram (2004) also implicitly see the niches of populations studied as multidimensional (as also Dobrev et al. 2006): the niche consists of parts related to resources and parts related to ideology, creating different types of interdependences among the populations. In addition, there is also research with a focus on niche dimensions other than market niche dimensions, primarily those related to labor (e.g. Korn & Baum 1994; Sorensen 2004).

Consequently, for the purposes of this study, I define the population niche, based on Hannan & Freeman (1977), as that area in a multidimensional resource space where the population's growth rate is non-negative. Thus, it is possible to divide a niche to N number of dimensions based on different environmental conditions/resources. This type of niche is called "fundamental" because it refers to the physiological capacities of the members of the population (Hannan, Carroll & Polos 2003).

2.2. Research on population interdependences

This section contains a comprehensive review on earlier ecological research on population interdependences. My focus is, in particular, on analytical frameworks, definitions of the population niche, and empirical variables and results of earlier research. Before going deeper into this research, I will discuss earlier community ecology research in general. Although much of the earlier research on population interdependences may also be categorized as population ecology type research (if the definitions for the three analysis levels are strictly followed), earlier research considers this type of research mostly as part of the community ecology paradigm (see e.g. Baum 1996; Aldrich & Ruef 2006). This study will follow earlier research in this respect.

The current community ecology paradigm has its intellectual origins in Hawley's (1950) research on human ecology. In his book, Hawley argued that human ecology should focus on its relational aspects: patterns of symbiosis and commensalism in populations. Further, Hawley emphasized two aspects of communities that became the focus of subsequent debate: relations between populations within a community, and the boundary between a community and its environment (Aldrich & Ruef 2006).

By building explicitly on Hawley, Hannan & Freeman (1977) introduced a community ecology approach to organizational settings, emphasizing in particular the similarities and differences between populations. Hannan & Freeman also presented a logistic growth model, building on the general Lotka-Volterra population ecology model, for estimating competitive interdependences among organizational populations. In the case of n competing populations, the equation for Lotka-Volterra community system becomes

$$\frac{dX_i}{dt} = r_i X_i \left(k_i - X_i - \sum \alpha_{ij} X_j\right) / k_i \text{ , } (i = 1, \ldots, n),$$

where X_i denotes the size of population i, k_i is the capacity of the environment to support X_i, and r_i is the so-called natural rate of growth of population i. The representative generalized Yule (GY) model of population growth, which can be used directly in estimating the interaction coefficients, can be then written in the following form (see Ruef 2004):

$$\exp\left(\frac{dN_i}{dt}\right) = N_{it}^{\alpha} \exp\left(\gamma N_{it}^2 + \eta \sum_{j \neq i}^{j} N_j\right),$$

where N_i is the density of organizations of organizational form i and η represents the competitive impact of other organizational populations. Although this model did not originally count for positive (or mutualistic) interdependence between populations, it has been later extended to cover these.

Although Hannan & Freeman (1977) explicitly introduced a community ecology perspective to answer the question of why there are so many (or few) different types of organizations, the later ecological research has focused mostly on the selection processes within the evolution of individual organizational populations. In reaction, Astley (1985) emphasized the importance of community ecology type research and argued that research on organizational ecology should also focus on the dynamics of community ecology. After Astley, during the 1980s and 1990s, the concept of community evolution became somewhat diffuse, as authors disagreed in subtle ways on how to conceptualize a community (Aldrich & Ruef 2006). For example, such labels as organizational field (DiMaggio & Powell 1983), societal sector (Scott & Meyer 1983), and organizational community (Astley 1985) came into broad use.

Currently, there are also different perspectives on communities and community ecology. As described by Aldrich and Ruef (2006), these perspectives differ mainly by their empirical strategies. First, a number of studies have attempted to measure inter-population flows of members, materials, and symbols directly (e.g. McPherson 1983; Popielarz & McPherson 1995; see also Sorensen 2004). The second perspective then follows Hannan & Freeman (1977) and considers two populations as interdependent insofar as one population affects the viability (i.e. vital rates) of another. This study focuses predominantly on research in the latter approach. With regard to this approach, the study also follows, at a general level, Aldrich & Ruef's (2006: 243) latest definition of an organizational community: "An organizational community is a set of co-evolving organizational populations joined by ties of commensalism and symbiosis through their orientation to a common technology, normative order, or legal regulatory regime."

Despite the importance of the research topic, community ecology research on interdependences among populations of organizations has been rare[3]. Sorensen (2004) suggests that this is, first, due to the difficulties inherent in assembling community ecology data. Because it requires a huge effort to

[3] Freeman & Audia (2006), however, suggest that recently this type of research has started to gain popularity.

compile solid datasets even from the evolution of one organizational population, the emphasis of earlier research on temporal depth (i.e. starting to study the evolution of a population from the entry of the first organization of a given type) in observation has meant a sacrifice in breadth. A second reason for the absence of community level research is related to measurement issues. First, estimating the patterns of interdependence in the form of a community matrix of competition coefficients between populations using Lotka-Volterra equations (Hannan & Freeman 1989) may be difficult, especially with a large number of populations. This is because the Lotka-Volterra models do not have analytical solutions (Carroll 1981). The second measurement issue is related to the approach, where one starts with a specification of a hypothesized pattern of interdependence between populations, and tests whether or not it has observable implications for the dynamics of a focal population. However, unless one measures patterns of resource utilization directly, this approach can only work if one is willing to make ad hoc arguments about which populations should be interdependent. Because the number of studied populations considered in community ecology is often high, this kind of an ad hoc approach is less likely to be persuasive.

In the following, I will finally turn into the review and analysis of earlier research on population interdependences. As mentioned above, the focus of the review is on earlier ecological analysis of population interdependences. The main conditions for a study to be taken into consideration in the review are that (1) it has to include organizational populations (or sub-populations) that are clearly differentiated of each other, and (2) interdependences are studied at least from the point of view of one organizational population. Thus, for example, many niche-width studies that consider organizational niches, and regard every individual organization as potentially occupying an own niche (e.g. Baum & Singh 1994a; 1994b), are not covered in the following. However, the review covers much of earlier resource-partitioning related research because it can be seen to, at the least, control for potential interdependences among the sub-populations studied[4]. On the basis of comprehensive literature searches[5], I argue that the reviewed literature should not only cover most of the earlier

[4] Again, if the niche is defined continuously, as, for example in recent research aiming at combining theories of niche width, resource partitioning and density dependence (Dobrev et al. 2001; 2003), the research is not taken into consideration.

[5] The sample of literature has been derived by doing literature searches from several databases (e.g. Isi Web of Science) and by identifying additional research from the list of references of already identified research.

ecological research that focuses explicitly on population interdependences, but also research that only controls for possible inter-population effects.

2.2.1. Types of interdependences among populations

Earlier research has been rather inconsistent about the possible types of interdependences among populations, as can also be noted in **Table 2-3**, which offers an overview of this research, with focus on the community studied and the suggested interdependences among the organizational populations / sub-populations. In particular, the use of the terms mutualism, commensalism, and symbiosis have had somewhat different meanings and connotations in many studies; these are listed and examined below. First, Brittain & Wholey (1988) identify the following types of interactions among two populations, j and k, where the signs for α_{jk} and α_{kj}, are respectively: (-,-) full competition, (-,0) partial competition, (+,-) predatory competition, (0,0) neutrality, (+,0) commensalism, and (+,+) symbiosis. Later, Baum & Korn (1994), Korn & Baum (1994), and Brittain (1994) follow this framework (see also Baum 1996).

Second, Hawley's (1950) division of population interdependences along symbiotic and commensalistic dimensions has been followed in several later studies (see e.g. Barnett & Carroll 1987; Barnett 1990; Baum & Oliver 1991; Boeker 1991; Carroll & Swaminathan 1992; Staber 1992; Baum, Korn & Kotha 1995; Lomi 1995; Ingram & Simons 2000; Audia et al. 2006; Dobrev et al. 2006). However, even these studies define and use the terms differently. For instance, Barnett & Carroll (1987) and Barnett (1990) suggest that interdependences among populations may vary from competitive (i.e. one organizational population has a negative effect on the vital rates of the other) to mutualistic (i.e. one population has a positive effect on the vital rates of the other). Additionally, Barnett & Carroll propose that mutualistic interdependences may have two distinct bases: commensalism, "...defined as positive interdependence based on supplementary similarities" (Barnett & Carroll 1987: 401) and symbiosis, "...which is positive interdependence based on complementary differences" (ibid.).

On the other hand, the latest refinement of this type of a framework by Aldrich & Ruef (2006) proposes somewhat different definitions. Also drawing on Hawley (1950), they consider that relationships among organizational populations in an evolving community revolve around two axes: symbiotic and commensalistic. The symbiotic axis refers to the interdependence of unlike forms, i.e. units of dissimilar functions, and the commensalistic axis refers to the interdependence of like forms, i.e. units of

similar functions. By reference to the definitions of symbiosis and commensalism, symbiosis denotes a mutual dependence between dissimilar units (or in this case, mutual dependence between two populations in different niches), whereas commensalism means that units make similar demands on the environment (or the interaction between two populations with similar overlapping niches) (Aldrich & Ruef 2006; cf. Hawley 1950).

Based on these premises, Aldrich & Ruef (2006) propose eight different relationships that may exist between populations (see **Table 2-2**). Six of these constitute various forms of commensalism (i.e. from full competition (-,-) to full mutualism (+,+)), and the seventh is symbiosis (+,+). The eighth type of interdependence is that of dominance, emerging as a hierarchical relation between populations, and based on the outcome of symbiotic and commensalistic interactions (see Hawley 1950).

Table 2-2: Types of population interdependences proposed by Aldrich & Ruef (2006).

I. Commensalism	
(- , -) Full competition	Growth in each population detracts from growth in the other E.g. competition between voluntary associations for members from the same socio-demographic groups (McPherson 1983)
(- , 0) Partial competition	Relationships are asymmetric, with only one having a negative effect on the other E.g. right-wing newspapers increased the failure rates of centrist papers in interwar Vienna (Barnett & Woywode 2004)
(+ , -) Predatory competition	One population expands at the expense of the other E.g. sharecropping and share tenancy arrangements developed at the expense of plantations in the postbellum South (Ruef 2004)
(0 , 0) Neutrality	Populations have no effect on each other E.g. founding rates of commercial and savings banks in Manhattan had no effect on each other (Ranger-Moore et al. 1991)
(+ , 0) Partial mutualism	Relationships are asymmetric, with only one population benefiting from the presence of the other E.g. the growth of brew pubs stimulated foundings of microbreweries, but not vice versa (Carroll & Swaminathan 1992)
(+ , +) Full mutualism	Two populations in overlapping niches benefit from the presence of the other E.g. small and large railroads and telephone companies benefited from each other's presence (Barnett 1995; Dobbin 1994)
II. Symbiosis	
(+ , +) Symbiosis	Two populations are in different niches and benefit from the presence of the other
III. Dominance	
	A dominant population controls the flow of resources to other populations (Hawley 1950); the effect depends on the outcome of commensalistic and symbiotic relations

Legend: Signs in parentheses refer to the effect of one population, A, on a second population, B.
+ positive effect
0 no effect
- negative effect

A third focus of studies examining interdependences is one that mainly considers competitive interactions among populations (see e.g. Hannan & Freeman 1989; Boeker 1991; Carroll & Wade 1991; Ranger-Moore, Banaszak-Holl & Hannan 1991; Budros 1994; Ingram & Inman 1996; Wezel & Lomi 2003; Audia & Rider 2010), often building on the theory of density-dependence (Hannan 1986; Hannan & Freeman 1989). Many of these studies only use inter-population effects as controls in their models, and theoretically focus on some other aspects of ecological theory.

Finally, in a somewhat similar vein to the research discussed above, many of the studies in **Table 2-3** do not explicitly discuss the possible types of interdependences, but use inter-population effects only as controls in their studies and/or focus on other theory fragments of organizational ecology. For instance, research on the theory of resource partitioning has often divided the population studied into one or more sub-populations and considered interdependences among them, although the interdependences have been interpreted from the point of view of the resource partitioning theory (e.g. Carroll & Swaminathan 2000; Swaminathan 2001; Boone et al. 2002; Boone, Carroll & van Witteloostuijn 2004)

Consequently, differences in earlier studies with regard to the types of interdependences that potentially exist among populations are considerable. For instance, where the framework presented by Brittain & Freeman (1988) does not make any assumptions about the overlaps/non-overlaps in the niches of the populations investigated, studies drawing on Hawley (1950) divide the possible types of interdependences according to whether the niches of the populations overlap (commensalistic populations) or not (symbiotic populations). This then results in differences in the definitions of the terms of commensalism, mutualism, and symbiosis. For example, where commensalism, in the language of Brittain & Freeman (1988), refers to a specific (+,0) interaction between two populations, in Barnett & Carroll (1987) it refers to a positive interaction based on supplementary similarities, and in Aldrich & Ruef (2006) it refers to several different types of interaction (varying from full competition to full mutualism) among populations with similar overlapping niches. Similarly, where Brittain & Freeman (1988) perceive symbiosis as a specific (+,+) interaction among populations, Barnett & Carroll (1987), and Aldrich & Ruef (2006), consider symbiosis as a positive interaction between complementarily different organizational populations. Finally, Brittain & Freeman (1988) do not use the term mutualism at all, Barnett & Carroll (1987) see mutualism as all kinds of positive interaction between two populations, and Aldrich & Ruef (2006) consider it as a positive interaction between two populations with similar, overlapping niches.

However, there are also similarities in earlier research with regard to types of interdependences. In particular, the concept of competition can be considered to have the same kind of meaning in all research studying population interdependences: competition refers to an interaction where one population has a negative effect on the vital rates of the other population (and possibly vice versa).

Table 2-3: Overview of previous studies with focus on population interdependences: a description of community/populations studied and the suggested interdependences among the studied populations.

Article / Book chapter	Community/populations studied	Possible types of interdependences among studied populations / sub-populations
Barnett & Carroll (1987)	Telephone companies in three counties of southeast Iowa, 1900-1917; Local and non-local commercials and local and non-local mutuals	Interdependences may vary from competitive to mutualistic; Mutualistic interdependences further divided into commensalistic and symbiotic
Brittain & Wholey (1988)	U.S. electronic components manufacturing industry 1949-1981; (1) Specialists, receiving tubes, (2) r-specialists, discrete components, (3) K-specialists, discrete components, (3) r-specialists, integrated circuits, (4) K-specialists, integrated circuits, (5) r-generalists, (6) K-generalists)	(1) (-,-) full competition (2) (-,0) partial competition (3) (+,-) predator-prey (4) (0,0) neutrality (5) (+,0) commensalism (6) (+,+) symbiosis
Hannan & Freeman (1989)	U.S. craft and industrial labor unions, 1836-1985	Focus on competitive interdependences
Barnett (1990)	Early Pennsylvania telephone companies, 1879-1934; Early Southeast Iowa telephone companies, 1900-1929; Magneto and common battery technologies; Common battery single- and multi-exchange companies	Interdependences may vary from competitive to mutualistic
Baum & Oliver (1991)	Day care centers and nursery schools in Metropolitan Toronto, 1971-1987	Interdependences may vary from competitive to mutualistic
Boeker (1991)	U.S. brewers in 45 states in the U.S.: national firms, regional firms, and local firms; 1962-1979	Focus on competitive interdependences
Carroll & Wade (1991)	Pennsylvania brewing industry: rural breweries and urban breweries, 1800-1988	Focus on competitive interdependences
Ranger-Moore, Banaszak-Holl & Hannan (1991)	Commercial and savings banks in Manhattan, 1792-1980; Mutual and stock life insurance companies in New York State, 1760-1937	Focus on competitive interdependences
Carroll & Swaminathan (1992)	U.S. brewing industry: microbreweries, brew pubs, and mass producers, 1975-1990	Interdependences may vary from competitive to mutualistic
Rao & Neilsen (1992)	U.S. mutual and stock savings and loan associations, commercial banks, life insurance companies, and mutual savings banks, 1960-1987	Focus on competitive interdependences
Staber (1992)	Worker, marketing, and consumer cooperatives and credit unions in three Maritime provinces of Atlantic Canada: New Brunswick, Nova Scotia, and Prince Edward Island, 1900-1987	Interdependences may vary from competitive to mutualistic
Wholey, Christianson & Sanchez (1992)	U.S. HMOs, 1976-1991: group HMOs and independent practice associations	Types of interdependences not explicitly discussed
Baum & Korn (1994)	200 largest public Canadian companies between 1984-1991 Organizations divided into five sectors based on SIC codes: (1) natural resources; (2) manufacturing; (3) transportation, communication, electrics, and gas; (4) wholesale, retail trades; and (5) finance, insurance and real estate	Types of interdependences based on Brittain & Wholey (1988)
Brittain (1994)	U.S. electronic component producers, 1947-1981: r-specialists, K-specialists, r-generalists, and K-generalists	Types of interdependences based on Brittain & Wholey (1988)

Table 2-3 (continues): Overview of previous studies with focus on population interdependences: a description of community/populations studied and the suggested interdependences among the studied populations.

Article / Book chapter	Community/populations studied	Possible types of interdependences among studied populations / sub-populations
Budros (1994)	New York's life insurance companies and savings banks, 1842-1904	Focus on competitive interdependences
Korn & Baum (1994)	200 largest public Canadian companies in each year 1985-1992; Organizations divided into five sectors based on SIC codes: (1) natural resources; (2) manufacturing; (3) transportation, communication, electric, and gas; (4) wholesale and retail traders; and (5) finance, insurance, and real estate organizations	Types of interdependences based on Brittain & Wholey (1988)
Baum, Korn & Kotha (1995)	Manhattan facsimile transmission companies: pre- and post dominant design cohorts, 1965-1992	Interdependences may vary from competitive to mutualistic
Lomi (1995)	Italian co-operative banks: rural co-operative banks, popular co-operative banks, (and savings- and loan institutions) 1936-1989	Interdependences may vary from competitive to mutualistic
Swaminathan (1995)	Wine industry in the U.S., 1941-1990: Mass wineries (generalists) and farm wineries (specialists)	Interdependences may vary from competitive to mutualistic
Ingram & Inman (1996)	Hotel populations at Niagara falls: New York hotels 1885-1991 and Ontario hotels 1904-1991	Focus on competitive interdependences
Ingram & Baum (1997)	Manhattan hotel industry, 1898-1980: chain affiliated (component) and independent hotels	Types of interdependences not explicitly discussed
Silverman, Nickerson & Freeman (1997)	For-hire trucking industry in the U.S., 1977-1989: Large carriers and small carriers	Interdependences may vary from competitive to mutualistic
Swaminathan (1998)	Beer brewing industry in the U.S., 1933-1995: Mass producers, microbreweries, and brewpubs	Interdependences may vary from competitive to mutualistic
Zucker, Darby & Brewer (1998)	U.S. biotechnology firms, 20 top universities, and venture capital firms, 1976-1989; U.S. divided into 183 regions based on functional economic areas as defined by the BEA	Types of interdependences not explicitly discussed
Carroll & Swaminathan (2000)	Beer brewing industry in the U.S., 1938-1997: Mass producers, microbreweries, brewpubs, and contract brewers	Types of interdependences not explicitly discussed; Focus on testing the theory of resource partitioning
Ingram & Simons (2000)	Israeli workers' cooperatives, Israeli banks, Israeli credit cooperatives, and Israeli kibbutzim, 1920-1992	(Ideological) Interdependences may vary from competitive to mutualistic
Ruef (2000)	Community of American health care sector, 1965-1994; 48 different organizational forms	Interdependences vary from competitive to symbiotic
Swaminathan (2001)	U.S. wine industry: farm wineries and mass production wineries, 1941-1990	Types of interdependences not explicitly discussed
Boone, Carroll & Wittelostuijn (2002)	Newspaper industry in the Netherlands, 1968-1994: National (generalist) newspapers, regional (specialist) newspapers, and regional newspapers in Ranstad area	Types of interdependences not explicitly discussed; Focus on testing the theory of resource partitioning
Greve (2002)	Banking industry in Tokyo: Bank headquarters and branches, 1894-1936	Types of interdependences not explicitly discussed
Simons & Ingram (2003)	Kibbutz population, moshav population, capitalist organizations, and development town population in Israel, 1910-1997	Focus on competitive interdependences (based on ideology)
Wezel & Lomi (2003)	Motorcycle industries in Belgium, Italy, and Japan, 1898-1993	Focus on competitive interdependences
Barnett & Woywode (2004)	Viennese newspapers, 1918-1938; left-wing, centrist, and right-wing newspapers	Focus on ideological competition among organizational populations
Boone, Carroll & Wittelostuijn (2004)	Newspaper industry in the Netherlands, 1968-1994: National (generalist) newspapers, regional (specialist) newspapers, and regional newspapers in Ranstad area	Types of interdependences not explicitly discussed; Focus on testing the theory of resource partitioning
Ruef (2004)	U.S. Medical schools, 1765-1999: regular (allophatic), secreterial schools, and nursing schools	Focus on competitive interdependences

Table 2-3 (continues): Overview of previous studies with focus on population interdependences: a description of community/populations studied and the suggested interdependences among the studied populations.

Article / Book chapter	Community/populations studied	Possible types of interdependences among studied populations / sub-populations
Simons & Ingram (2004)	Two types of Jewish agricultural cooperatives (the moshaw and the kibbutz), credit cooperatives, and corporations, 1910-1997; Analyses at the level of 10x10 km regions	Interdependences based on ideology may vary from mutualistic to competitive
Sorensen (2004)	84 industries in Denmark, 1980-1991	Focus on competitive interdependences
Audia, Freeman & Davidson Reynolds (2006)	Community of instrument manufacturers in the U.S.: Instrument manufacturers and their suppliers and purchasers, 1976-1988; A community is defined based on LMA (Labor market area): In total, paper divides U.S. instrument manufacturers into 382 communities	Interdependences may vary from competitive to mutualistic; Mutualistic interdependences are further divided into symbiotic or commensalistic
Dobrev, Ozdemir & Teo (2006)	Financial cooperatives and commercial banks in Singapore, 1925-1994	Interdependences among commensalistic populations with similar, overlapping niches may vary from competitive to mutualistic.
Nunez-Nickel & Moyano-Fuentes (2006)	Olive oil production industry in the province of Jaen, 1944-1998: Mutual oil mills and stock oil mills	Focus on competitive interdependences
Audia & Rider (2010)	Footwear manufacturing plant population in the U.S., 1975-1991; Additionally, chemical plants and rubber plants	Types of interdependences not specifically discussed
de Figueiredo & Silverman (2010)	Desktop laser printer industry in the U.S., 1984-1996; Engine manufacturers and printer manufacturers	Interdependences may vary from mutualistic to competitive

2.2.2. (Assumed) niche overlaps/non-overlaps among the organizational populations studied

In this section, I will analyze how earlier research has taken into consideration the overlaps/non-overlaps in the niches of the populations that have been studied. As **Table 2-4**, summarizing how earlier research has considered the overlaps/non-overlaps in the niches of the populations studied, suggests, most of the earlier research has focused on the interdependences between populations assumed to have considerable overlap in their niches. This is rather understandable, because this kind of approach usually requires the gathering of data on the evolution of only one industry or organizational population. The "original" population is then later divided into two or more sub-populations according to some differing characteristics.

In some studies of this type, the populations studied are differentiated on the basis of differences in their organizational form. For example, in their study of the evolution of the U.S. brewing industry, consisting of sub-populations of microbreweries, brewpubs, and mass producers, Carroll & Swaminathan (1992) state that both the microbrewery and brewpub differ from the mass production brewery in terms of four core properties – stated goals, forms of authority, core technology, and marketing strategy – that are commonly used to define an organizational form (see also e.g.

Swaminathan 1998; Carroll & Swaminathan 2000). Similarly, in a study of interdependences among worker cooperatives, marketing cooperatives, and consumer cooperatives and credit unions in the three maritime provinces of Atlantic Canada, Staber (1992) finds that although different forms of cooperatives may be distinguishable in terms of technologies, strategies and structure, they tend to draw on similar aspects of the same general environment. Thus, although each form might occupy a unique ecological niche, their niches overlap considerably.

Studies also often differentiate sub-populations on the basis of differences in the niche dimensions related to product markets. This is rather logical, taking into consideration that earlier ecological research has commonly defined populations in terms of the recognized product markets (Baron 2004; Sorensen 2004; Popielarz & Neal 2007). In these dimensions, differences in the niches of the sub-populations are generally based on strategies (e.g. generalism vs. specialism) (Barnett & Carroll 1987; Brittain & Wholey 1988; Hannan & Freeman 1989; Brittain 1994; Swaminathan 2001; Boone et al. 2002; Boone et al. 2004) or on geographic location or scope (Boeker 1991; Carroll & Wade 1991; Greve 2002). For instance, Barnett & Carroll (1987) divide the telephone companies in three counties of southwest Iowa into sub-populations based on their main strategy and geographic location (i.e. commercial companies located in cities and mutual companies located in rural areas). Boone et al. (2002; 2004), on the other hand, divide the newspaper firms in Netherlands into national (i.e. generalist) newspapers and regional (i.e. specialist) ones: national newspapers target the whole Dutch readership audience, whereas regional newspapers target local residence populations.

Technology has also been used to differentiate sub-populations from each other. For example, Barnett (1990) proposes that it is often technological similarities or differences that create at the least mutual interdependences among organizations and organizational populations. Similarly, in dividing a population of instrument manufacturers into several sub-populations, Brittain & Freeman (1988) and Brittain (1994) use technological differences as one dimension.

Some studies also consider interdependences created by overlaps or non-overlaps in identity space (Ingram & Simons 2000; Simons & Ingram 2003; Barnett & Woywode 2004; Simons & Ingram 2004; Dobrev et al. 2006). Ingram & Simons (2000), Barnett & Woywode (2004) and Simons & Ingram (2004) focus specifically on interdependences among organizational populations created by differing ideologies. In particular, Ingram & Simons (2000) study the community of workers' cooperatives, banks, credit cooperatives, and kibbutzim, all in Israel, with a focus on how

banks, credit cooperatives, and kibbutzim affect the vital rates of workers' cooperatives. They suggest that workers' cooperatives share the same ideology with credit cooperatives and kibbutzim, but that the ideologies between workers' cooperatives and banks are somewhat opposite. Although the article suggests that it is ultimately the differences or similarities in ideology that create interdependences between the studied populations, it also points out that interdependences between, for instance, workers' cooperatives and banks may be based on resource dependencies: banks are an important supplier of money for workers' cooperatives (see Ingram & Simons 2000: 34).

Extending Ingram & Simons' article, Barnett & Woywode (2004) examine the effects of ideological interdependences between left-wing, right-wing, and centrist Viennese newspapers between 1918 and 1938. Differing from Ingram & Simons, Barnett & Woywode consider that the niches of all the three sub-populations substantially overlap (e.g. product or labor markets), and this overlap is accentuated by different ideologies creating overlaps/non-overlaps in the identity space of the populations. The total interdependence among the populations is thus created by both resource and ideology (identity) niche overlap/non-overlap.

Building on and extending Ingram & Simons (2000) and Barnett & Woywode (2004), Simons & Ingram (2004) examine ideology-related interdependences among two types of Jewish agricultural cooperatives (moshaw and kibbutz), credit cooperatives and corporations from 1910 to 1997, and uses both ideological and resource-related characteristics to differentiate the four populations from each other. The niches of the first two populations are highly similar. The moshaw and kibbutz share a similar set of resources (e.g. land, customers, and potential participants) and a similar kind of ideology as well. However, their ideologies are not identical: the moshaw do not give the same priority to the interests of the collective over those of the individual and family as do the kibbutz. Considering then the differences between moshavim and kibbutzim and credit cooperatives, Simons & Ingram suggest that they share a similar kind of ideology but their niches with regard to resources do not overlap. Finally, corporations do not share either resource base or ideology with the kibbutzim and moshaw.

With regard to the aggregate interdependence among populations, Simons and Ingram (2004) argue that when two populations have overlap in their niches with regard to resources (i.e. the populations rely on some of the key resources), then the main effect of their ideological similarity (i.e. overlap also in the identity space of the niches) creates competitive relationship among the populations. On the other hand, when the

populations do not rely on the same key resources, ideological similarity results in mutualism born of affinity (Simons & Ingram, 2004). Thus, it seems that the resource overlap creates stronger interdependence among populations and overrules the interaction created by identity overlap.

As a final research that considers interactions related to identity, Dobrev et al. (2006) study the dynamics of interdependences among financial cooperatives and commercial banks in Singapore between 1925 and 1994. What differentiates their article from the two earlier ones is that it explicitly divides the niches of the studied populations into two dimensions, resource space and identity space. In particular, relating to their research context, Dobrev et al. suggest that the two populations have considerable overlap in their functional (or product) identity (relating to the services that an organization provides) and differences in their ideological identity (relating to structure of ownership, authority relationships, and governance); these together create both competitive and mutualistic interdependences between the populations.

A further issue is that interdependences among organizational populations have also been studied from the perspective of the population niche dimension related to labor (Korn & Baum 1994; Sorensen 2004). Korn & Baum (1994) focus on employment dynamics among the 200 largest public enterprises in Canada between 1985-1992, divided into five sub-populations based on SIC codes, and Sorensen (2004) examines recruitment-based competition between 84 industries in Denmark between 1980-1991. Owing to their explicit focus on labor, they do not consider how the niches of the studied populations might overlap in the other dimensions.

Next, some studies do not explicitly discuss the differences in the niches of the populations. For example, when examining the dynamics of interdependences among the 200 largest companies in Canada that were divided into five sub-populations based on SIC codes, Baum & Korn (1994) consider that one population affecting negatively on the vital rates of another implies a competitive interaction, and one population affecting positively on the vital rates of another implies a mutualistic interaction.

Studies focusing on interdependences that are not directly based on niche overlap are rare (but see also Simons & Ingram (2004) above). One of the studies that explicitly focuses on these types of interdependences is that of Audia, Freeman & Davidson-Reynolds (2006) (or at least they implicitly assume that no overlaps exist). In particular, they examine the interdependence of U.S. instrument manufacturers and their suppliers and purchasers. As a second example, the study by Audia & Rider (2010), focusing on the evolution of footwear manufacturing plant populations in

the U.S. between 1975-1991, controls for the possibility that chemical plants and rubber plants, important suppliers to the footwear manufacturing plants, affect the vital rates of the footwear manufacturers. In the results section of their study (because the results imply that the two supplier populations exert both mutualistic and competitive effects on the footwear manufacturing plants), they speculate whether, in addition to being important suppliers for the footwear manufacturers, the niches of the supplier populations and footwear manufacturers would also overlap because chemical and rubber plants may employ similar workers and target the same local investors as the footwear manufacturers. As a final example, De Figueiredo & Silverman (2010) focus on the interdependences among engine and printer manufacturers in the U.S. desktop laser printer industry. In this context, engine manufacturers are important suppliers for printer manufacturers. Additionally, some of the printer manufacturers are vertically integrated to manufacturing engines, which also creates the potential for niche overlap among the populations.

Finally, one interesting study to discuss is that of Ruef (2000), which considers the emergence of new organizational forms in the American health care sector between 1965-1994. In total, Ruef identifies 48 distinct organizational forms that differ in particular with regard to their identity. According to Ruef (2000), the realized identity of organizational forms is constituted by their pattern of textual association with other publicly recognized symbols. Potential form identities are represented as regions of the discourse where discussions of procedures, actors, values, and other symbols may ultimately become formalized as novel organizational arrangements. By going through textual data extracted from MEDLINE, Ruef (2000) then constructs a list of symbols (referring to terms that were consistently applied by human coders over the period covered by the corpus, in order to characterize the content of each text) and associates these with different organizational forms, thus creating a multidimensional space that enables the separation of the different organizational forms from each other.

Table 2-4: Overview of previous studies with focus on population interdependences: Assumed overlap/non-overlap in the niches of the studied populations.

Article / Book chapter	Assumed overlap/non-overlap in the niches of the studied populations
Barnett & Carroll (1987)	Sub-populations differentiated on the basis of their main strategy (i.e., commercial or mutual) and location in cities (commercials) or rural areas (mutuals);
Brittain & Wholey (1988)	Sub-populations differentiated on the basis of differences in strategies related to technical and market breadth dimensions
Hannan & Freeman (1989)	Sub-populations have differences especially in niche dimensions related to 'markets'
Barnett (1990)	Focus on interdependences in niche dimensions related to technology (The assumption is that the technological dimension is the major niche dimension that causes at least mutual interdependences among these sub-populations)
Baum & Oliver (1991)	Sub-populations differentiated on the basis of differences in markets and human capital assets
Boeker (1991)	Sub-populations differentiated on the basis of their geographical scope, i.e. breweries may operate on a national scale, regional scale, or local scale
Carroll & Wade (1991)	Sub-populations may have differences in their markets because of different geographical location
Ranger-Moore, Banaszak-Holl & Hannan (1991)	Commercial and savings banks in Manhattan, 1792-1980: Sub-populations differentiated on the basis of differences in the market dimension Mutual and stock life insurance companies in New York State, 1760-1937: Sub-populations differentiated on the basis of differences in ownership structure
Carroll & Swaminathan (1992)	Considerable differences in the niches of the sub-populations (e.g. microbreweries and brewpubs differ from mass production breweries in terms of four core properties - stated goals, forms of authority, core technology and marketing strategy - that are commonly used to define the organizational form)
Rao & Neilsen (1992)	Differences in the niches of mutual and stock SLAs related to differences in their ownership rights and the allocation of control between managers and owners Differences in the niches of both types of SLAs and other populations not explicitly discussed
Staber (1992)	The paper suggests that although different forms of cooperatives may be distinguishable in terms of technologies, strategies, and structure, they tend to draw on similar aspects of the same general environment; thus, although each form might occupy a unique ecological niche, their niches overlap considerably.
Wholey, Christianson & Sanchez (1992)	Assumes that the niches of sub-populations partially overlap
Baum & Korn (1994)	Does not make any predictions about possible niche overlaps/non-overlaps
Brittain (1994)	Sub-populations differentiated on the basis of differences in their strategies
Budros (1994)	Sub-populations assumed to have overlap in niche dimensions related to product markets
Korn & Baum (1994)	Focus on interdependences in the niche dimension related to labor. Possible overlap/non-overlap in other dimensions not discussed
Baum, Korn & Kotha (1995)	Sub-populations differ on the basis of technology
Lomi (1995)	RCBs and PCBs differ on the basis of their strategies: RCBs are specialists, PCBs generalists; Niche differences between savings and loan institutions and RCBs and PCBs are not explicitly discussed
Swaminathan (1995)	Mass and farm wineries differ at least in terms of their organization, technology, and marketing strategy
Ingram & Inman (1996)	Sub-populations differ because of geographic location
Ingram & Baum (1997)	Sub-populations differ mainly on the basis of whether they are chain-affiliated or not
Silverman, Nickerson & Freeman (1997)	Niches of large and small carriers considered to be highly overlapping; Differences are related to the fact that large firms are established, small firms have mainly entered after the regulatory reform
Swaminathan (1998)	Mass producers, microbreweries, and brewpubs constitute separate organizational forms (i.e. their niches are not the same) to the extent that they encounter very different environments and respond differently to those distinct environments.
Zucker, Darby & Brewer (1998)	Niche overlaps/non-overlaps not explicitly discussed
Carroll & Swaminathan (2000)	Mass producers, microbreweries, brewpubs, and contract brewers constitute separate organizational forms (i.e., their niches are not the same) to the extent that they encounter very different environments and respond differently to those distinct environments. Mass producers are generalists, the others specialists.

Table 2-4 (continues): Overview of previous studies with focus on population interdependences: Assumed overlap/non-overlap in the niches of the studied populations.

Article / Book chapter	Assumed overlap/non-overlap in the niches of the studied populations
Ingram & Simons (2000)	Overlaps in the niches discussed from the point of view of ideology: (1) Coops and banks do not share the same ideology; (2) Coops, credit cooperatives, and kibbutzim share the same ideology
Ruef (2000)	Populations differ with regard to their organizational form
Swaminathan (2001)	Sub-populations differ in their strategies (i.e., specialists vs. generalists)
Boone, Carroll & Wittelostuijn (2002)	Subforms differentiated on the basis of differences in the market dimension: National (generalist) newspapers target the whole Dutch readership audience, regional (specialist) newspapers target local residential populations, Ranstad regional newspapers have higher overlap in the market niche dimension with national newspapers than other regional newspapers
Greve (2002)	Banks conducting business only in one location embody a very different conception of banking than branch banks, as they rely more on adaptation to a local customer base and less on the cost advantages of large-scale operation and standardized services.
Simons & Ingram (2003)	(1) The kibbutz population does not share the resource base or ideology with corporations (2) The moshavim are like kibbutzim in that they are permanent settlements that employ cooperative principles with regard to work, and were traditionally focused on agriculture and, like the kibbutzim, have more recently expanded the scope of their economic activities. Unlike the kibbutzim, the moshavim have always employed traditional forms of consumption: the members live in nuclear families, in their own homes, and spend their share of the organization's profits as they choose (3) The development town represents the juxtaposition of an alternative settlement form and the cultural values of Sephardim. Development towns are government-planned communities, created mostly in Israel's first decade. The social life in the development towns was defined mainly by the family, community, and religious values of the Sephardim. The attitudes of the towns' residents have always been hostile toward the kibbutzim, reflecting differences in cultural values and political and economic interests.
Wezel & Lomi (2003)	Niche overlaps/non-overlaps not explicitly discussed
Barnett & Woywode (2004)	Niches of the newspaper sub-populations considered to be substantially overlapping, however accentuated by ideology
Boone, Carroll & Wittelostuijn (2004)	See Boone, Carroll & Wittelostuijn (2002)
Ruef (2004)	Sub-populations differentiated on the basis of differences in the market dimension
Simons & Ingram (2004)	(1) Moshavim and kibbutzim populations rely on a similar set of resources (land, customers, potential participants) and have a similar kind of ideology. However, their ideologies are not identical: the moshaw do not give the same priority as the kibbutz to the interests of the collective over those of the individual and family. (2) Moshavim and kibbutzim do not share a similar resource base with credit cooperatives but share a similar kind of ideology (3) Moshavim and kibbutzim populations do not share the resource base or ideology with corporations
Sorensen (2004)	Focus on interdependences in niche dimension related to employees/labor. Possible overlap/non-overlap in other dimensions not discussed
Audia, Freeman & Davidson Reynolds (2006)	From the point of view of instrument manufacturers, the focus is on niche dimensions related to output markets and input markets (i.e. interdependences with suppliers and purchasers)
Dobrev, Ozdemir & Teo (2006)	Sub-populations have substantial overlap related to function (or product) identity and differences related to ideological identity (mission and core strategy)
Nunez-Nickel & Moyano-Fuentes (2006)	Sub-populations are differentiated on the basis of their ownership structure; Both subforms operate in the same business, customer market, but they differ in (1) the nature and motivation of those who constitute the organization, (2) the governance system, (3) profit sharing, (4) the support received from public administration, and (5) their taxation status
Audia & Rider (2010)	Chemical plants and rubber plants function as important suppliers for footwear manufacturing plants.
de Figueiredo & Silverman (2010)	Engine manufacturers are important suppliers for printer manufacturers (i.e. populations vertically related); However, some of the printer manufacturers are vertically integrated to manufacturing engines, resulting in niche overlap

As a conclusion, it is rather obvious that the earlier research on interdependences among populations of organizations has primarily focused on studying interactions between populations that can be considered as having considerable overlap in their niches (often referred to as commensalistic populations, see e.g. Aldrich & Ruef 2006; Dobrev et al. 2006). The main differences between these sub-populations are often related to strategy, geographic location, and technology. Additionally, some studies have explicitly focused on interdependences originating from overlaps in one specific niche dimension, like labor. Furthermore, studies considering interactions between populations with no considerable niche overlap have been rare (often referred to as symbiotic organizational populations, see e.g. Aldrich & Ruef 2006; Dobrev et al. 2006).

2.2.3. Dependent variables and measures of interdependence

Ecological research considers two populations to be interdependent insofar as one population affects the viability of the other (and possibly vice versa). Based on this, earlier research on population interdependences has been rather uniform with regard to the dependent and independent variables used for measuring interdependences. Most often, studies have employed either the rate of organizational founding or mortality as their dependent variable. The most widely used measure of interdependence is population density (i.e. the number of organizations in a population at a certain point of time), as can be seen in **Table 2-5**. Employing these variables is also rather logical, taking into consideration that the studies primarily use the density-dependence model (Hannan & Freeman 1977; Hannan 1986; Hannan & Carroll 1992) as their modeling framework. The model has been extended to account for dynamics at the level of the ecological community (two or more related populations) by considering the effects that one population exerts on another.

Only a few studies have measured interdependences between populations by measures other than population density. For instance, Baum & Korn (1994) employ each population's aggregate assets as their measure of interdependence between five sub-populations consisting of 200 of Canada's largest public companies. Two studies with a focus on interdependences created by labor dynamics measure interactions directly by resource utilization related to labor: Korn & Baum's (1994) measure is the aggregate number of employees of all sample organizations in a productive sector, and Sorensen's (2004) measure is labor market overlap density.

Nunez-Nickel & Moyano-Fuentes (2006) introduce new measures for population interdependences. Basically, they suggest and demonstrate empirically that population mass and concentration may be good alternatives to population density in measuring population interdependences (in particular competition). It is, however, worth noting that, for instance, Ruef (2000) already uses population mass as one measure of interdependence[6].

Finally, Audia et al. (2006) introduce three measures of interdependence to measure purchaser and supplier symbiosis and commensalism among U.S. instrument manufacturer communities: (1) community supplier symbiosis is measured as the degree to which a community is characterized by the presence of organizational populations that supply inputs to the focal population, (2) community purchaser symbiosis is measured as the degree to which a community is characterized by the presence of organizational populations that purchase goods from the focal population, and (3) community commensalism is the degree to which a community is characterized by the presence of populations of organizations that have a pattern of transactions similar to that of the focal population.

Table 2-5: Overview of previous studies with focus on population interdependences: Dependent variables and measures of interdependences.

Article / Book chapter	Dependent variable	Interdependence measured by
Barnett & Carroll (1987)	(1) Rate of organizational mortality; (2) Rate of organizational growth	(1) Population density
Brittain & Wholey (1988)	(1) Growth of densities of component manufacturers (11 sub-populations in total)	(1) Population density
Hannan & Freeman (1989)	(1) Rate of organizational founding (2) Rate of organizational mortality	(1) Population density
Barnett (1990)	(1) Rate of organizational mortality	(1) Population density
Baum & Oliver (1991)	(1) Rate of organizational mortality	(1) Population density
Boeker (1991)	(1) Change in the total size of national breweries, measured as sales volume (2) Change in the total size of regional breweries, measured as sales volume (3) Change in the total size of local breweries, measured as sales volume	(1) Population density
Carroll & Wade (1991)	(1) Rate of organizational founding (2) Rate of organizational mortality	(1) Population density
Ranger-Moore, Banaszak-Holl & Hannan (1991)	(1) Rate of organizational founding	(1) Population density
Carroll & Swaminathan (1992)	(1) Rate of organizational founding (2) Rate of organizational mortality	(1) Population density
Rao & Neilsen (1992)	(1) Rate of organizational mortality	(1) Population density
Staber (1992)	(1) Rate of organizational mortality	(1) Population density
Wholey, Christianson & Sanchez (1992)	(1) Rate of organizational mortality	(1) Population density

[6] In addition, an extension of the theory of density dependence, mass dependence (Barnett & Amburgey 1990), already introduced population mass as a measure for competition in one-population settings.

Table 2-5 (continues): Overview of previous studies with focus on population interdependences: Dependent variables and measures of interdependences.

Article / Book chapter	Dependent variable	Interdependence measured by
Baum & Korn (1994)	(1) Firm profit, defined as net income after taxes excluding ordinary gains and losses; (2) Firm revenue, defined as total revenue from operations; (3) Firm size, defined as total assets	(1) Each sector's aggregate assets (size)
Brittain (1994)	(1) Rate of organizational founding	(1) Population density
Budros (1994)	(1) Rate of organizational founding	(1) Population density
Korn & Baum (1994)	(1) Size of the labor force employed by organization i in productive sector j at time t	(1) Aggregate number of employees of all sample organizations in a productive sector
Baum, Korn & Kotha (1995)	(1) Rate of organizational founding (2) Rate of organizational mortality	(1) Population density
Lomi (1995)	(1) Rate of organizational founding	(1) Population density
Swaminathan (1995)	(1) Rate of organizational founding (Farm wineries at the state level)	(1) Population density
Ingram & Inman (1996)	(1) Rate of organizational mortality (estimated as a single population)	(1) Population density
Ingram & Baum (1997)	(1) Rate of organizational mortality	(1) Population density
Silverman, Nickerson & Freeman (1997)	(1) Rate of organizational mortality (large carriers)	(1) Population density
Swaminathan (1998)	(1) Rate of organizational founding (brewpubs and microbreweries at state level)	(1) Population density
Zucker, Darby & Brewer (1998)	(1) Rate of organizational founding	(1) Population density
Carroll & Swaminathan (2000)	(1) Rate of organizational founding (microbreweries, brewpubs, and contract brewers) (2) Rate of organizational mortality (mass producers, microbreweries, brewpubs, and contract brewers)	(1) Population density
Ingram & Simons (2000)	(1) Rate of organizational mortality	(1) Population density
Ruef (2000)	(1) Rate of founding of new organizational forms	(1) Form density (2) Form mass
Swaminathan (2001)	(1) Rate of organizational founding (2) Rate of organizational mortality	(1) Population density
Boone, Carroll & Wittelostuijn (2002)	(1) Market share (Regional newspapers) (2) Circulation growth (Regional newspapers)	(1) Population density
Greve (2002)	(1) Rate of organizational founding	(1) Population density
Simons & Ingram (2003)	(1) Rate of organizational founding (Kibbutz population)	(1) Population density
Wezel & Lomi (2003)	(1) Rate of organizational founding	(1) Population density
Barnett & Woywode (2004)	(1) Rate of organizational mortality (2) Rate of organizational growth	(1) Population density
Boone, Carroll & Wittelostuijn (2004)	(1) Rate of organizational growth (2) Profitability (return on sales, ROS)	(1) Population density (2) Population mass (3) Population concentration
Ruef (2004)	(1) Growth of organizational density (i.e. annual entries - exits)	(1) Population density
Simons & Ingram (2004)	(1) Rate of organizational founding (Moshavim and kibbutzim entries)	(1) Population density
Sorensen (2004)	(1) Yearly number of new employers (firms) that appear in an industry	(1) Labor market overlap density (number of firms in other industries are weighted by the degree of labor market overlap)

Table 2-5 (continues): Overview of previous studies with focus on population interdependences: Dependent variables and measures of interdependences.

Article / Book chapter	Dependent variable	Interdependence measured by
Audia, Freeman & Davidson Reynolds (2006)	(1) Rate of organizational founding (instrument manufacturers)	(1) Community supplier symbiosis (the degree to which a community is characterized by the presence of organizational populations that supply inputs to the focal population) (2) Community purchaser symbiosis (the degree to which a community is characterized by the presence of organizational populations that purchase goods from the focal population) (3) Community commensalism (the degree to which a community is characterized by the presence of populations of organizations that have a pattern of transactions similar to the of the focal population) (4) Unrelatedness of the community's dominant population
Dobrev, Ozdemir & Teo (2006)	(1) Rate of organizational mortality	(1) Population density
Nunez-Nickel & Moyano-Fuentes (2006)	(1) Rate of organizational mortality	(1) Population density (2) Population mass (3) Population concentration
Audia & Rider (2010)	(1) Rate of organizational mortality (footwear manufacturing plants)	(1) Population density
de Figueiredo & Silverman (2010)	(1) Rate of organizational mortality (printer manufacturers)	(1) Population density

2.2.4. Suggested interdependences

The empirical results of the studies reveal that the interdependences among populations (or sub-populations) may vary from negative (often competitive) to positive (often mutualistic), as suggested by **Table 2-6**[7]. In particular, most studies report that both negative and positive interactions are present between the studied populations. This is especially true for those that consider interactions between a great number of different populations (e.g. Brittain & Wholey 1988; Staber 1992; Brittain 1994; Korn & Baum 1994). When the number of studied populations grows, however, interpretation of the interaction coefficients becomes more difficult because the populations affect each others' fates, not only through the direct

[7] The notations summarizing the interdependences among the populations should be interpreted as follows: Population A & Population B (+ , -) implies that population A has a positive effect on the vital rates of population B (for example, population A decreases the rate of mortality of organizations in population B, or population A increases the rate of founding of organizations to population B), and population B has a negative effect on the vital rates of population A. The question mark (?) implies that the interdependence in question has not been studied empirically.

relationships between them, but also through the indirect interactions and feedback flowing through the community (see e.g. Korn & Baum 1994).

The comparison of the results is also not easy. This is firstly because the distinction between the sets of organizations has often been driven by scholars' own interpretation of the empirical context rather than by a clear definition of forms and populations. Furthermore, conceptual distinctions between organizational groups, types, firms, and sub-forms have been based on criteria widely divergent. Secondly, earlier studies have used different kinds of strategies in modeling population interdependences. For example, Barnett & Carroll (1987) claim that when density effects were conditioned upon geographic location, mutually organized telephone firms affected the survival chances of commercial firms both positively (at low-level density) and negatively (high-level density). The empirical model employed by Barnett & Carroll did not, however, estimate the failure rates of the two forms independently, so it is difficult to affirm that the mutualistic effect did occur among different sub-populations rather than in the same population.

Table 2-6: Overview of previous studies with focus on population interdependences: Suggested interdependences between studied populations.

Article / Book chapter	Suggested interdependences
Barnett & Carroll (1987)	(1) Commercials & Rurals (+,+) (2) Non-local firms of both sub-populations increase the rate of mortality of the firms (3) Local mutuals decrease the mortality hazard of other mutuals (except in very high density) (4) Local commercials increase the mortality hazard of other commercials
Brittain & Wholey (1988)	A complex web of interdependences between different forms
Hannan & Freeman (1989)	Craft unions & Industrial labor unions (-,0)
Barnett (1990)	(1) Magneto-companies & Common-battery companies (-,0) (2) Single-exchange companies & Multi-exchange companies (+,+)
Baum & Oliver (1991)	Day care centers & Nursery schools (-,-)
Boeker (1991)	(1) National breweries & Regional breweries (-,-) (2) National breweries & Local breweries (-,+) (3) Regional breweries & Local breweries (-,-)
Carroll & Wade (1991)	(1) Rural breweries & Urban breweries (-,+) (founding, low density) (2) Rural breweries & Urban breweries (-,-) (founding, high density) (3) Rural breweries & Urban breweries (0,+) (failure, low density) (4) Rural breweries & Urban breweries (0,-) (failure, high density) Additionally, the paper tests the effect of the spread of mechanical refrigeration (number of ice plants) and expansions of railroads on the founding and mortality of these sub-populations: (1) The number of ice plants has no effect on the founding of rural breweries, but it lowers their rate of mortality, however (2) Railroads have no effect on the founding or mortality of rural breweries (3) The number of ice plants has no effect on the founding or mortality of urban breweries (4) Railroads decrease the rate of the founding of urban breweries and increase their rate of mortality
Ranger-Moore, Banaszak-Holl & Hannan (1991)	(1) Commercial banks & Savings banks (0,0) (2) Mutual companies & Stock companies (0,+)

Table 2-6 (continues): Overview of previous studies with focus on population interdependences: Suggested interdependences between studied populations.

Article / Book chapter	Suggested interdependences
Carroll & Swaminathan (1992)	(1) Mass producers & Microbreweries (0,?) (founding) (2) Mass producers & Brewpubs (0,?) (founding) (3) Microbreweries & Brewpubs (0,+) (founding) (4) Mass producers & Microbreweries (-,0) (failure) (5) Mass producers & Brewpubs (0,0) (failure) (6) Microbreweries & Brewpubs (0,0) (failure)
Rao & Neilsen (1992)	(1) Mutual SLAs & Commercial banks (?,-) (both local and non-local) (2) Mutual SLAs & Life insurance companies (?,-) (both local and non-local) (3) Mutual SLAs & Mutual savings banks (?,0) (both local and non-local) (4) Stock SLAs & Commercial banks (?,-) (both local and non-local) (5) Stock SLAs & Life insurance companies (?,0) (both local and non-local) (6) Stock SLAs & Mutual savings banks (?,-) (only non-local mutual savings bans create a significant competitive effect)
Staber (1992)	Complex web of interdependences between the different forms
Wholey, Christianson & Sanchez (1992)	Group HMOs & Independent HMOs (0,0)
Baum & Korn (1994)	Complex web of interdependences between the productive sectors
Brittain (1994)	Complex web of interdependences between the different forms
Budros (1994)	Savings banks & Life insurance companies (-,?)
Korn & Baum (1994)	Complex web of interdependences among the productive sectors
Baum, Korn & Kotha (1995)	(1) Pre-dominant design companies & Post-dominant design companies (-,?) (founding) (2) Pre-dominant design companies & Post-dominant design companies (0,-) (failure)
Lomi (1995)	(1) Rural co-operative banks & Popular co-operative banks (+,0) (2) Savings and loan institutions & Rural co-operative banks (+,?) (3) Saving and loan institutions & Popular co-operative banks (-,?)
Swaminathan (1995)	State level farm wineries & Out-of-state farm wineries (?,0) State level farm wineries & State mass production wineries (?,-) State level farm wineries & Out-of-state mass production wineries (?,0)
Ingram & Inman (1996)	(1) New York hotels & Ontario hotels (-,-)
Ingram & Baum (1997)	(1) Independent hotels & Component hotels (+,+)
Silverman, Nickerson & Freeman (1997)	(1) Small carriers & Large carriers (+,?) (low small carrier density) (2) Small carriers & Large carriers (-,?) (high small carrier density) (3) Although mutualism between large and small carriers may operate, the competitive effect on large carrier mortality appears to quickly swamp any mutualistic effect between the populations as of small density increases
Swaminathan (1998)	(1) State level microbreweries & Out-of-state microbreweries (?,+) (2) State level microbreweries & State level brewpubs (+,0) (3) State level microbreweries & National mass brewers (?,-) (4) State level brewpubs & Out-of-state brewpubs (?,+) (5) State level brewpubs & National mass brewers (?,0)
Zucker, Darby & Brewer (1998)	(1) Top universities & Biotechnology companies (+,?) (2) Venture capital companies & Biotechnology companies (-,?) (The effect of venture capital firms is positive when human capital measures are not included in the models)
Carroll & Swaminathan (2000)	Rate of org. founding: (1) Microbreweries & Brewpubs (+,+) (2) Microbreweries & Contract brewers (+,0) (3) Brewpubs & Contract brewers (-,0) Rate of org. mortality: (1) Mass producers & Microbreweries (?,0) (2) Mass producers & Brewpubs (?,0) (3) Mass producers & Contract brewers (0,0) (4) Mass producers & State level microbreweries (+,?) (5) Mass producers & State level brewpubs (0,?) (6) State level microbreweries & Out-of-state microbreweries (?,0) (7) State level microbreweries & State level brewpubs (?,+) (8) State level microbreweries & Contract brewers (?,-) (9) State level brewpubs & Out-of-state brewpubs (?,+) (10) State level brewpubs & Microbreweries (?,-) (11) State level brewpubs & Contract brewers (?,0) (12) Contract brewers & Microbreweries (?,0) (13) Contract brewers & Brewpubs (?,0)
Ingram & Simons (2000)	(1) Banks & Coops affiliated with Merkaz (-,?) (2) Banks & Unaffiliated coops (+,?) (3) Credit cooperative & Coops (+,?) (4) Kibbutzim & Coops & (+,?)

Table 2-6 (continues): Overview of previous studies with focus on population interdependences: Suggested interdependences between studied populations.

Article / Book chapter	Suggested interdependences
Ruef (2000)	Rate of founding of new organizational founding follows the logic of density-dependence: the increasing density and mass of the existing organizational populations serves to legitimate novel arrangements with corresponding identity attributes, enhancing the probability of regulatory legitimation for those new forms. Beyond that critical point, highly saturated niches tend to deter the appearance of new arrangements due to competition among existing organizations.
Swaminathan (2001)	Mass production wineries & Farm wineries (-,?) (foundings) Mass production wineries & Farm wineries (-,?) (failure)
Boone, Carroll & Wittelostuijn (2002)	Market share: (1) Regional newspapers & National newspapers (?,0) (2) Ranstad newspapers & National newspapers (?,0) Circulation growth: (3) Regional newspapers & National newspapers (?,0) (4) Ranstad newspapers & National newspapers (?,0)
Greve (2002)	(1) Bank headquarters & Branches (+,0) (low density) (2) Bank headquarters & Branches (-,0) (high density)
Simons & Ingram (2003)	(1) Kibbutz & Corporations (?,-) (2) Kibbutz & Moshav (?,-) (3) Kibbutz & Development towns (?,-)
Wezel & Lomi (2003)	(1) Belgium motorcycle industry & Italian motorcycle industry (0,+) (2) Belgium motorcycle industry & Japanese motorcycle industry (+,+) (low density) (3) Belgium motorcycle industry & Japanese motorcycle industry (+,-) (high density) (4) Italian motorcycle industry & Japanese motorcycle industry (+,0)
Barnett & Woywode (2004)	(1) Left-wing newspapers & Centrist newspapers (-,0) (2) Left-wing newspapers & Right-wing newspapers (-,0) (3) Right-wing newspapers & Centrist newspapers (-,+)
Boone, Carroll & Wittelostuijn (2004)	Rate of organizational growth: (1) Population density: Regional newspapers & National newspapers (0,0) (2) Population density: Ranstad newspapers & National newspapers (?,0) (3) Population mass: Regional newspapers & National newspapers (0,-) (4) Population mass: Ranstad newspapers & National newspapers (?,+) (5) Concentration: Regional newspapers & National newspapers (?,+) (6) Concentration: Ranstad newspapers & National newspapers (?,0) Profitability: (1) Population density: Regional newspapers & National newspapers (0,-) (2) Population density: Ranstad newspapers & National newspapers (?,0) (3) Population mass: Regional newspapers & National newspapers (0,+) (4) Population mass: Ranstad newspapers & National newspapers (?,+) (5) Concentration: Regional newspapers & National newspapers (?,+) (6) Concentration: Regional newspapers & National newspapers (?,+)
Ruef (2004)	(1) Secreterian schools & Regular medical schools (-,?) (2) Nursing schools & Regular medical schools (-,?)
Simons & Ingram (2004)	(1) Moshavim population & Kibbutzim population (-,-) (2) Credit cooperatives & Kibbutzim population (+,?) (3) Credit cooperatives & Moshavim population (+,?) (3) Corporations & Kibbutzim population (-,?) (4) Corporations & Moshavim population (-,?)
Sorensen (2004)	The labor market is a source of competitive interdependence between organizational populations Rates of entrepreneurship therefore depend on the degree of the labor market constraint faced by an industry
Audia, Freeman & Davidson Reynolds (2006)	(1) Community supplier symbiosis & Instrument manufacturers (+,?) (the positive effect diminishes as the density of instrument manufacturers increases) (2) Community purchaser symbiosis & Instrument manufacturers (+,?) (the positive effect diminishes as the density of instrument manufacturers increases) (3) Community commensalism & Instrument manufacturers (+,?) (the positive effect diminishes as the density of instrument manufacturers increases) (4) Community's unrelated dominant population & Instruments manufacturers (-,?) (the negative effect diminishes as the density of instrument manufacturers increases)
Dobrev, Ozdemir & Teo (2006)	(1) Low-level increases in the number of banks (low density) decrease the failure rate of financial cooperatives; (2) High-level increases in the number of banks (high density) elevate the failure rate of financial cooperatives; (3) The negative effect of low-level increases in the bank density on the failure rate of financial co-ops is a decreasing function of the number of categorical name changes by financial co-ops

Table 2-6 (continues): Overview of previous studies with focus on population interdependences: Suggested interdependences between studied populations.

Article / Book chapter	Suggested interdependences
Nunez-Nickel & Moyano-Fuentes (2006)	NOTE: The results are highly inconsistent in different models (2) Population density: Stock subform & Mutual subform (0,+) (low mutual subform density) (3) Population density: Stock subform & Mutual subform (0,-) (high mutual subform density) (4) Population mass: no consistent effects (5) Population concentration: Stock subform & Mutual subform (0,+) (low mutual subform concentration) (6) Population concentration: Stock subform & Mutual subform (0,-) (high mutual subform concentration) (7) The mutual subform seems to be ecologically stronger than the stock subform
Audia & Rider (2010)	Footwear manufacturing plants & Chemical plants (?,+) (low chemical plant density) Footwear manufacturing plants & Chemical plants (?,-) (high chemical plant density) Footwear manufacturing plants & Rubber plants (?,-) (low rubber plant density) Footwear manufacturing plants & Rubber plants (?,+) (high rubber plant density)
de Figueiredo & Silverman (2010)	(1) Printer manufacturers & Engine manufacturers (?,+) (Non-integrated engine manufacturers have the strongest effect on lowering printer manufacturer mortality, fully-integrated ones have the lowest effect) (2) The level of competition experienced by the printer manufacturers depends on the level of printer manufacturer's vertical integration (fully integrated printer manufacturers create the strongest competitive effect)

2.2.5. Summary

As suggested by the discussion in the previous sections, I argue that the earlier research concerning interdependences among organizational populations has been rather incoherent and unstructured. This has not only been due to differences in the frameworks and definitions of the terms used in analyzing the interdependences, differences in what kinds of interaction the research has focused on (i.e. overlaps/non-overlaps in the niches of the populations), but also differences in the modeling strategies the studies have employed. I will summarize these differences in the following.

First, differing frameworks and definitions for the central terms describing the types of population interdependences, such as commensalism, mutualism, and symbiosis, create potential for misunderstandings, and also make the earlier research incoherent. For example, while Brittain & Freeman (1988) suggest that population interdependences may be divided into six types without considering possible niche overlaps or non-overlaps among the populations studied, research drawing on Hawley (1950; 1986) usually makes a distinction between populations that have considerable niche overlap and populations that do not. However, even this research uses the concepts of commensalism, symbiosis, and mutualism in a different way (compare e.g. Barnett & Carroll 1987; Barnett 1990; Aldrich & Ruef 2006).

Second, and related to the previous point, earlier research and frameworks for analyzing population interdependences have not fully taken into account the potential complexity inherently associated with

overlaps/non-overlaps in the niches of organizational populations and the multidimensionality of the concept of niche. For instance, although Aldrich & Ruef (2006) (see also Dobrev et al. 2006) suggest that interdependences between populations can be divided into two dimensions that are based on whether the niches of populations have considerable overlap (commensalistic organizational populations) or have no overlap (symbiotic organizational populations), it still remains unclear how much or little niche overlap there has to be in order to be able to consider two populations as commensalistic or symbiotic. Furthermore, current frameworks, at a general level, do not take into consideration that there may be specific interdependences that are only related to specific niche dimensions, or that two populations may have several different types of interdependences based on different niche dimensions. Examples of these types of interdependences are offered in research on interdependences related to labor niche dimensions (Korn & Baum 1994; Sorensen 2004) and in research showing that Singaporean financial cooperatives and commercial banks have different types of interdependences based on the niche dimensions related to identity and resources (Dobrev et al. 2006).

Third, as earlier research has not explicitly taken into consideration the possible different types of interactions related to different niche dimensions, the use of density as a measure of interdependence may be considered problematic. This is because two populations may have both positive and negative interdependences between their different niche dimensions. Consequently, a density measure may not, as such, be able to take into consideration the complexity related to all lower level interactions that are present between the populations. However, this is not to say that density should not be used as a measure of interdependence: if different types of interactions between different niche dimensions of studied populations are explicitly taken into consideration, the use of density may be argued.

Finally, I have discussed the problems related to the generalizability and comparability of the empirical results of earlier research. Because the distinction between sets of organizations has often been driven by scholars' own interpretation of the empirical context rather than by a clear definition of forms and populations, and due to some differences in modeling strategies, the issue of when competition or mutualism exists between organizational populations (see e.g. Baum 1996: 86) still remains somewhat unanswered.

3. A New Theory of Population Interdependences

Building on the discussion above, this chapter presents a new theoretical framework for analyzing interdependences between two organizational populations[8]. The first sub-section aims at offering an overview of the framework and the theories upon which it builds. In the succeeding sections, I will then elaborate on the different types of interactions related to the framework and formulate propositions about their effects on the vital rates of organizational populations. In particular, for the type of interdependence in question, I will first formulate a rather abstract level proposition covering all possible types of interdependences between two populations. Second, again with regard to the type of interdependence in question, I will formulate more detailed propositions of the potentially most typical interdependences.

3.1. An overview of the framework

The framework consists of the following building blocks. First, I consider the niche of an organizational population as a multi-dimensional construct divisible into several sub-dimensions, as already defined in section 2.1.2. In addition to the product market, often implicitly assumed to comprise of the whole niche of a population, and identity (discussed below), what kind of other niche dimensions may be relevant in the analysis of population interdependences? First, as already mentioned, technology may be a source of both mutualistic and competitive relations among populations. The importance of technology is especially emphasized in many high technology

[8] The framework can naturally also be applied to analyzing interdependences between more than two populations.

industries, such as semiconductors (Podolny et al. 1996) or biotechnology (Mattsson & Järvinen 2010), where developing and mastering new technologies is essential for success. However, technology may also create important interactions in other industries and populations (see e.g. Barnett 1990). Second, labor is also an important resource dimension to consider in analyzing the interdependences between organizational populations. This is demonstrated by the studies of Korn & Baum (1994) and Sorensen (2004), showing how labor creates competitive interactions between different types of populations in organizations. Third, input resources (i.e. raw materials or different types of services) may also create interdependences between organizational populations. For instance, two organizational populations dependent on the same raw material may engage in a competitive (but also mutualistic) interdependence. In general, taking into consideration a huge number of different types of input resources that populations usually use (varying from raw materials to production machinery), the input resources may be a source of a considerable number of interactions.

The fourth niche dimension that may be relevant in the analysis of population interdependences, financing, can also be considered an important niche dimension able to exert interdependences among populations. In particular, financing may create competitive interdependences, for instance between young industries, such as biotechnology and nanotechnology industries, which compete for the same venture capital and other types of financing. Fifth, other possible resource niche dimensions to mention are institutional environments in general, and e.g. political conditions (for instance, it is possible to consider that populations of organizations "compete" for beneficial legislation from their perspective).

Population identity (that itself may also be considered as one type of a resource), may also be further divided into different types of sub-dimensions. First, Dobrev et al. (2006) divide identity along two dimensions: functional (or product) identity (relating to the services that an organization provides), and ideological identity (relating to the structure of ownership, authority relationships, and governance). The importance of ideological identity as a means to create interdependences among populations has also been emphasized in a few other studies (Ingram & Simons 2000; Barnett & Woywode 2004).

The second building block is developed by following recent ecological research and theory related to the identities of organizations and populations (Hsu & Hannan 2005), Dobrev (2001), and particularly Dobrev et al. (2006). Following this research, I divide the niche into two main parts: (1) dimensions related to resources and (2) dimensions related to

identity. This division is important, because the logics behind the interactions among resources and identities can be considered to be very different. For instance, the results of Dobrev et al. (2006) suggest that while overlaps in resource space often lead to competitive interactions between the populations studied, overlaps in identity space may function as an important source of positive or mutualistic interdependences.

As a third building block, I suggest that the following two types of basic interdependences may exist between any two niche dimensions inside the aforementioned parts of the niches of populations: (1) interactions between same or like niche dimensions (henceforth, type 1 interactions) and (2) interactions between different or unlike niche dimensions (henceforth, type 2 interactions). This argument is related to Hawley (1950) who divides the interdependences among populations into symbiotic and commensalistic. Considering first the whole animal kingdom (Hawley's description of different types of interactions among organisms is still relevant as regards the current ecological theory in biology, see e.g. Townsend, Begon & Harper 2003), Hawley (1950) defines symbiotic interdependences as mutual dependencies between unlike organisms. Because these unlike organisms make dissimilar demands on the environment, members of different species may supplement the efforts of one another. Commensalism, then, refers to dependencies between organisms making similar demands on the environment. Literally interpreted, commensalism means "eating from the same table" (Hawley 1950: 39). One type of commensalistic interdependence is that of competition, the name given to the kind of interaction where each individual affects the behavior of every other by its effect upon the common supply of sustenance materials. As Hawley suggests, competition is always present when individuals with like demands crowd in around limited resources. A further important commensalistic relationship is that of mutual support, or combination, that similar organisms render one another. Organisms with similar requirements frequently combine their efforts to maintain favorable life conditions; "an aggregate acting in concert can accomplish what a lone individual cannot" (Hawley 1950: 215).

After the discussion of interdependences in the animal kingdom, Hawley (1950) turns to analyzing the interrelatedness of human life. He states that, similar to other organisms, the collective life of man also revolves simultaneously about two axes, one of which is symbiotic, the other commensalistic. The two types of relationship are found in all organized populations. Each represents a peculiar and complementary integrative force and therefore they together constitute the basis of community

cohesion. The community is thus both a symbiotic and a commensalistic phenomenon.

Given the above, type 1 interactions can be considered as analogous to Hawley's commensalistic interactions. Similarly, type 2 interactions can be considered as analogous to Hawley's notion of symbiotic interaction. The main difference between type 1 and 2 interactions and the commensalistic and symbiotic interactions suggested by Hawley (1950) is related to the level of analysis: type 1 and 2 interactions are interactions between the different niche dimensions of the populations, Hawley's commensalistic and symbiotic interactions occur at the level of populations.

As a fourth building block, I argue that, at a general level, the effects of interdependences vary from positive to negative (e.g. one population has a positive effect on the vital rates of another). Finally, the framework builds on a principle that, at time *t*, the aggregate or total interdependence between two populations is a function of all of the sub-interdependences between the various niche dimensions. Thus, in order to "calculate" the aggregate interdependence between two organizational populations, it is essential to take into consideration all the lower level interdependences among different niche dimensions, whether negative or positive. **Figure 3-1** offers an overview of the building blocks of the framework and how this may be applied to analyzing interdependences between two populations. Population A and B both have multidimensional niches; the squares represent the different niche dimensions. Type 1 interactions may be present between two same niche dimensions, as indicated, and type 2 interactions between two different niche dimensions.

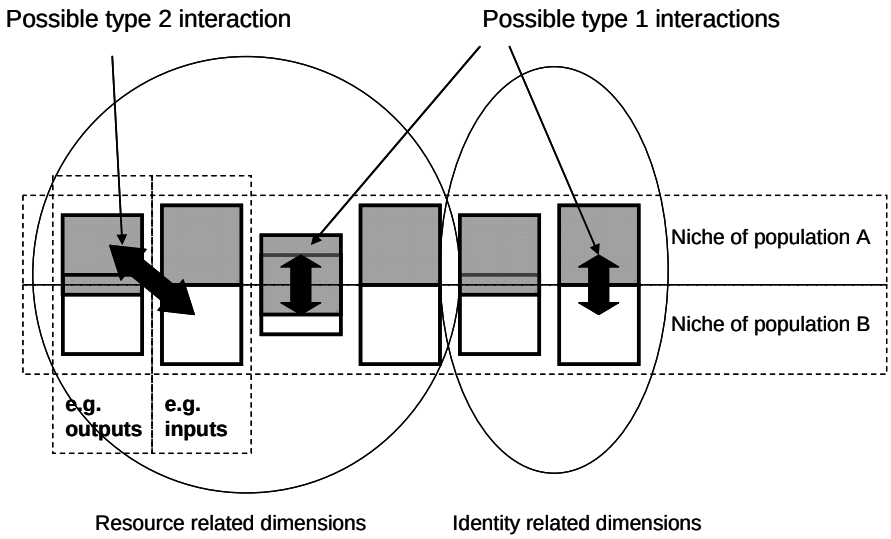

Figure 3-1: A hypothetical example of the different types of interdependences between two populations, A and B.

3.2. Type 1 interactions related to resources

In this section, I will formulate propositions of the effects of different types of type 1 interactions related to resources. I will start with a proposition that covers all possible interactions among two same niche dimension related to resources, and then turn to more specific ones and bring forward more detailed causal mechanisms behind these. However, I will not formulate propositions for all possible types of interdependences; only to those that can be considered the most typical. It is also important to note that the propositions of interdependences are formulated *ceteris paribus* of other possible interdependences (and naturally, also of everything else). The final proposition of the aggregate interdependence among the populations then takes into consideration the possibility that the different types of interactions may interact and combine in different ways[9].

As discussed in the previous section, type 1 interactions related to resources are suggested to occur between two same niche dimensions of two organizational populations. Further, it was suggested that their effects may vary from negative to positive. This argument is rather self-evident, taking into consideration both earlier frameworks on population interactions and empirical findings, discussed in earlier sections. For

[9] This paragraph may also be applied to all later subsections discussing different types of interactions.

instance, Aldrich & Ruef (2006) suggest that commensalistic interactions (i.e. interactions between populations with niche overlap) between populations of organizations vary from full competition (i.e. negative) to full mutualism (i.e. positive) (see also **Table 2-3**). Although this research does not operate at the level of niche dimensions, it can still be considered to support the argument, because much of this research has seen population niche as equivalent to product market, that is, one specific dimension of a population niche. However, research focusing on population interactions related to some specific dimensions of a niche (mostly labor) also supports the argument (see e.g. Korn & Baum 1994; Sorensen 2004). Thus, I formulate the following proposition:

Proposition 1: *The effects of type 1 interactions, between same niche dimensions related to resources, on the vital rates of two interacting populations vary from full competition (both populations have a negative effect on each other's vital rates) to full mutualism (both populations have a positive effect on each other's vital rates).*

In general, the theory in organizational ecology suggests that an overlap in the fundamental niches of two organizational populations creates potential for competition between them (negative interaction between the populations) (Hannan & Freeman 1977; Hannan & Freeman 1989; Hannan & Carroll 1992). This is because the overlap indicates that the populations (and the organizations in them) rely on a similar set of resources; this is important for their survival. When the populations (and the organizations in them) then try to obtain the necessary resources, they engage in a competitive relationship. In particular, if the populations have reached environmental carrying capacity with regard to the resources in question, the competition between them can be intense. Further, the level of competition also depends on the level of niche overlap: the more similar the resource requirements, the greater the potential for intense competition (Hannan & Freeman 1977; Hannan & Freeman 1989). Similar arguments have also been made and tested on the level of organizational niches. For instance Baum & Singh (1994a; 1994b) suggest that niche overlap (operationalized based on the product market of the organizations) among organizations in a population results in competition between the organizations. Further, the more the niches overlap, the more intense the competition. Empirical research both on the level of organizational populations and organizations also support these arguments (Baum & Singh 1994a; 1994b)(See also **Table 2-6**).

I will now extend the arguments to the level of one niche dimension, and propose that an overlap between two same niche dimensions related to resources of two organizational populations typically results in a competitive (negative) interaction between the populations. Further, I propose that the more the niche dimensions overlap the more intense the competition. Following the logic of the earlier arguments, competitive interaction is created by a similar resource requirement related to the niche dimension in question.

Proposition 1.1: *Typically*[10]*, an overlap between same niche dimensions related to the resources of two organizational populations results in a competitive interaction between the populations, that is, both populations affect each other's vital rates negatively.*

Proposition 1.2: *Typically, the more two same niche dimensions related to the resources of two organizational populations overlap, the more intense the competitive interaction between the populations.*

In the proposition above, an implicit assumption is that the two populations in question are similar in their ability to compete of the resources, that is, their fitness, defined as the probability that the organizational population would persist in a certain environment (Hannan & Freeman 1977; 1989), is equal. However, this must not always be the case. For example, let us consider two organizational populations with niche overlap between two same niche dimensions. Now, for example, if one organizational population has a common organizational characteristic that makes it more fit with regard to obtaining the resource related to the niche dimension in question, in comparison to the other organizational population, this may, in equilibrium, result in a situation where the weaker organizational population is totally eliminated (Hannan & Freeman 1977). In particular, this may be the case if the resource related to the niche dimension in question is sufficiently important for the survival of the whole population.

The difference in fit, thus, results in an asymmetric competitive interdependence between the populations: the effect of the fitter organizational population on the vital rates of the less fit one is more negative than the effect of the less fit population on the vital rates of the fitter one. In ultimate cases, when the difference in fit is significant enough,

[10] I use the term typically here because due to some contingencies it is possible that the overlap does not necessarily result in a negative interaction between the populations.

the effect of the less fit population on the vital rates of the fitter one may be zero or even positive. In earlier research, the case in which one population exerts a negative effect on the vital rates of another population but the second one has no effect on the vital rates of the first has been referred to as partial competition (Brittain 1994; Baum 1996; Aldrich & Ruef). Earlier research at the level of organizational populations also offers empirical evidence of this type of relationship (see **Table 2-6**). For example, the results reported by Brittain (1994) suggest that the r-generalists negatively affected the rate of failure of the K-generalists in the U.S. electronics component producer industry but the K-generalists did not have a significant effect on the vital rates of the r-generalists.

Further, the most extreme type of asymmetric competitive relationship between populations (that is a relationship in which one population is able to exert a negative effect on the vital rates of another but the effect of the second one on the vital rates of the first one is positive) has been referred to as predatory competition or a predator-prey relationship (Brittain 1994; Baum 1996; Barnett & Woywode 2004; Aldrich & Ruef 2006). Earlier literature at the level of organizational population (see **Table 2-6**) also offers empirical evidence of this type of interdependence. For example, Barnett & Woywode (2004) identify a predator–prey relationship between Austrian right-wing and center -oriented newspapers: right-wing newspapers drove up the failure rate of the center-oriented newspapers and also fed on the center in terms of organizational growth. The authors discuss that the predator–prey type of relationship between the two sub-population of newspapers was enabled by a change in environmental conditions (right-wing ideology became more favored), which resulted in right-wing newspapers becoming fitter with regard to the environment due to the ideology that the organizations in the population shared. Thus, the right-wing -oriented newspapers became considerably stronger in competing for customers[11]. Similarly, according to the results from Brittain (1994), the K-specialists had a negative effect on the rate of failure of the r-specialists in the U.S. electronics component producer industry but the r-specialists had a positive effect on the K-specialists.

Thus, based on the discussion above, I propose that the differences in the fit of two organizational populations that have overlap between two same niche dimensions of their niches typically result in an asymmetric

[11] Note, however, that the interaction between the sub-populations may also be interpreted from the perspective of type 1 interactions related to identity (see proposition 2.2), as I already discuss. The aggregate interaction between the sub-populations is potentially a function of at least type 1 interaction related to resources (e.g. product market) and type 1 interaction related to identity (e.g. ideology).

competitive interdependence with regard to the niche dimension in question. That is, the fitter (stronger) population has a negative effect on the vital rates of the less fit (weaker) one, and the effect of the less fit population on the vital rates of the fitter one varies from weaker negative to positive effect (covering also a neutral effect). As a further complication, on the basis of the argumentation resulting in proposition 1.2, I propose that the magnitude of the interdependence is contingent upon the overlap in the niche dimension in question: the more overlap there is in the niche dimension, the more intense the interdependence (i.e. the negative effect of the fitter population on the more unfit is stronger and the effect of the less fit population on the fitter is weaker (that is, less negative or more positive)).

Proposition 1.3: *Typically, an overlap between same niche dimensions related to the resources of two organizational populations that have differences in fit with regard to the niche dimension in question, results in an asymmetric competitive interdependence between the populations; that is, the fitter population has a negative effect on the vital rates of the less fit one and the less fit has an effect on the vital rates of the fitter one that may vary from negative (the strength of which is weaker than the strength of the negative effect of the fitter population on the vital rates of the less fit one) to positive.*

Proposition 1.4: *Typically, the more two same niche dimensions related to the resources of two organizational populations overlap, the stronger the asymmetric competitive interdependence between two populations which differ in fit; that is, the effect of the fitter population on the vital rates of the less fit population is more negative and the effect of the less fit population on the vital rates of the fitter population is either less negative or more positive.*

How about potential cooperative (i.e. mutualistic or positive) type 1 interdependences between two same niche dimensions? I propose that if this type of interdependence exists between two same resource niche dimensions of two organizational populations, it typically results from total non-overlap or only small overlap in the niche dimension in question. First, this is because non-overlap implies that the two populations are not dependent on the underlying resource related to the niche dimension in question, thus eliminating the possibility of competition of the resource in question (see e.g. Delacroix, Swaminathan & Solt 1989; Hannan & Ranger-Moore 1990; Carroll & Wade 1991; Swaminathan & Wiedenmayer 1991;

Baum & Mezias 1992). Second, if the non-overlap is the result of differentiation that segments or separates the resource requirements (such as, product market), it may lead to complementary functional differences related to the niche dimension and result in mutualistic interdependence related to the niche dimension in question. For example, the results reported by Barnett & Carroll (1987) suggest that at the population level in the early points in the life cycle of telephone companies, mutual and commercial firms (commercial ones located in cities, mutuals in rural areas) were often mutually related. The large networks of commercial phone companies enhanced the survival chances of the smaller (mutual) firms that were connected to them, and the smaller firms benefited the commercial firms by enlarging the market area they served. This mutualistic interdependence can be interpreted to result from only a small overlap in the product market dimension (i.e. the customers) of the niches of the populations. Similarly, Dobbin (1994) argues that in the early phases of the U.S. railway industry, the small railroad firms benefited from the existence of the large firms and vice versa.

Third, it is possible to think of a differentiated product market (differentiated in a sense that the niche of two populations do not overlap in this dimension) where two populations cooperate by offering products or services that create complementary demand. Finally, the results reported by Baum & Singh (1994a; 1994b) also offer empirical evidence of mutualistic interdependences between organizations created by niche non-overlaps: the less the niches (operationalized according to the product market) of day-care organizations overlapped, the lower the organizational failure rate and the higher the entry rate of the organizations.

Proposition 1.5: *Typically, non-overlap between same niche dimensions related to the resources of two organizational populations results in a mutualistic interaction between the populations; that is, both populations affect each other's vital rates positively.*

To end the discussion of type 1 interactions related to resources, I will consider other possible kinds of type 1 interdependences, not (explicitly) covered by the propositions, and discuss the reasons for using the term typically in every proposition formulated. First, as my first proposition suggests, asymmetric mutualistic (i.e. only one population has a positive effect on the vital rates of the other) is also possible. The reason I do not formulate a proposition for this is that it can be considered to be a special case of the fully mutualistic interaction. For example, an important contingency to all types of interdependences, dominance (discussed in

section 6.8), may cause this type of asymmetric interdependence between the populations.

Second, the reason for using the term "typically" is related to the fact that, in particular, a niche overlap does not need to result in competitive interactions in every case; in some instances, a niche overlap may also result in mutualistic interaction. A recent interesting paper by Ingram & Yue (2008) tackles this issue and argues that there is actually a fine line between competition and cooperation, and that there are various instances where niche overlap between organizations or organizational populations may not result in competitive interaction. In addition, Ingram & Yue suggest that much of earlier research has neglected the fact that organizations may actually cooperate and compete at the same time (which is, however, at least partly in line with the current framework). For example, if organizations compete because they rely on the same set of resources, they may cooperate to (1) increase those resources or to (2) exclude others from accessing them. Ingram & Yue mention different forms of collusion (e.g. competitors try to maintain price levels by cooperation or establish research and development consortia) as examples of cooperative practices that may exist among otherwise competing organizations. All in all, Ingram & Yue (2008) argue that whether competition or cooperation exists between organizations is strongly dependent on the empirical research context in case.

3.3. Type 1 interactions related to identity

Although identity can also be considered as one type of resource, this framework considers identity-related type 1 interactions separately from other types of resources because, as already discussed, the logic behind population interaction created by identity differs considerably of those created by other types of resources (cf. Dobrev et al. 2006). Following the same logic as in the previous section, I will start by formulating a general proposition of all possible types of interdependences that may exist between two same niche dimensions of two organizational populations, and after that formulate more specific propositions of the most typical interactions.

As already mentioned, I argue that the effects of identity-related type 1 interactions may vary from fully negative to fully positive. Although earlier research, primarily on the level of organization population, offers neither theoretical justification for, nor empirical evidence of, the existence of all

different types of identity-related interdependences (see **Table 2-6**), it, however, covers at least both competitive and mutualistic interactions.

Proposition 2: *The effects of type 1 interactions between same niche dimensions related to identity on the vital rates of two interacting populations vary from full competition (both populations have a negative effect on each other's vital rates) to full mutualism (both populations have a positive effect on each other's vital rates).*

With regard to type 1 interdependences related to identity between same niche dimensions, I first propose that niche overlap between same niche dimensions related to identity typically results in mutualistic interdependence between the populations of the organizations in question. In particular, I base this proposition on the arguments of Dobrev et al. (2006) and Simons and Ingram (2004). First, building on the recent ecological research and theory related to the identities of organizations and populations (Hannan 2005; Hsu & Hannan 2005; Hannan et al. 2007), Dobrev et al. (2006) argue that organizational forms have most-restrictive (identity that distinguishes the form from its counterparts) and less-restrictive identities (identity that the form may share with other forms), and because the less-restrictive identities of one organizational form may overlap with the less-restrictive identities of other organizational forms, this creates the potential for identity-related interdependence. Further, Dobrev et al. (2006) suggest that the identity overlap shared by two organizational populations results in mutualistic (positive) interdependence between the populations. For example, as Dobrev et al. (2006) also show empirically, overlap in the identity spaces of an established and an emergent organizational population allows the emergent one to source legitimacy from the established one, thus creating a mutualistic interdependence between the populations. Ruef (2000) makes a similar argument about the emergence of new organizational forms in the American health care sector: overlaps in the identity spaces of new and old organizational forms enabled the new ones to source legitimacy from the old ones, and thus, increased the probability of entry of new organizational forms into the identity space (creating mutualistic interdependence between the forms).

Second, Simons & Ingram (2004) suggest that overlaps related to the ideological identity of two organizational populations may result in mutualistic interdependence. This is especially the case if an organizational population has the power to affect the resources of another population by helping it in one way or another. They also find empirical evidence for this proposition by studying the evolution of and interdependence between

credit cooperatives and moshavim and kibbutzim populations in Israel (moshavim, kibbutzim, and credit cooperatives have overlaps in their niche dimension related to ideological identity but do not rely, for example, on the same kind of resources). Mutualistic interdependence existed between moshavim and kibbutzim and credit cooperatives because they shared the same ideology, and credit cooperatives were able to affect the resources of the moshavim and kibbutzim populations (see also Ingram & Simons 2000).

Thus, as earlier research suggests, if two same niche dimensions related to the identity of two organizational populations overlap, this typically creates mutualistic (positive) interaction. This may, for example, be due to the legitimacy transfer between the populations or because two populations sharing identity (in particular, related to ideology) may want to help and encourage each other.

How about the strength of the identity related mutualistic interdependence? Following the argumentation in the earlier section regarding how higher overlap in the considered resource related niche dimensions increases the intensity of the competitive relationship between the populations, I argue that the higher overlap in the considered identity related niche dimension offers the potential for a stronger mutualistic relationship. For example, considering the above example of the legitimacy transfer between populations, it is possible that the more the identity dimensions overlap, the higher the potential for legitimacy transfer (cf. Dobrev et al. 2006). In addition, the more the relevant identity related dimensions overlap, the more the populations may want to help and encourage each other. Consequently, I formulate the following two propositions regarding the mutualistic identity related interactions between two same niche dimensions.

Proposition 2.1: *Typically, an overlap between same niche dimensions related to the identity of two organizational populations results in mutualistic interaction between the populations; that is, both populations affect each other's vital rates positively.*

Proposition 2.2: *Typically, the more two same niche dimensions related to the identity of two organizational populations overlap, the stronger the mutualistic interaction between the populations.*

How about identity-related niche non-overlap? I suggest that if this type of interdependence exists, it will be competitive. I base this argument on Simon & Ingram (2004) (see also Ingram & Simons 2000), who propose

that if two populations have no overlap in the niches with regard to ideological identity, it will affect the populations competitively. In particular, this will be the case if an organizational population has the power to affect the resources of another population. This is, for example, because ideologically "rival" organizational populations may influence others that represent rival ideologies by making the provision of resources to those others contingent upon change in specific elements of their structures (i.e., via the process of ideological coercion, see Simons & Ingram 1997), or because organizations or populations may refuse to exchange with organizations or populations with rival ideologies altogether. Simons & Ingram (2004) also show empirically that competitive interdependence, created by non-overlap in the niche dimensions related to ideological identity, existed between corporations and moshavim and kibbutzim (that share neither ideological identity nor resource base) in Israel.

Although earlier research shows only that a dissimilar ideological identity may be a source of competitive (negative) interdependence between organizational populations, due to the mechanisms discussed, it is also possible to extend the argument to different niche dimensions related to identity: the mechanisms behind the argument can also be considered to be the same in other identity-related niche dimensions. Thus, if there is interdependence that is related to non-overlap between two same niche dimensions related to identity, it will typically be competitive:

Proposition 2.3: *Typically, non-overlap between same niche dimensions related to the identity of two organizational populations results in competitive interaction between the populations; that is, both populations affect each other's vital rates negatively*.

Finally, it is important to discuss the possibility that identity related interactions are asymmetric, as proposition 2 already suggests. First, dominance may be an important cause of asymmetrical identity related interactions between populations (cf. Barnett & Woywode 2004; Simons & Ingram 2004). For example, if a population is in a dominant position in a community (perhaps due to identity related factors), it may be able to exert a highly positive or negative effect on the vital rates of another population, when considering interactions between two same identity related niche dimensions. In contrast, the effect of the other population on the vital rates of the dominant population may be considerably weaker or even opposite. I discuss the effect of dominance more in section 3.5.

Second, consider for example the case of legitimacy transfer in the context of an emergent and established organizational population (cf. Dobrev et al.

2006). It is possible that in this situation that the relationship between the populations is asymmetric. This is because the legitimacy transfer, and thus, the mutualistic interdependence, is more important from the perspective of the emergent population because it has not yet reached a high level of legitimacy. For the vital rates of the established population, the relationship may not be that important. In general, if a population is able to benefit more from the identity related interaction between the populations than is another population, the effects of the interaction on the vital rates of the populations may be asymmetric.

3.4. Type 2 interactions

In contrast to type 1 interactions, I suggest that type 2 interactions take place between two different niche dimensions (related to either resources or identity[12]) of two organizational populations. Further, I suggest that the effects of type 2 interactions may also vary from positive to negative (neutral interaction included), and thus resemble the population level symbiotic interdependences discussed by Hawley (1950). Although earlier research on population interdependences has considered these type of interactions only as positive (at the level of organizational populations; Aldrich & Ruef, 2006; Audia et al., 2006; de Figuiredo & Silverman, 2010), I will later in this section discuss contexts where this type of interdependences may be potentially negative, at least from the point of view of one organizational population.

Generally, the ecological literature has not paid attention to type 2 interactions related to resources. In a sense, this is peculiar because of the potentially important role of such interactions in the evolution of any organizational population. For example, Hawley (1986) considers the role of symbiotic interactions as highly important, and even argues that at least from a superficial view, the symbiotic sector appears to have a prior claim of importance in comparison with the commensalistic sector, because it mediates the relationship of population to its environment from which the vital flow of sustenance materials is obtained. Furthermore, the quantity and kinds of sustenance materials made available fixes the degrees of freedom within which the aggregate may elaborate upon its structure. In a

[12] I will, however, limit the discussion of type 2 interactions to those between different niche dimensions related to resources, and leave the possible analysis of type 2 interactions related to identity and interactions between niche dimensions related to resources and identity for further research. This is principally because earlier research is silent about these latter types of interactions.

similar vein, Hawley (1986) states that the aforementioned effects do not happen without support from the commensalistic sector.

Proposition 3: *The effects of type 2 interactions between two different niche dimensions related to resources on the vital rates of two interacting populations vary from fully negative (both populations have a negative effect on each other's vital rates) to fully positive (both populations have a positive effect on each other's vital rates) interactions.*

The most typical type 2 interdependence related to resources is that based upon some type of resource dependence between the populations. One population may be, for example, dependent on the product, service or financing produced of another population, thus creating interdependence between them. In particular, in the early phases of population evolution, this type of interdependence may be highly beneficial to both populations. Let us first consider two vertically related populations. Now, the population located more upstream in the value chain benefits when the number of downstream firms increases and the markets for their products or services grow. On the other hand, the population located more downstream in the value chain also benefits from multiple upstream firms, because this offers the downstream population many avenues to obtain the products or services they need. This is because such resources as physical components and the knowledge embedded with them will be more widely available the more suppliers there are. Moreover, the cost of these resources will be lower than they would be under more concentrated upstream population, due to upstream competition (see e.g. Porter 1980). In addition to these kinds of direct economic benefits, de Figuiredo & Silverman (2010) also suggest that the upstream population may also help in legitimating the downstream industry, and thus enhance its life chances. They suggest that this is because the ability to point to multiple potential suppliers that can provide components and technical assistance in the construction of new products will enhance a downstream population's constitutive legitimacy in the eyes of other providers of resources. Further, according to de Figuiredo & Silverman (2010), demonstrating that the value chain is large and diverse, with complementary parts of the chain making investments on the survival of the entire chain, serves as a powerful legitimating mechanism for the downstream firm and reduces the risk for those who wish to provide resources for organizations.

As a second example, a similar kind of beneficial relationship may also develop between emergent populations and financers. For example, Aldrich & Ruef (2006) describe the relationship between growing businesses

needing capital and the firms supplying it. According to these authors, in the United States, venture capital firms have played several important roles in the emergence of new technology-based communities. First, they have provided funding for growing firms that are too young and unknown to obtain funding from more traditional sources, such as banks. Second, as early investors, venture capital firms have legitimated risky investments for other, more conservative investors. Third, venture capital firms have served as facilitators and catalysts for the creation of alliances, acting as brokers in bringing complementary organizations together (Podolny 2001).

Earlier empirical ecological research on these types of interdependences, conducted mostly in the context of emergent organizational populations, also suggests that interdependences of type 2 are beneficial to both populations in question (e.g. Audia et al. 2006; de Figueiredo & Silverman 2010). For example, the results of Audia et al. suggest that the rate of founding of instrument manufacturers in the U.S. had a relationship with the existence of both their suppliers and purchasers in the community: the more of both suppliers and purchasers there were in the community, the higher was the founding rate of instrument manufacturers. The effects of type 2 interactions on the viability of populations have, additionally, been reported in other research (see e.g. the discussion in Aldrich & Ruef 2006)(Bonaccorsi & Giuri 2001; Murmann 2003; Malerba et al. 2008a; 2008b). For example, Saxenian's (1994) case study emphasizes the role of inter-population symbiotic (i.e. type 2 interactions at the population level) interdependences as an important factor for the contrasting evolutionary patterns in Silicon Valley and the Route 128 region around Boston.

Proposition 3.1: *A typical type 2 interaction between two different niche dimensions of two organizational populations related to resources results in a situation where both populations have a positive effect on each other's vital rates.*

Let us now consider again two vertically related populations in later phases of their evolution. What if one population now starts to decline or concentrate? If it is the downstream population, for the upstream population this means, for example, that the amount of available supplied resource declines or the market power of the downstream population (for example in setting prices) starts to grow. Similarly, if it is the upstream population that concentrates or declines, the downstream population experiences, for example, lower demand for the resource it produces, or growing market power of the upstream population. Both these effects may, in the long run, result in negative interdependence between the

populations: one population affects the vital rates of the other negatively, resulting in decline or concentration also in this population.

This kind of pattern of one population affecting negatively on the vital rates of another population, to which it is linked by type 2 interdependences, has also been reported in an empirical study by Bonaccorsi & Giuri (2001). In particular, they found that during the co-evolution of a turboprop engine and turboprop aircraft, the concentration and declining density of the turboprop aircraft caused the turboprop engine industry to concentrate or decline as well. They further argue that the partitioned network structure of the turboprop aircraft and turboprop engine industry caused the observed evolutionary pattern.

Thus, I suggest that the decline or concentration of one population connected to another population by type 2 interdependence related to resources may result in a negative interdependence between the populations, where at least the vital rates of one population are negatively affected by the other.

Proposition 3.2: *Typically, population decline or concentration leads to type 2 interaction, where both populations have a negative effect on each other's vital rates, or where the effects that populations have on each other's vital rates are asymmetric.*

3.5. The effect of a dominant population

An important contingency with regard to every ecological interdependence discussed so far is that of dominance. As defined by Hawley (1950), a dominant organizational population operates in a more central part of the organizational community and is able to coordinate and thereby control the flow of resources into and through the community. "Such influence may be exercised directly or indirectly through the control over the allocation of space to different activities, the determination of who shall be employed, the regulation of credit, the censoring of news and information regarding the community, and in many other ways" (Hawley 1950: 221). In a sense, this kind of dominance results naturally when a population adapts to the structure of resource flows within a community, but organizations and populations may also act strategically to enhance their dominant positions (Alrdich & Ruef 2006). Hawley (1950) notes that organizations often band together in collective activities that affect the conditions of existence for others, such as in price-fixing cartels and collusions that create restraints

on trade. As examples of potentially dominant populations, Aldrich & Ruef (2006) bring forward money lending and credit institutions in the financial sector and wholesale organizations in the retail sector. According to Aldrich and Ruef, these forms may reach a dominant role in a community since they enable organizations to communicate or connect with others more quickly.

What kind of dynamics does the existence of a dominant population then exert on the interdependences between two organizational populations at the level of niche dimensions? Basically, based on earlier ecological research on the level of organizational populations, I suggest that dominance either strengthens or weakens the identified interdependence between the populations studied (cf. Aldrich & Ruef 2006). For instance, in the case of a competitive interaction, the competitive effect on the vital rates of the dominant population is weaker than the competitive effect on the vital rates of a "weaker" population (however, this does not have to result in a predator-prey relationship discussed above, and does not result from differences in the fitness of the populations with regard to the resource in question). Similarly, in the case of mutualistic interdependence, the effect of mutualism on the vital rates of a dominant population is stronger than the effect of the interaction on the vital rates of a "weaker" organizational population. This is due to the central role of the dominant population in the community and its ability to control the flow of resources to other populations.

For example, the results of Barnett (1990) suggest that in the early history of the U.S. telephone industry, multi-exchange telephone firms and single-exchange telephone firms were mutually related, but the multi-exchange firms were the dominant population in comparison with the more peripherally located single-exchange firms, because they were able to obtain scarce human and physical capital, information about markets, and rights-of-way from the single-exchange firms. Thus, the viability of the multi-exchange firms was increased more than the viability of the singe-exchange firms with regard to the mutualistic interaction in question. As an example of a dominant population in the case of competitive interaction, in the Spanish olive-oil production industry Nunez-Nickel & Moyano-Fuentes (2006) suggest that the mutual sub-form was the dominant organizational population compared to the stock sub-form: the competitive effect exerted by the mutual sub-form on the stock sub-form was stronger than that of the effect exerted by the stock sub-forms on the mutual sub-form. Thus, I propose as follows:

Proposition 4: *The interdependence between the niche dimensions of two organizational populations (either type 1 or type 2) is contingent on the dominance of another organizational population in comparison to the other: A dominant population exerts a stronger negative or weaker positive effect on the vital rates of another organizational population.*

3.6. Aggregate interdependence between organizational populations

Thus far I have only discussed the effects of type 1 or 2 interactions on the vital rates of populations independently. However, it is highly plausible that two organizational populations may have multiple different types of interaction between their different niche dimensions (either type 1 or 2), as has been already suggested. These interdependences can be either different kinds of type 1 interactions (related to such dimensions as product market, technology, labor, or ideology), different types of type 2 interactions (e.g. resource dependences), or combinations of both. The total or aggregate interdependence, at time *t*, between two populations is then a function of all of the sub-interdependences between different niche dimensions.

It is not difficult to give examples of populations with multiple different types of interdependences. First, by definition, the aggregate interaction of commensalistic organizational populations with overlapping niches (the focus of most of earlier research on inter-population interdependences), consists of several different types of type 1 interactions, of which some might be positive and some negative. Second, several type 2 interdependences between organizational populations may be created simply by different purchaser-supplier relationships; e.g. one population can function as a supplier for some product or service for the other population, and vice versa for another product. Finally, as an example of populations with both type 1 and type 2 interactions, we may think of two populations engaged in a supplier-purchaser relationship who have also similar resource requirements, e.g. related to labor.

Albeit rarely, earlier ecological research has also explored multiple interdependences between organizational populations and their combined effects on the aggregate interaction between them. To start with, Simons & Ingram (2004) formulate and test a theory of how similarities related to ideological identity and other resource space interact and result in either mutualistic or competitive interaction. In particular, Simons & Ingram argue that when the resource space of the populations does not overlap,

ideological similarity between the populations results in mutualistic interaction, when an organizational population has the power to affect the resources of the other population. In contrast, when two organizational populations have dissimilar ideological identity (and their resource spaces do not overlap), and an organizational population has the power to affect the resources of the other population, the resulting interaction will be competitive (see also Ingram & Simons 2002). Further, the more similar the ideological identity and the more the resource spaces of the populations overlap, the more competitive the interaction among them (cf. Barnett & Woywode 2004).

As another example, based on their empirical results, Audia & Rider (2010) speculate on the possibility that U.S. footwear manufacturers and their important suppliers, rubber plants and chemical plants, have multiple types of interdependences between them. First, the purchaser–supplier relationship (i.e. type 2 interdependence) results in mutualistic interdependence, but second, a potential niche overlap related to resources (in particular related to labor and financing; type 1 interdependence) results in competitive interaction. Together, they cause a density-dependent type of interaction dynamics between the two populations (see **Table 2-6**).

Proposition 5: *The total or aggregate interaction (i.e. how two populations affect each other's vital rates) between two organizational populations is a function of all type 1 and type 2 interactions existing between the niche dimensions of the two organizational populations.*

3.7. Summary and conclusion

This chapter introduced a new theoretical framework of interdependences between organizational populations. By considering population niche as a multidimensional construct, the framework suggests that two basic types of ecological interdependences may exist between two niche dimensions of two organizational populations: type 1 interdependences, which exist between two same niche dimensions, and type 2 interdependences, which exist between two different niche dimensions. The aggregate interaction among the population is then a function of all the sub-interdependences between the different niche dimensions. **Table 3-1** summarizes the main arguments of the theoretical framework in the form of the formulated propositions.

The first set of propositions covers type 1 interdependences between the populations related to resources: in general, the effects of type 1 interdependences on the vital rates of organizational populations may vary from fully positive to fully negative. The more specific propositions relating to the competitive and mutualistic interactions with regard to type 1 interdependences suggest that typically, competitive type 1 interactions are a result of niche overlap with regard to the niche dimension in question, and mutualistic type 1 interactions are a result of non-overlap in the considered niche dimensions. Asymmetrical competitive interactions result from an overlap in the respective niche dimensions and difference in the fit of the organizational populations with regard to the niche dimension in question.

The second set of propositions concerns type 1 interdependences related to identity. In general, it is suggested that the effects of these interdependences on the vital rates of organizational populations may vary from fully positive to fully negative. More specifically, the framework proposes that competitive identity -related type 1 interactions are typically a result of non-overlap in the considered niche dimensions. Overlap in the considered identity-related niche dimensions, in contrast, typically results in a mutualistic interdependence between the populations.

The next set of propositions covers type 2 interactions related to resources. First, the framework proposes that the effects of these interactions may also vary from fully positive interactions to fully negative ones. Further, it is suggested that typically these interactions affect positively upon the vital rates of both populations. However, some contingencies, like population decline or concentration are proposed to result in negative type 2 interactions between the organizational populations.

Further, dominance is suggested to be an important contingency with regard to both types of interactions: a dominant organizational population with regard to the considered interdependence at the level of a niche dimension exerts a stronger negative or weaker positive effect on the vital rates of the other organizational population (in comparison to the effects the first one has on the vital rates of the other). Finally, the aggregate interaction between the populations is proposed to be a function of all sub-interdependences between the different niche dimensions.

Table 3-1: Summary of the formulated propositions.

Type 1 interdependences

Related to resources

Proposition 1: The effects of type 1 interactions, between same niche dimensions related to resources, on the vital rates of two interacting populations vary from full competition (both populations have a negative effect on each other's vital rates) to full mutualism (both populations have a positive effect on each other's vital rates).

Competitive (negative) interaction

Proposition 1.1: Typically, an overlap between same niche dimensions related to the resources of two organizational populations results in a competitive interaction among the populations

Proposition 1.2: Typically, the more two same niche dimensions related to the resources of two organizational populations overlap, the more intense the competitive interaction between the populations.

Asymmetric competitive interactions

Proposition 1.3: Typically, an overlap between same niche dimensions related to the resources of two organizational populations that have differences in fit with regard to the niche dimension in question, results in an asymmetric competitive interdependence between the populations; that is, the fitter population has a negative effect on the vital rates of the less fit one and the less fit has an effect on the vital rates of the fitter one that may vary from negative (the strength of which is weaker than the strength of the negative effect of the fitter population on the vital rates of the less fit one) to positive.

Proposition 1.4: Typically, the more two same niche dimensions related to the resources of two organizational populations overlap, the stronger the asymmetric competitive interdependence between two populations which differ in fit; that is, the effect of the fitter population on the vital rates of the less fit population is more negative and the effect of the less fit population on the vital rates of the fitter population is either less negative or more positive.

Mutualistic (positive) interaction

Proposition 1.5: Typically, non-overlap between same niche dimensions related to the resources of two organizational populations results in a mutualistic interaction between the populations.

Related to identity

Proposition 2: The effects of type 1 interactions between same niche dimensions related to identity on the vital rates of two interacting populations vary from full competition (both populations have a negative effect on each other's vital rates) to full mutualism (both populations have a positive effect on each other's vital rates).

Mutualistic (positive) interaction

Proposition 2.1: Typically, an overlap between same niche dimensions related to the identity of two organizational populations results in mutualistic interaction between the populations.

Proposition 2.2: Typically, the more two same niche dimensions related to the identity of two organizational populations overlap, the stronger the mutualistic interaction between the populations.

Competitive (negative) interaction

Proposition 2.3: Typically, non-overlap between same niche dimensions related to the identity of two organizational populations results in competitive interaction between the populations.

Type 2 interdependences

Related to resources

Proposition 3: The effects of type 2 interactions between two different niche dimensions related to resources on the vital rates of two interacting populations vary from fully negative (both populations have a negative effect on each other's vital rates) to fully positive (both populations have a positive effect on each other's vital rates) interactions.

Positive interaction

Proposition 3.1: A typical type 2 interaction between two different niche dimensions of two organizational populations related to resources results in a situation where both populations have a positive effect on each other's vital rates.

Negative interaction

Proposition 3.2: Typically, population decline or concentration leads to type 2 interaction, where both populations have a negative effect on each other's vital rates, or where the effects that populations have on each other's vital rates are asymmetric.

The effect of a dominant population

Proposition 4: The interdependence between the niche dimensions of two organizational populations (either type 1 or type 2) is contingent on the dominance of another organizational population in comparison to the other: A dominant population exerts a stronger negative or weaker positive effect on the vital rates of another organizational population.

Aggregate interdependence among the populations

Proposition 5: The total or aggregate interaction (i.e. how two populations affect each other's vital rates) between two organizational populations is a function of all type 1 and type 2 interactions existing between the niche dimensions of the two organizational populations.

4. Research Design

This chapter presents the research design of the empirical part of the study. I will start with the objectives of the empirical part and an overview of the research design. Next, I will more specifically discuss the research setting of the study. A description of the data (statistical and life-history data of the paper and pulp industries) and how it has been gathered, follows. Finally, I will give an overview of the methods of the study, with a focus on historical descriptive analysis of the evolution of the studied industries.

4.1. Overview and objectives of the empirical research

The focus of the empirical part of the study is on applying the developed theoretical framework of the population interdependences in an analysis of ecological interdependences between the paper and pulp industries within four European countries – Finland, Sweden, Germany, and the UK – during the time period 1950-2005. To achieve this objective, the empirical part of the study is built as follows. I will start with a historical descriptive analysis of the evolution of the industries and aim at identifying the main evolutionary trends and incidents affecting the evolution of the industries during the research period. The written historical narratives based on reading industry histories are complemented by statistical data of the evolution of the industry. The statistical data includes the main variables frequently employed by research for industry evolution: the number of firms, employees, and the volume of production. The historical narratives are followed by an analysis of the ecological interdependences between the industries, based on the theoretical framework and quantitative data of the resource flows between the studied industries. Next, I will formulate hypotheses of the interdependences between the industries on the basis of earlier analysis. Finally, I will test the hypotheses from the perspective of

the paper and pulp industry with quantitative research methodology, using the growth of paper and pulp firms in the four countries as the dependent variable. The objectives of the empirical research may thus be summarized as follows:

- To apply the framework in the analysis of evolutionary interdependences between paper and pulp and printing and publishing industries in four European countries – Finland, Sweden, Germany, and the UK – during the time period 1950-2005
    - To analyze the evolution of the industries descriptively
    - Based on the theoretical framework, to identify the interdependences between the industries and to analyze the interdependences by quantitative data of resource flows among the industries
    - To develop hypotheses of the interdependences between the industries
    - To test the hypotheses by quantitative research methodology from the perspective of paper and pulp industries.

In general, the research design of the study follows earlier ecological research tradition. According to Carroll & Hannan (2000), the empirical research strategy of organizational ecology has four distinguishing characteristics: (1) it selects populations of organizations and then examines their full histories; (2) it gathers life-history data on all organizations in the populations, including the large and famous as well as the small and insignificant; (3) it records detailed information about the type of entry (e.g. new founding, entry from another industry, merger, division of an existing organization) and exit (disbanding, acquisition, transformation) for each organization; (4) it estimates the effects of the characteristics of the organization, population, and environment on the patterns of entry and exit. This kind of population-research strategy enables systematic study of changes in the composition and diversity of the worlds of organizations (Hannan 2005).

The main characteristic that differentiates the current study from earlier ecological research is that the study goes deeper in the analysis of the evolutionary dynamics of the industries. Although earlier ecological research has naturally offered a short introduction to the research context and the evolution of the considered population(s), the historical analysis has mostly focused on the number of organizations in the population(s) and the rate of organizational entries and exits. Only rarely has earlier research

(for exceptions, see e.g. McKendrick & Carroll 2001) aimed at analyzing the evolution of considered population(s) in greater depth. When considering the objectives of ecological research (e.g. the theory of density dependence) of generating highly generalizable theoretical arguments, the focus of earlier research is understandable. However, when considering the introduced theoretical framework, I believe that analyzing the evolution of the industries more thoroughly is essential in order to understand how the industries are interdependent and what factors affect the interdependences. Finally, it is also important to note that the research does not consider the whole evolution of the two industries; an issue discussed in the next section.

4.2. Research setting

4.2.1. Short definitions of the industries

Briefly, the paper and pulp industry consists of firms manufacturing paper; many of the firms also produce pulp. Pulp, either mechanical or chemical, is the basic ingredient for the manufacture of paper and board; pulp, is produced from wood or, increasingly, from recovered fiber. The main types of paper products are newsprint, different types of printing and writing papers (uncoated or coated mechanical papers and uncoated or coated wood-free papers), sack paper, containerboard (kraft and testliner; used as the outer and inner layers of corrugated board), and cartonboard (used for packaging boxes for food, beverages, cosmetics, and chemicals, among others) (Diesen 2007).

The printing and publishing industry covers firms engaged in the printing of paper and/or publishing of different types of paper-based printing products. The printing side of the industry covers such market segments as the printing of newspapers (some 20 percent of the production of the industry), magazines and periodicals (some 20 percent of the production), books (10 percent of the production), and advertising materials (direct mail catalogues, prospectuses, posters, and advertising inserts and leaflets) (Hazley 2000). The main market segments of the publishing side of the industry, then, include newspapers, periodicals, books, corporate publishing, directories, and direct marketing. The publishing of non-paper products (such as games, databases, internet publishing, or TV and radio broadcasting) are not considered to be part of the industry.

4.2.2. Choice of the industries

The choice of the four countries as the research setting of the study was mainly based upon the characteristics of the two industries in the four countries. First, Germany, Finland, and Sweden are the largest paper producing countries in Europe. Historically, the UK has also been among the leading paper producing countries in Europe, although its significance has declined considerably after the Second World War. The share of the four countries of the total paper and board production in Europe is considerable: still in 2005, they produced 56 percent of the total paper and board manufactured in Europe.

Second, the four countries have very different size of markets for printing and publishing products. The smaller countries, Finland and Sweden, have small printing and publishing industries in comparison with Germany and the UK, the latter having the largest markets for printing and publishing products in Europe. As such, the demand for printing and publishing products in Finland and Sweden would not have allowed the growth of the respective paper and pulp industries to their current size.

Third, in the two Nordic countries (Finland in particular), the paper and pulp industry has since the early 20th century been one of the largest (if not the largest) domestic manufacturing industries. The importance of the industry to the Finnish (and also Swedish) economy was naturally one of the starting points of the study. In particular, the question of how important a role the two largest printing and publishing markets in Europe (i.e. Germany and the UK, see above) had when considering the growth of the Finnish and Swedish industries is of a particular focus of the study. In general, the UK and Germany have, since the Second World War, become the most important export countries for the Finnish and Swedish paper and pulp industries. For example, with regard to printing and writing papers, the share of Germany and the UK of the total exports of printing and writing papers of Finland and Sweden has been some 40 percent since the Second World War (see section 5.12).

Thus, the four countries offer an interesting research setting for a study of interdependences between the paper and pulp and printing and publishing industries. In particular, with regard to Finland and Sweden, it is obvious that the growth of the paper and pulp industries in the countries would not have been possible without foreign markets. The two largest printing and publishing industry markets in Europe, Germany and the UK, have clearly had an important role in the evolution and growth of the Nordic paper industries.

4.2.3. Choice of the research period

Both of the studied industries have a long history. Why then does this study focus only on the period 1950-2005? The decision is mainly based on the development that took place in Western Europe after the Second World War, but also on issues related to data. First, the first half of the 20th century was characterized by periods of considerable instability in Europe (for example, two world wars), and especially Finland and Germany were strongly affected by these events[13]. The period was also characterized by protectionism. For example, in particular from 1930s onwards, the UK market was protected by tariffs with regard to paper products. Moreover, cartels controlled much of paper production in Germany (and the UK) during the period, thereby inhibiting paper imports from the Nordic countries. Thus, studying the dynamics of the interactions between the industries within the four countries would not have been relevant during the period. It was only after the Second World War that gradual trade liberalization in Western Europe enabled the current types of dynamics among the industries to develop.

Second, the availability of data seriously restricted the potential study period. Ideally, of course, a research period for studying industry evolution should start from the very first entry of a firm to the industry in question. Even if the studied industries were considered to have been born after their mechanization, this would mean that the research period should start from the early 19th century. However, it would have been impossible to gather consistent time-series or life-history data of the studied industries for the whole period. Even statistical data of the industries was not generally published before the 20th century (in Finland, however, the first industry statistics were published already in 1884). The problem concerning statistical data, in particular, was also that, for example, in Germany the principles for gathering and reporting statistical data changed several times even during the first half of the twentieth century. Industry directories, on the basis of which the life-history databases of the firms in the industries were constructed (see next section), published before 1950 were also not generally available and thus restricted any choice to widen the research period.

Thus, the research period of the study, 1950-2005, does not only reflect the result of the changes that took place in Western Europe after the Second World War and which enabled the current types of interdependences

[13] See descriptions of the evolution of the industries starting in section 5.3 for more information of the factors affecting the evolution of the industries during the first half of the 20th century.

between the studied industries to develop, but also the serious limitations related to the availability of data before the chosen research period.

4.3. Data

4.3.1. Statistical data

Several data sources were examined during the process of compiling the data sets for the analysis of evolution of interdependences between the two industries in the studied four countries. In the following, I will go through these data sources according to the type of data, and explain the adjustments I made to the data in constructing the time series. The variables for which I collected data were (1) the number of establishments/firms/enterprises in the paper and pulp and printing and publishing industries in the four countries; (2) the number of employees in the industries; (3) the output of the printing and publishing industries; (4) the production figures of total paper and board, and the production figures of different paper grades (newsprint and printing and writing papers in particular) of the four paper and pulp industries; (5) a country's total exports and imports of paper and board products; (6) a country's total exports and imports of main paper and board grades; (7) a country's total exports and imports of main paper and board grades to and from the other countries considered; (8) the gross domestic product (GDP) of the country; (9) and the population of the country. **Table 4-1** summarizes the data, its sources, and main adjustments.

The values for the number of establishments (an establishment is defined as a production unit that is owned by one enterprise, is located on one site, and operates within one industry; in other words, produces goods and services of mainly one particular type) for both industries in Finland were collected from annual industry statistics (Teollisuustilasto 1884-2006). The values were gathered starting from the first year for which data was available, 1884. Although the classifications of statistics changed several times during the time period, I was able to track down the data for several sectors of the industry until the current date. In particular, the sub-sectors in the paper and pulp industry remained rather same for the whole period. Thus, starting from 1884, I was able to count the number of establishments for total paper and pulp production, for the production of paper and board, and for the production of pulp. For the printing and publishing industry, I was able to track down the number of different types of printing

establishments for the whole time period. Data for different types of publishing (e.g. newspapers, magazines, books) establishments was then available from 1954 onwards. Due to the fact that the principles of the industry statistics changed considerably in 1995, I had to scale the data from this year onwards in order to present a coherent and consistent time-series. The scaling was carried out based on a scaling factor[14] that may be used for adjusting the data so that the values of the measure become comparable. In essence, based on the new principles of categorizing and gathering statistical data, the figures for the number of establishments were considerably higher for the period after 1995.

The data for the Swedish paper and pulp, and printing and publishing industry establishments (an establishment defined as in Finland) was collected from Swedish industry statistics (Industri 1911-1958; 1959-1995; Industrins varuproduktion 1995-2006). Although, again, the industry classifications changed several times during the time period, I was able to assemble time-series data for the most important sectors of both industries, starting from 1911. First, for the paper and pulp industry, time-series data of the number of establishments was available separately for paper and board establishments and pulp establishments. Second, for the printing and publishing industry, the number of printing establishments was available for the whole time period. It is important to note, however, that in the Swedish industry statistics the printing establishments also included newspaper publishing establishments until 1993 (they were classified separately only from 1993 onwards). Thus, in order to make data comparable, from 1993 onwards, I combined the printing establishments to include also newspaper publishing establishments. The publishing establishments covered in the statistics from 1993 onwards include all other types of publishing establishments (such as book publishing). Finally, the principles of constructing statistics changed considerably in 1993 and 1997. In order to construct a continuous time-series of the values of the establishments, I scaled the values for the establishments based on a scaling factor (see the explanation above).

With regard to Germany, the data of the number of firms was gathered from Statistical Yearbooks first for West Germany and after 1990 for the Federal Republic of Germany (Statistisches Jahrbuch 1950-1989; 1990-2007). The data was only available at the main industry level (i.e. paper and pulp industry, and printing and publishing industry) until 1995 (even in the industry statistics). Thus, it was not possible to present the number of establishments for any sub-sectors of the industry. In contrast to Finland

[14] The scaling factor is constructed by comparing the values of the measures compiled on the basis of the different methods.

and Sweden, a firm was the unit of analysis for which data is presented in the German statistics. Further, the principles of constructing statistics changed in 1977 and 1995. First, before 1977, firms with more than 10 employees were covered in the statistics, but starting from 1977, only firms with more than 20 employees were covered. Starting from 1995, again, the statistics covered firms with more than 10 employees. Thus, for the period 1977-1994, I scaled the values of firms based on the values of firms in the last year reported by different principles. Although I suspect that the scaling does not have a considerable effect on the number of paper and pulp firms (as most of the firm have been large in size for the whole period), the effect of scaling is potentially more significant for the number of printing and publishing firms, as most of the firms in the industry have been small in size.

For the UK, I gathered data for the paper and pulp and printing and publishing firms from the industry statistics of the country (Census of production 1970-1992; Historical record of the census of production 1978; Pacstat 1993-1995; ABI 1996-2007). For the paper and pulp industry, I was only able to track down the number of firms at the industry level from 1958 onwards. Furthermore, before 1970, the Census of Production was only published in 1958, 1963, and 1968. Values for the missing years were linearly interpolated. With regard to the printing and publishing industry, I was able to track down the total number of enterprises in the industry from 1963 onwards (as in the paper and pulp industry, values for years for which the Census was not published, were linearly interpolated). Additionally, from 1958 onwards, I was able to track down the number of enterprises related to printing and publishing of newspapers and periodicals. Finally, it is important to note that the level for which the figures are reported was a firm. The principles of gathering the statistics changed considerably in 1984, when more firms were included in inquiries, and this resulted in an increase in the number of firms. From this year onwards, I scaled the number of firms on the basis of the figures for the year 1983. Due to the scaling, the absolute numbers of firms may be somewhat distorted.

The numbers of employees were collected from the same sources as the numbers of establishments and firms. For Finland, the data source was the annually published industry statistics (Teollisuustilasto 1884-2006). As for the number of employees, for the paper and pulp industry, I was able to track down the number of employees in the production of paper & board and pulp for the whole time period. With regard to the printing and publishing industry, the number of employees for different types of printing establishments was available for the whole period, and for the publishing establishments from 1954 onwards. The figures did not require scaling, as

the methods for gathering the statistics seemed to remain constant for the whole period for which data was available.

With regard to Sweden, the data of the number of employees was also collected from industry statistics (Industri 1911-1958; 1959-1995; Industrins varuproduktion 1995-2006). Again, I was able to track down the number of employees for the same sectors as for the number of establishments: for paper and pulp industry for paper & board and pulp production, and for printing and publishing industry for printing and newspaper publishing establishments (1911-2006) and other publishing establishments (1993-2006). Due to changes in constructing statistics in 1993 and 1997, I scaled the figures for the number of employees based on a scaling factor.

For Germany, the source from which the data for the number of employees was gathered was the Statistical Yearbook (Statistisches Jahrbuch 1950-1989; 1990-2007). The data was only available at the level of main industries. Due to changes in the methods of constructing statistics in 1977 and 1995 (the aforementioned changes), I scaled the employment figures for the period 1977-1994 on the basis of the figures in 1976. With regard to the UK, the data of the number of employees was gathered from the industry statistics (Census of production 1970-1992; Historical record of the census of production 1978; Pacstat 1993-1995; ABI 1996-2007). The sub-sectors and years for which data was gathered were as for the number of enterprises. As it seemed that the methods of gathering data with regard to the number of employees did not change considerably during the period, no scaling of the values was necessary.

The data concerning the output of printing and publishing industries was gathered from the same sources and was generally available at the same level as the data for the number of establishments/firms and the number of employees. Some noteworthy issues of the process of gathering and modifying the data should be remarked upon, however. First, with regard to the Finnish industry, the total output of the industry was measured by using the gross value of production (values that were available for the whole period), defined as follows: turnover + deliveries to the enterprise's other establishments + change in the inventory of finished products + production for own use + other operating profits - transfer gains from fixed assets - purchases of goods for resale. The values of the gross value required no scaling. Further, the values were inflation-adjusted, but the adjustment was only possible for figures after 1950. In the analysis, the gross value of production is presented in constant 1999 Euros.

Second, with regard to Sweden, the total output of the industry was measured by the total value of production (produktionsvärde). Because data relating to the publishing industry was available only from 1993

onwards, the total value of production of printing establishments (including the publishing of newspapers) was considered to be the total output of the industry for the whole period. Owing to the changes in the methods of constructing the statistic in 1993 and 1997, the values for the value of production were scaled from 1993 with methods already described. The values of the production value were also inflation-adjusted and converted to constant 1999 Euros. Third, for Germany, the total revenue of the printing and publishing firms was used as the measure of the total output of the industry (since no other measures were reported). No scaling of the measure was required. Further, the values of the measure were inflation-adjusted and converted to constant 1999 Euros.

Fourth, with regard to the UK, I was able to retrieve figures for the total sales and net output (or gross value added) of the printing and publishing industry[15]. The values were available for the whole printing and publishing industry for 1949-2007 and for the printing and publishing of newspapers and periodicals for 1949-1992. For years for which the Census of production was not published, the values of the measures were estimated by linear interpolation. As in the other countries, the values were inflation-adjusted and converted to constant 1999 Euros. Finally, it is important to note that although the figures for every country were converted to constant 1999 Euros, they should not be compared directly, due to the differences in how they were calculated. It was, however, impossible to find fully comparable figures of the output of the industry for the studied countries.

Turning to the production figures for paper and board, and different grades of papers and board, first, with regard to Finland, I used industry statistics (Teollisuustilasto 1920-1966) in gathering the data of the total production of paper and board and the production of main paper grades for the period from 1920 to 1966. From 1964 onwards, I retrieved the respective data from the database compiled by FAOStat (www.faostat.fao.org), including the data of the production, imports and exports of different types of paper and board. Collecting overlapping data from two sources for a few years enabled me to check the consistency of the data. As has been constantly applied in earlier research on the paper and pulp industry (for recent research, see e.g., Kärkkäinen 2005; Lamberg et al. 2006; Diesen 2007), I use quantities of paper in metric tons as the basic unit when considering the production, imports and exports of paper and board.

Second, similar to Finland, I gathered data of the production of paper and board in Sweden from the industry statistics from 1911 to 1966

[15] The total sales is the measure used in the quantitative models as the measure of the total output of the industry.

(Industri 1911-1958; 1959-1995). From 1964 onwards, the respective data was retrieved from the database of FAOStat. Third, with regard to Germany, I used Statistical Yearbooks in retrieving the production figures. The figures from 1964 onwards were retrieved from the FAOStat database. Finally, for the UK, I used Hills (1988) and Wray (1978) for gathering the data of the production figures for 1949-1966. From 1964 onwards, I retrieved the respective data from the FAOStat database.

With regard to the countries' total imports and exports of paper and board and main paper and board grades (newsprint and printing and writing papers in particular), I went through every country's statistics of foreign trade until 1963, after which I collected the respective data from the OECD.Stat database (http://www.oecd-ilibrary.org/content/data/data-00285-en) covering imports and exports of main paper and board grades in the four studied countries from 1963 to the current date. More specifically, in the case of Finland, I used the statistics for foreign trade (Ulkomaankauppatilasto 1920-1965) in gathering data of the main paper and board grade flows between the four countries during 1920-1965. In the Swedish case, the respective statistical publication was also the statistics for foreign trade (Utrikeshandel 1930-1965), which I examined for 1930 to 1965. For Germany, I went through the respective foreign trade statistics during the period 1950 to 1965 (the first volume was published in 1950) (Aussenhandel 1950-1965). Finally, for the UK, I retrieved the data for the period 1950 to 1965 from the foreign trade statistics of the country (Overseas trade statistics 1949-1965). It is important to note that the figures with regard to exports and imports vary somewhat by the reporting country (which is, of course, natural). In the analyses that follow, I consistently use the volume of exports and imports reported by the country the analysis focuses on.

Finally, with regard to the time-series for the gross domestic product and population of the countries, the data was retrieved from the total economy database compiled and maintained by The Conference Board of Groningen Growth and Development Centre (http://www.conference-board.org/data/economydatabase/). The GDP figures for the countries from 1950 onwards are presented in constant 1999 US dollars (converted at Geary Khamis PPPs).

4.3.2. Life-history data of paper and pulp firms

The life-history databases of the paper and pulp industry firms operating in the four studied countries were built on the basis of the international paper industry database (see e.g. Järvinen, Lamberg, Murmann et al. 2009),

including information of the firms operating in paper and pulp industry in several cross-cutting years (1875, 1910, 1938, 1950, 1974, and 2000), with the primary source of data being Phillip's Paper Trade Directory of the World (Phillips 1910; 1938; 1950; 1974; 2000). Because similar industry directories have been used commonly in earlier ecological research in constructing life-history databases of the studied industries, including newspapers (Barnett & Carroll 1987; Dobrev 2001; Boone et al. 2004), semiconductor manufacturers (Hannan & Freeman 1989), banks (Barnett 1997), hotels (Baum & Mezias 1992; Ingram 1996), art museums (Blau 1995), trade associations (Aldrich, Zimmer, Staber et al. 1994), telephone firms (Barnett 1990), wineries (Swaminathan 1995), microprocessors (Wade 1996), and health maintenance organizations (Wholey et al. 1992), I decided to use the same approach in this study and construct the databases using Phillip's Trade Directories of the World as the main source of data. The primary objective was to go through every published directory during the research period, but due to the availability of the directories and time restrictions, I decided to examine at least every second directory. Finally, 40 of the total of 56 directories, published during the time period in question were included, resulting in one period with a two-year gap in the directories (1951-1952) and 14 with a one-year gap (missing directories are from years 1955, 1957, 1963, 1967, 1970, 1973, 1975, 1978, 1980, 1982, 1984, 1986, 1988, 1991) .

The coding process of the data proceeded as follows (see Table 4-1 for the summary of the coding process). First, all relevant information with regard to paper and pulp mills in the directory were coded (the data in the directories was mainly at the mill level). The information included the name of the mill, its owner, location, address, type of production (paper and board and/or pulp), number of paper and board machines, their width, amount of production of paper, and the types of manufactured products. After completing the mill level coding, the data was aggregated to firm level by following the ownership information for individual mills. In general, the mills were categorized under their owner firms in the directories, and if this was not the case, and the mill was a part of a larger firm, the mill entry usually included the name of the owner firm. Subsidiary firms with a head office of their own were considered as independent firms.

After the aggregation procedure, annual life-histories of the firms were formed. As has been the norm in earlier ecological research using directories in constructing life-history databases, the firm entry date was defined by the first appearance of the firm in the database, and the exit date by the last appearance of the firm in the database, if no other information of the entry and exit year was available (in particular, the year of entry was in

some cases mentioned in the directories). If the firm appeared during a gap year, the entry year was coded according to the year the firm first appeared in the directory, and if the firm had exited during a gap year, the exit year was coded according to the last year the firm appeared in the directory. Although the gap years may have resulted in some inaccuracies in the annual life-histories, with regard to the entry and exit years of the firms, their effects in the analysis should not create significant problems. Finally, in general, the directories did not permit the type of entry or exit of the firms to be determined.

In order to test the reliability of the data, the Birkner European Paper Industry Directory and Nordisk Papperskalender was checked first for a few cross-cutting years, 1950, 1974, and 2000 (Birkner 1900 - 2000; Landberg, Lyche & Ojala 1950). Second, for the Finnish industry, I went through various sources, including the websites of individual firms, firm histories (e.g. Hoving 1947; 1949; Nordberg 1980; Kahiluoto 1990; Ahvenainen 1992; Nordberg 1998; Tuuri 1999), and industry histories and related evolutionary research (e.g. Näsi, Lamberg, Ojala et al. 2001; Kuisma 2006; Jensen-Eriksen 2007; Kuisma 2008), in order to check the life-history data related to the industry, and in particular, the entry and exit dates of the firms (and also entry and exit types). On the basis of the sources, I was able to identify "accurate" entry and exit years for almost every paper and pulp firm operating in the industry during the research period. Additionally, the sources enabled me to construct a life-history database of the firms in the industry from the very first entry to the industry until the current date (however, no data of production figures, for example, was available before 1949). In general, the entry and exit years defined on the basis of the directories corresponded to the years from other sources. Additionally, the life-history database constructed on the basis of the directories covered all the firms in the industry. Third, with regard to procedures for checking the reliability of the data with regard to the four life-history databases, I also checked whether the total production volume of paper and board calculated based on the information in the directories corresponded to figures retrieved from statistics. Additionally, I also went through the annual reports of the largest firms during the last decade and checked the correspondence of the figures.

As the production figures of the firms (i.e. firm growth) are used as a dependent variable in the quantitative analysis of the study, it is important to consider the process by which the annual production figures for the firms were derived (for justification for growth as a dependent variable, see section 6.1.1). First, with regard to the aforementioned gap years, linear interpolation was used to derive the values for the years. Second, as the

figures were not available even for all the years for which directories were examined, linear interpolation was used in deriving the values for the years. However, this type of linear interpolation was rare, because in most cases, if a firm's amount of production was reported even for one year, it was reported for every year of the firm's existence. Third, firms for which no data of production existed created a problem. This was relevant only for the German and UK industry[16], however. For the German industry, production figures were not available for 193 of 517 paper and pulp firms (37 per cent of the firms). The respective figures for the UK industry were 137 out of 317 firms (43 per cent of the firms). Because I was not able to gather production data for these firms, I had to leave them out of the quantitative analysis. Thus, admittedly, the life-history data with regard to production figures of the German and UK industries is potentially distorted. However, since very little information of these firms was available (of many firms, I only knew their year of entry and exit, location and some information about their products), I was not able to take the problem further into consideration. In any case, because the production figures of the four industries, calculated on the basis of firm-specific production figures, were generally in line with the production figures of the industries reported in the official statistics of the countries, the firms of which data was missing must have been rather small in size (of course, this does not address the original problem).

As a conclusion, it can be stated that the four life-history databases should cover the firms and their information reliably, in particular for the Finnish and Swedish paper and pulp industries during 1949-2005. The database for the Finnish industry covers in total 37 firms, and the Swedish industry 126. Although the life-history databases for the German (517 firms in total) and UK (317 firms in total) paper and pulp industries should also cover the firms in the industries rather reliably, the main problem in the databases is the missing production figures, as I use firm growth measured by the production figures as a dependent variable in the quantitative analysis. The main problem, however, why I decided to use firm growth as a dependent variable in the first place is that I was not able to detect the types of entries and exits for firms in the four industries. I will discuss this problem more thoroughly in section 6.1.1.

[16] With regard to Finnish paper and pulp firms, the data of production was available for all the firms (the total number of firms was 37). For Swedish firms, the data for eight firms was missing (all these firms were in existence for a few years only). As the total number of firms was 126, the production figures for six per cent of the firms were not available.

Table 4-1: Summary of the gathered data: Measures, sources, time period, and adjustments.

Country / industry / data	Data sources	Time period for which data is gathered	Main adjustments
Finland			
Paper & pulp industry			
(1) Number of establishments	• Annual industry statistics (Teollisuustilasto 1884-2006)	• 1884-2006: Paper & board establishments • 1884-2006: Pulp establishments	• Due to changes in reporting of the data (1995-), the values for 1995-2006 were scaled based on a scaling factor
(2) Number of employees	See above	• 1884-2006: Production of paper & board • 1884-2006: Production of pulp	
(3) Industry production	• Annual industry statistics (Teollisuustilasto 1920-1966) • FAOStat (1964-2006)	• 1920-2006: Production of paper & board (in metric tons) • 1949-2006: Production of main paper & board grades (in metric tons)	
(4) Paper & board imports and exports	• Foreign trade statistics (Ulkomaankauppatilasto 1920-1965) • OECD.Stat (1964-2006)	• 1920-2006: Paper & board imports and exports (total and main grades; in metric tons) • 1920-2006: Paper & board imports and exports from and to the considered countries (total and main grades; in metric tons)	
Printing & publishing industry			
(1) Number of establishments	• Annual industry statistics (Teollisuustilasto 1884-2006)	• 1884-2006: Printing establishments • 1954-2006: Publishing establishments	• Due to changes in reporting of the data (1995-), the values for 1995-2005 were scaled based on a scaling factor
(2) Number of employees	See above	• 1884-2006: Printing • 1954-2006: Publishing	
(3) Industry production	See above	• 1950-2006: Gross value of production of printing • 1954-2006: Gross value of production of publishing	• The values were inflation -adjusted and converted to constant 1999 Euros
Sweden			
Paper & pulp industry			
(1) Number of establishments	• Annual industry statistics (Industri 1911-1995; Industrins Varuproduktion 1995-2006)	• 1911-2006: Paper & board establishments • 1911-2006: Pulp establishments	• Due to changes in reporting of the data (1993- and 1997-), the values for 1993-1997 were scaled based on a scaling factor
(2) Number of employees	See above	• 1911-2006: Production of paper & board • 1911-2006: Production of pulp	See above
(3) Industry production	• Annual industry statistics (Industri 1911-1966) • FAOStat (1964-2006)	• 1911-2006: Production of paper & board (in metric tons) • 1911-2006: Production of main paper & board grades (in metric tons)	
(4) Paper & board imports and exports	• Foreign trade statistics (Utrikeshandel 1930-1965) • OECD.Stat (1964-2006)	• 1930-2006: Paper & board imports and exports (total and main grades; in metric tons) • 1930-2006: Paper & board imports and exports from and to the considered countries (total and main grades; in metric tons)	
Printing & publishing industry			
(1) Number of establishments	• Annual industry statistics (Industri 1911-1995; Industrins Varuproduktion 1995-2006)	• 1911-2006: Printing and newspaper publishing establishments • 1993-2006: Other publishing establishments	• Due to changes in reporting of the data (1993- and 1997-), the values for 1993-1997 were scaled based on a scaling factor
(2) Number of employees	See above	• 1911-2006: Printing and newspaper publishing • 1993-2006: Other publishing	See above
(3) Industry production	See above	• 1911-2006: Total value of production of printing and newspaper publishing • 1993-2006: Total value of production of other publishing	• Due to changes in reporting of the data (1993- and 1997-), the values for 1993-1997 were scaled based on a scaling factor • The values were inflation -adjusted and converted to constant 1999 Euros

Table 4-1 (continues): Summary of the gathered data: Measures, sources, time period, and adjustments.

Country / industry / data	Data sources	Time period for which data is gathered	Main adjustments
Germany			
Paper & pulp industry			
(1) Number of firms	• Statistical yearbooks (Statistisches Jahrbüch für die Bundesrepublik Deutschland 1950-2006)	• 1950-2006: Paper, board & pulp firms	• Due to changes in reporting of the data (1977- and 1995-), the values were scaled for 1977-1994
(2) Number of employees	See above	• 1950-2006: Production of paper, board & pulp	See above
(3) Industry production	• Statistical yearbooks (Statistisches Jahrbüch für die Bundesrepublik Deutschland 1950-1966) • FAOStat (1964-2006)	• 1950-2006: Production paper & board (in metric tons) • 1950-2006: Production of main paper & board grades (in metric tons)	
(4) Paper & board imports and exports	• Foreign trade statistics (Aussenhandel 1950-1965) • OECD.Stat (1964-2006)	• 1950-2006: Paper & board imports and exports (total and main grades; in metric tons) • 1950-2006: Paper & board imports and exports from and to the considered countries (total and main grades; in metric tons)	
Printing & publishing industry			
(1) Number of firms	As for the paper & pulp industry	• 1950-2006: Printing & publishing firms	As for the paper & pulp industry
(2) Number of employees	See above	• 1950-2006: Printing & publishing	See above
(3) Industry production	See above	• 1950-2006: Total revenue of printing & publishing	• The values were inflation -adjusted and converted to constant 1999 Euros
the UK			
Paper & pulp industry			
(1) Number of firms	• Censuses of production (Historical record of the census of production 1907-1970 1978; The annual census of production 1970-1992; Annual business inquiry (ABI) 1996-2007)	• 1958-2006: Paper, board & pulp firms	• The values were linearly interpolated for years (1959-1962; 1964-1967; 1969) in which the census of production was not published • Due to changes in reporting of the data, the values for 1984-2007 were scaled on the basis of the figures for the year 1983
(2) Number of employees	See above	• 1958-2006: Production of paper, board & pulp	• The values were linearly interpolated for years (1959-1962; 1964-1967; 1969) in which the census of production was not published
(3) Industry production	• Wray (1978) • Hills (1988) • FAOStat (1964-2007)	• 1949-2006: Production of paper & board (in metric tons) • 1949-2006: Production of main paper & board grades (in metric tons)	
(4) Paper & board imports and exports	• Foreign trade statistics (Overseas trade statistics 1949-1965) • OECD.Stat (1964-2006)	• 1949-2006: Paper & board imports and exports (total and main grades; in metric tons) • 1949-2006: Paper & board imports and exports from and to the considered countries (total and main grades; in metric tons)	
Printing & publishing industry			
(1) Number of firms	As for the paper & pulp industry	• 1958-2006: Printing and publishing of newspapers & periodicals firms • 1963-2006: Printing and publishing firms	As for the paper & pulp industry
(2) Number of employees	See above	• 1958-2006: Printing and publishing of newspapers & periodicals firms • 1963-2006: Printing and publishing firms	As for the paper & pulp industry
(3) Industry production	See above	• 1949-1992: Total sales and net output of printing and publishing of newspapers and periodicals • 1949-2006: Total sales and net output of printing & publishing	• The values were linearly interpolated for years (1959-1962; 1964-1967; 1969) in which the census of production was not published • The values were inflation -adjusted and converted to constant 1999 Euros

Table 4-1 (continues): Summary of the gathered data: Measures, sources, time period, and adjustments.

Country / industry / data	Data sources	Time period for which data is gathered	Main adjustments
Data with country/industry independent data sources			
Paper & pulp industry			
(5) Firm entry and exit years, information of firms	• Phillip's paper trade directory of the world (1949-2005) • Birkner European paper industry directory & Nordisk papperskalender (1950;1974;2000), internet pages, firm and industry histories	• -2005: Firm entry and exit years for Finland • 1949-2005: Firm entry and exit years for Germany, Sweden, and the UK	• Firm level data aggregated from mill level data • Firm entry year: Defined by the first appearance of the firm in the database, if no other information available • Firm exit year: Defined by the last appearance of the firm in the database, if no other information available
(6) Number of firms	See above	• -2005: Number of firms for Finland • 1949-2005: Number of firms for Germany, Sweden, and the UK	• The values were linearly interpolated for years for which data was not available
(7) Firm level paper & board production	See above	• 1949-2005: Paper & board production (in metric tons)	• The values were linearly interpolated for years for which data was not available
GDP	• Groningen total economy database	• 1950-2006: GDP in every considered country in constant 1999 USD	
Population	• Groningen total economy database	• 1950-2006: Population in every considered country	

4.4. Overview of the methods

The study uses two types of methodology: historical, more qualitative narrative analysis of the evolution of the eight industries and the interdependences between the industries, and a quantitative methodology in the form of regression analysis to test the hypotheses formulated on the basis of the theoretical framework and the historical analysis of the industries and interdependences (the quantitative methodology is described in chapter 6). The starting point of the empirical analysis is the historical narratives of the eight studied industries. As described by Lamberg (2005), the general aim of historical narratives is to include contextual factors (institutional and competitive antecedents among others) in the analysis through realistic narration. Further, as Tsoukas (1989) states, realistic narratives help to identify generative mechanisms that are the driving processes of the underlying structures. In general, narrative analyses can be considered essential for understanding the trends affecting the evolution of the industries and to make sense of the overall quantitative results. In this study, the narratives will be written on the basis of reading the literature related to the evolution of the eight industries, complemented by quantitative statistical time-series data of the industries. For every industry, figures of the number of firms and/or establishments, the number of employees, and the output will be presented. Thus, the data covers the basic variables usually analyzed in the research on industry evolution. I will also construct a timeline of the most important evolutionary trends and incidents that have contributed to the evolution of the industries during the research period.

The narratives are followed by a descriptive analysis of the resource flows between the industries during the research period. The resource flows between the industries and changes taking place in them are interpreted in the light of the narratives. On the basis of the analysis of the resource flows, I will then formulate empirically testable hypotheses of the ecological interdependences between the industries.

5. Evolution of and Interdependences between Paper & Pulp and Printing & Publishing Industries

This chapter begins the empirical analysis of the study. The first main objective of the chapter is to offer short historical descriptive analyses of the evolution of the paper and pulp and printing and publishing industries in the four analyzed countries – Finland, Sweden, Germany, and the UK. In particular, I aim at outlining the most important changes in the respective industries and the factors (both at the level of the industry and the economy in question) affecting the changes and evolutionary dynamics of the industries, in particular after the year 1950, the period of focus of the study. Before going deeper into the country-specific evolutionary dynamics, I will describe the general characteristics and evolutionary patterns of the industries. Although the section covers the general evolutionary trends of the paper and pulp industry, historical country level analyses approach the evolution from the perspective of the production of newsprint and printing & writing papers. This is because the focus of this study on the interdependences between the paper and pulp and printing and publishing industries. With regard to the printing and publishing industry, my focus in the publishing side of the industry is mostly on printed media.

The second main objective of the chapter is to descriptively analyze the interdependences between the four paper and pulp, and printing and publishing industries, based on the resource flows between the industries. The third objective is to combine the descriptive historical analysis of the evolution of the industries and resource flows between the industries with the theoretical framework of the study and to formulate testable hypotheses of the ecological interdependences between the considered industries in the four countries during the time period 1950-2005.

In order to achieve the objectives, the chapter proceeds as follows. I will start with the general characteristics of paper & pulp and printing &

publishing industries. Descriptive analyses of the eight studied industries follow. I will then discuss the possible types of interdependences between the industries, and end up by arguing that the main interdependence between the industries is created by paper. By building on the historical analyses and the fact that the main ecological interdependence between the industries is created by resource flows related to paper, I will next analyze the paper flows between the industries during the research period of the study and formulate testable hypotheses of the interdependences between the industries.

5.1. General characteristics and evolution of the paper and pulp industry

In general, the paper and pulp industry can be considered rather old: the first paper production mills e.g. in France and Germany were established already in 1320 (e.g. Krawany 1910; Salzman 1911; Munsell 1980). However, before the nineteenth century, paper was hand-made in small-scale manufacturing plants, using rags as raw materials (Krawany 1910; Coleman 1958). The production figures of paper were respectively very small. It was not until 1797, after the invention of the "modern" paper machine (referred to as "Fourdrinier") that larger scale production of paper began. The first Fourdrinier machine commenced operation in the U.K. in 1803 (Hills 1988), and during the first half of the nineteenth century the machines were introduced to all the countries analyzed in this study (Coleman 1958). The basic operational principle of a Fourdrinier machine has basically remained the same for the whole history of the industry.

Although the basic operation principle of the paper machine, as such, has remained the same during the evolution of the industry, a large number of technological improvements have taken place both in the paper machine and in the industry in general. First, considerable improvements in the paper machine technology have enabled an enormous growth in the size and capacity of the machines. For example, an average machine of 1805 was 135 centimeters wide and produced 11 meters of paper per minute, approximately 300 tons per year. In 1905, an average machine was already 315 cm wide, produced 60 meters of paper in a minute, resulting in 3 000 tons per year. The modern paper machine of 2005 was on average 930 centimeters wide, produced 1800 meters of paper in a minute and 400 000 tons per year (Dykes Spicer 1907; Lund 1999; Diesen 2007). The current maximum widths and speeds of the machines are even greater. In essence,

therefore, the technological history of paper making is a story of increasing scale: the annual output of new machines has increased exponentially since the beginning of the industry, due to the fact that engineers have introduced very sophisticated new technologies in the parts that make up a paper machine (Järvinen et al. 2009).

After the invention of the paper machine, the next major technological development in the industry was the change of the main raw material for pulp (as well as paper) from rags to wood. The paper production procedure related to wood was patented in 1854 and gave an advantage to countries with considerable wood resources, such as Finland and Sweden in Europe. The chemical pulping processes invented in 1867 (sulphite) and 1884 (sulphate) (Dykes Spicer 1907) were also important technological improvements and made it possible for the firms to gain scale advantage. In addition, in the second half of the nineteenth century, different types of minerals and chemicals (such as china clay added to the pulp to give body and weight to finished sheets) were started to be used in the paper making processes. Furthermore, chemical processes for bleaching and coloring paper were introduced.

Although much of the basic technologies used in paper making were already introduced in the nineteenth century, the technological development of the industry was still considerable during the twentieth century. However, as is typical for the industry, the technology developed in small steps (Landes 1969; Cohen 1984; Stier & Bengtson 1992; Magee 1997; Laurila 1998). Technological developments during the twentieth century included the integration of the paper production process with that of pulp production, automation and computerization of the production control systems, improved productivity through "giant" machines, and environmental control that induced raw material and energy saving production (Dykes Spicer 1907; Kettunen 2002; Diesen 2007). During the late twentieth century in particular, technological improvements included the introduction of coated paper grades, a change from sulphite to sulphate pulp[17], the development of thermo and pressure mechanical pulp, the use of recycled fiber in paper making, and the creation of different "wood-free" paper grades (Ojala, Lamberg, Ahola et al. 2006).

Another important characteristic or evolutionary trend in the paper industry during the late twentieth century, in addition to technological progress, was continuous growth (Diesen 2007). The forest industries were actually among the fastest growing lines of business during the whole

[17] The change from sulphite to sulphate pulp took place especially after the industry had to start to change its operating technology to more environmentally friendly one during the 1960s. The sulphate pulp process produces considerably less discharges than the suplhite process.

twentieth century (Lamberg & Ojala 2006). In general, the total world production of paper grew from less than 10 million tons in 1900 to 43 million tons in 1950, and further to 366 million tons in 2005. According to Diesen (2007), the average annual growth of the paper industry since 1950 has been four percent. Economic factors, the growth of population, and the level of industrial production have all contributed to this growth. The growth of the GDP has actually been found to have a strong positive correlation with the level of paper consumption (Hetemäki & Obersteiner 2001; Kangas & Baudin 2003; Diesen 2007). Since 1950, the growth of global paper consumption has exceeded the growth of the GDP by a factor of 1-1.5, depending on the time, period, and region. At the firm level, the increase in paper production is due to the growth of the firms. In the beginning of the twentieth century, an average paper firm produced 7 000 tons of paper annually. In 2000, the average amount of production was already 235 000 tons (Lamberg & Ojala 2006).

Related to the factors affecting the growth of the industry, an important characteristic of the industry has been its cyclicality (Berends & Romme 2001; Diesen 2007). The main reason for the cyclicality is fluctuations in the prices of end products – market pulp, newsprint, fine papers, and board grades, among others (Diesen 2007). The causes behind such price fluctuations are, first, the volatility in the demand and supply balance, and second, inventory speculation by customers.

During the second part of the 20th century and early 21st century, the industry has also been characterized by significant concentration (Lamberg & Ojala 2006; Diesen 2007). For example, in Europe the share of the top 5 companies of the total capacity increased from 25 percent in 1992 to 40 percent in 2005 (Diesen 2007). A similar kind of concentration development has also taken place in the U.S. (even earlier than in Europe). The concentration development is also evident when the development in the number of firms operating in the industry is considered. According to Lamberg & Ojala (2006), in the beginning of the twentieth century there were still more than 4 000 paper producers in the world, but by the end of the century the number of firms had dropped below 2 000.

It is, however, important to note that the concentration of the industry is still lagging behind many other lines of business, for example, cars (Lamberg & Ojala 2006; Diesen 2007). In addition, it is in particular the paper and pulp industries in western countries that have concentrated (Lamberg & Ojala, 2000). But even in western countries, the concentration development has been different in different countries. In particular, the industries in the Nordic countries, Finland and Sweden, have concentrated significantly. Finally, it is evident that the paper and pulp industry was

throughout the twentieth century a mixture of large players that concentrated even further, and a number of small and medium sized firms that were important local actors (Moen & Lilja 2001). In the end of the twentieth century, the industry was still rather regional by nature. Although the concentration process resulted in increasing internationalization of the firms, the internationalization development concentrated in geographical domains: there was only a limited amount of internationalization, for example, between North America and Europe (Sajasalo 2003).

The industry is also characterized by huge investments in production technology, making the industry exceptionally capital-intensive (Diesen 2007). Thus, the production in the industry is typical for a manufacturing industry where economies of scale is a decisive factor. Investments within the industry have been increasingly growing in size due to the expansion in size and capacity of machinery.

As a conclusion, the paper and pulp industry can be characterized as a mature industry, with incremental development in process technology and strong correlation with macro business cycles. Although the industry concentrated considerably during the latter part of the twentieth century, it is still in many ways rather regional and consists of both large multinational firms and a large number of more regional small or medium sized firms with focus on certain product niches.

5.2. General characteristics and evolution of the printing and publishing industry

In a similar manner to the paper and pulp industry, the printing and the publishing industries have a long history. The beginning of printing is often dated back to the mid fifteenth century and the invention of the first printing press by Gutenberg in Germany in 1445 (e.g. Clair 1976; Steinberg 1996; Twyman 1998). Although the art of printing soon spread to many neighboring countries after Gutenberg's invention, and the volume of printed matter (books in particular) started to grow, printing remained a small-scale activity, accomplished with basically the same type of machinery as developed by Gutenberg, for the next 350 years (Steinberg 1996; Twyman 1998).

The turn of the eighteenth century to the nineteenth marked a decisive stage in the history of printing: printing technology started to advance considerably (Twyman 1998). Since then, the industry has been characterized by rapid technological change. First, a new generation of

printing presses was introduced. The Stanhope press, built completely from iron, was a major step forward and could print a larger sheet at one pull by the pressman. Steam-powered presses were the next advancement in printing technology and this enabled increasing productivity of the letterpresses (the main printing method at the time, used for example in the printing of newspapers) (Steinberg 1996). In addition to these advances in the letterpress process, the lithography printing technique, which started to become more successful only during the twentieth century was also introduced, had actually already been introduced at the end of the eighteenth century (Marshall 1983). Second, advancements in paper making technology, including the Fourdrinier machine and wood pulp as the raw material of the paper, were essential for the growth of the industry. By the end of the century, cheap mass circulation press had become a reality (Smith 1979).

Despite the growth in productivity of printing machines during the 19th century, the type itself was still laboriously set by hand: composition was the weakest point in the printing and publishing industry, because it was labor-intensive, slow and costly. The first machines for composition that really began to have a general impact, were introduced in the first years of the twentieth century: Linotype and Monotype (Twyman 1998). These machines successfully integrated the two functions of type-casting and type-assembly, the Linotype producing whole lines, while the Monotype brought together individual letters to form each line. At the same time, considerable development took place in the lithography printing process. In particular, the principle of offset lithography, solving the problems of the earlier lithography printing technique generations, was introduced (Twyman 1998). Offset lithography developed further to be the main printing technique of the late twentieth century. Additionally, the third main printing process of the twentieth century, gravure, was introduced at the same time as offset lithography. It was especially the technique called photogravure that later became an important printing process for magazines (Marshall 1983).

The technological breakthrough that was crucial for offset to become the main printing method after the mid twentieth century was phototypesetting, introduced already in the 1920s. It was, however, only in the late 1970s that phototypesetting truly gained ground (Marshall 1983; Twyman 1998). The method was not only an essential part of the success of offset lithography but also, by breaking the centuries-old techniques of casting and letter assembly, heralded a new conception of type composition. The method soon became the most common method of typesetting. The second important development in printing technology during the second

half of the twentieth century was the introduction of web-offset (offset printing from continuous reels of paper), introduced in the 1960s (Marshall 1983). In the late 1980s, the highest demand with regard to printers was for these types of printing machines (Hazley 2000).

The latest developments in printing technology have been the introduction of flexographic printing (a new variation of the old letterpress technique, but making use of aniline inks and flexible rubber plates instead of cast metal letters) in the late 1970s, and digital printing in the 1980s (currently including techniques such as inkjet and laser) (Hazley 2000). Several smaller scale technological developments also took place in the printing industry during the period considered in this study. These include the ability to print in multiple colors, the introduction of electronic controls facilitating the control of inking units to automate the inking process, the computerization of scanners to automate inking under different printing conditions, and the use of electronics in the pre-print preparation for different photo-typeset techniques (Hazley 2000). Finally, in particular, computerization has had a profound impact on the printing and publishing industry during the last decades, enhancing the productivity of it significantly.

In addition to considerable technological change, another important characteristic of the industry is its heterogeneity and a large number of small-sized firms, in both the printing and publishing sides of the industry (Hazley 2000; European Comission 2007). The structure of the industry has actually not changed significantly since the mechanization in the nineteenth century (Twyman 1998). At the beginning of the 21st century, more than 85 percent of the firms in the EU were still small and medium-sized firms employing less than 20 employees. Only less than 0.5 percent of the firms employed 500 people or more (European Comission 2007). Similar figures apply also to the publishing side of the industry. Different sized printing industry firms also serve different types of markets. Smaller firms often supply to a local client base, with products such as personal or commercial printed matter. Medium-sized firms tend to produce advertising material, books or continuous stationary for a regional market. In the case of larger firms, the client base is much wider in coverage, with such products as newspapers, catalogues, magazines, books, and advertising material. In general, the printing of newspapers, magazines, periodicals, and books account for 50 percent of the output of the industry (Hazley 2000).

The large number of mainly small-sized firms does not imply anything of the level of concentration of the industry, however. Already from the mid eighteenth century, the largest firms have had a considerable share of the

total production of the printing industry (Twyman 1998). The small printers have survived because the scale of much of the printing work is small; and while the increased capacity of a large printing works allows more ambitious jobs to be undertaken more efficiently, the small printer can often undertake small jobs just as well, and in many cases more economically (Twyman 1998). The publishing side of the industry, and the printed media in particular, are currently also rather concentrated, if measured by the share of total production of the industry. In several European countries, only a few large publishing firms control much of the market. For example, in Germany, the largest publishing groups had a market share of 55.6 percent in the early 1990s (Kleinsteuber 1997). More generally, Ojala & Uskali (2005) describe the current era in the media industry as the time of media giants, controlling all segments of the media industry.

The industry can also be characterized as rather country-specific, or in some respects even regional by nature (Hazley 2000). The main reason for this is that foreign trade is limited by several natural barriers. These barriers include language barriers preventing wider distribution of products; the structure of the industry, being composed mainly of small- and medium-sized firms that have limited resources; the need for a close client-customer relationship, especially during the printing process; and high transportation costs. Despite the use of digital technology and the internet, which smaller firms increasingly use for marketing, exports remain at less than 10 percent of the turnover in the European industries (Hazley 2000). The European printing industry is currently facing increasing competition from imported products from Eastern Europe and Asian countries, in particular China (European Comission 2007). Despite the regional nature of the industry, the ownership of the largest firms is not country-specific (Marshall 1983; Compaine & Gomery 2000).

The industry is also sensitive to economic trends, and recession periods usually have a significant effect on the growth of the industry. In general, printing is demand-based, and products are made to order, which prohibits firms from keeping stocks. Due to the reliance of the industry in the newspaper, magazine, book, and advertising markets, changing consumer preferences and disposable income levels are also significant factors affecting the industry. At the same time, paper prices in particular, but also electricity prices, seasonal demand, political developments, and legislation equally can affect the industry. (Hazley 2000)

Finally, an important trend that has affected the industry since the Second World War has been the technological development related to electronic media (e.g. Ojala & Uskali 2005). First, since 1950, television

quickly became highly popular and was one of the factors affecting newspaper demand and the death of many newspapers since the 1960s (Ojala & Uskali 2005). Since the 1990s, digital technology and the internet have started to affect the industry considerably. The whole printing and publishing industry has even been forecasted to decline considerably in the near future. Some segments of the industry have, indeed, declined during the last decades. For example, newspaper circulation in Europe has dropped almost continuously since the beginning of the 1990s (Hazley 2000). A similar development has taken place in the book and catalogue segment of the industry, in particular during the 21st century (European Comission 2007). In contrast, some of the segments of the industry are still growing, such as magazine publishing (European Comission 2007). In general, it seems that although digitalization and the internet will probably continue to affect some of the segments of the industry negatively, an industry based on printed paper is far from dying.

5.3. Paper and pulp industry in Finland

The history of paper making in Finland has often been considered to begin in 1667, when the oldest known paper producing machine started its operation (Nykänen 2005; Kuisma 2006). However, during the next two hundred years the growth of paper making in the country was extremely slow, not only due to the location of Finland at the periphery, but also due to the low standard of living and the small population (Kuisma 2006). Although the first "modern" paper machine started its operation already in 1842, it was not until the end of the century that considerable growth of the industry started (Nykänen 2005; Kuisma 2006). In particular, it was the building of the basic infrastructure in the country and the growth of the paper and pulp market in Russia that allowed Finland to start to exploit its significant forest resources (wood had already become the main raw material for paper making) and its cheap hydro energy, two important determinants behind the growth and competitive advantage of the Finnish forest industry (Kuisma 2006).

The growth of the industry during the late nineteenth century and early twentieth century is also evident in **Figure 5-2** and **Figure 5-3**. As the figures indicate, during the period 1885-1919, the number of firms in the industry increased from 20 to an all-time maximum 61. Similarly, the number of establishments grew from 20 to more than one hundred (also almost reaching its maximum level). The growth in the production figures

during the period 1885-1913 was also considerable: on average, paper and pulp production grew by 11.2 percent annually (Heikkinen 2000). This growth was mainly due to growth in exports. The main market for the Finnish forest industry at the time was the Russian empire (Heikkinen 2000; Kuisma 2006).

Although not shown in the figures, the growth period of the industry ended in 1914, due to the First World War. Additionally, the collapse of the Russian empire in 1917, resulting in a collapse of exports to that country, had severe effects on the industry (Heikkinen 2000; Häggman 2006). However, the industry soon started to find new customers in Western countries. Common sales organizations (for example Finnpap for paper products), taking care of the sales of the production of the industry, particularly outside Finland, were important in finding new customers for the industry.

The years from 1920 until the end of the 1930s were generally a time of growth for the industry (Häggman 2006). In particular, the production of wood pulp grew considerably as did also the production of newsprint (Häggman 2006). The Finnish Winter War and the Second World War temporarily ended the growth of the industry. As **Figure 5-2** and **Figure 5-3** indicate, the war period was also the start of concentration of the industry. For example, the number of firms declined by 20 during the war period[18]. Although recovery from the war was slow, the industry started to grow again in the late 1940s: in 1950 the industry already produced some one million tons of paper, whereas in 1939 the respective figure was a little over 500 000 tons.

Turning to the analysis period of the study, 1950-2005, **Figure 5-1** presents a summary of important environmental, economical, technological and evolutionary trends that have affected the evolution of the industry during the period. Further, **Figure 5-2** and **Figure 5-3** present the number of firms and establishments, respectively, operating in the industry. Additionally, **Figure 5-4** and **Figure 5-5** present the number of employees in the industry annually and the total paper and board production of the industry, as well as the total paper and board exports, imports, and apparent paper and board consumption in Finland.

The analysis period of the study started with the Korean War and resulted in a significant rise in prices of all commodities, including paper and pulp (Jensen-Eriksen 2007). Of course, this had a highly positive effect on the industry. In general, the period starting from this war until the first oil

[18] Although some of the decline was due to the fact that parts of Finland were made over to the Soviet Union after the war, many firms also went bankrupt and mergers and acquisitions took place (Aunesluoma 2007)

crisis in 1973 were characterized by considerable economic growth in Western Europe: on average, the gross domestic product of these countries grew by 4.8 percent annually. The growth figures for paper consumption were even higher, on average 5-6 percent annually (Jensen-Eriksen 2007). Because Western Europe was also by far the most important market for the Finnish paper and pulp industry, this meant considerable growth for the industry during the 1950s and 1960s. The growth of the industry is also evident on the basis of the production figures. As **Figure 5-5** suggests, the total production of the industry grew from one million tons in 1950 to almost 6 million tons in 1973. Exports accounted for more than 80 percent of the production for the whole period.

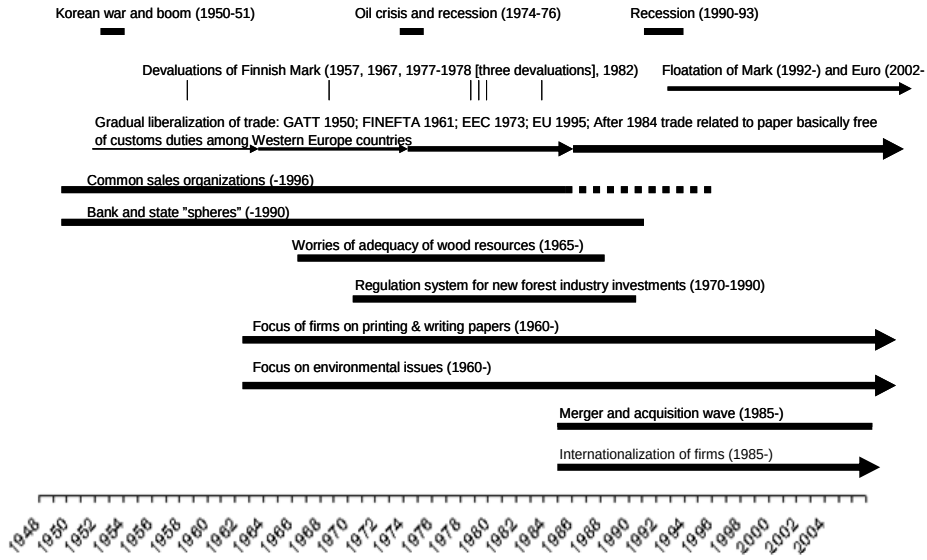

Figure 5-1: Chart of the evolution of the Finnish paper and pulp industry, 1950-2005.

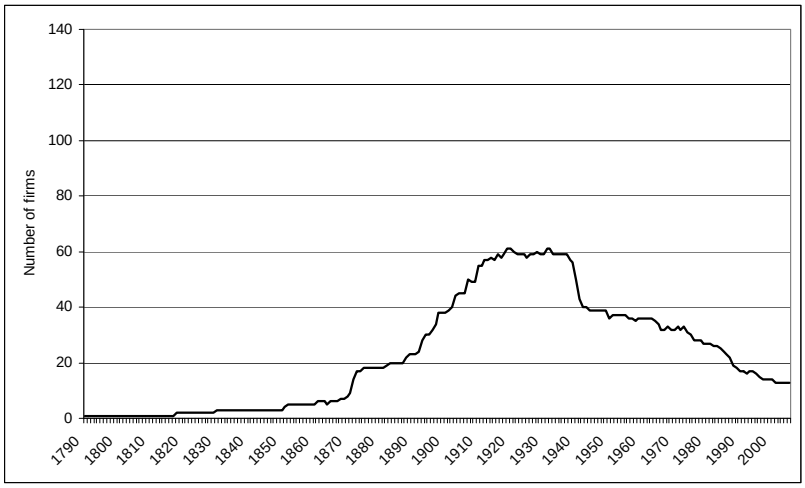

Figure 5-2: Number of firms in the Finnish paper and pulp industry, 1790-2006.

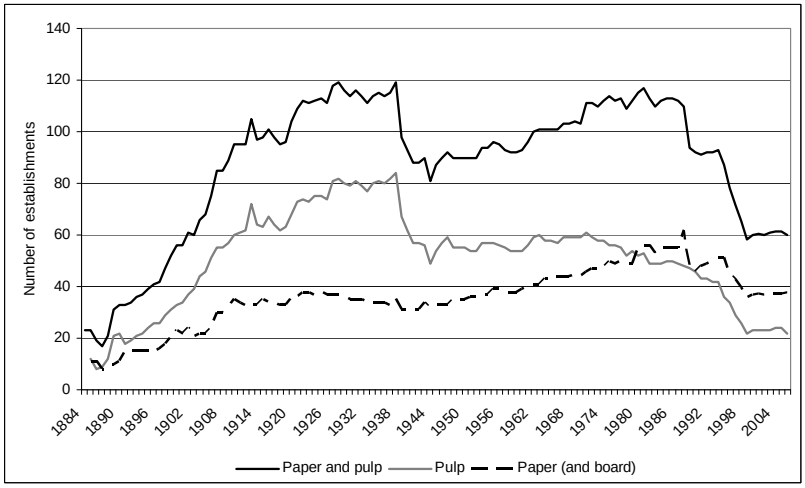

Figure 5-3: Number of establishments (note the definition for an establishment) in the Finnish paper and pulp industry, 1884-2006.

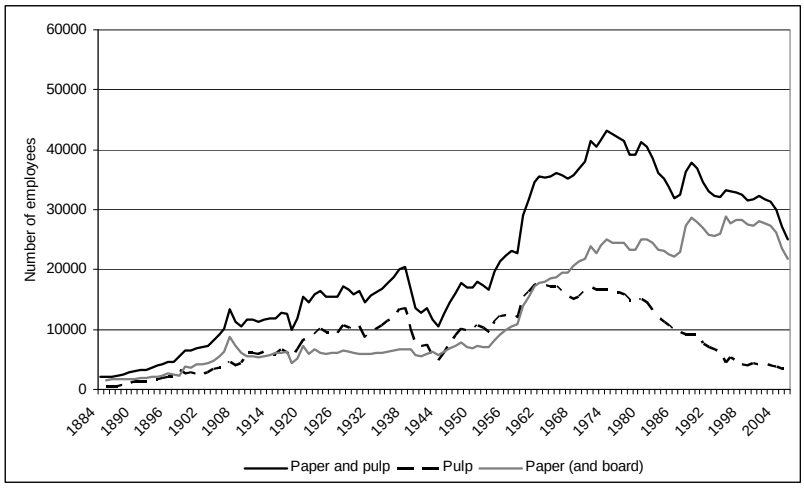

Figure 5-4: Total number of employees in the Finnish paper and pulp industry, 1884-2006.

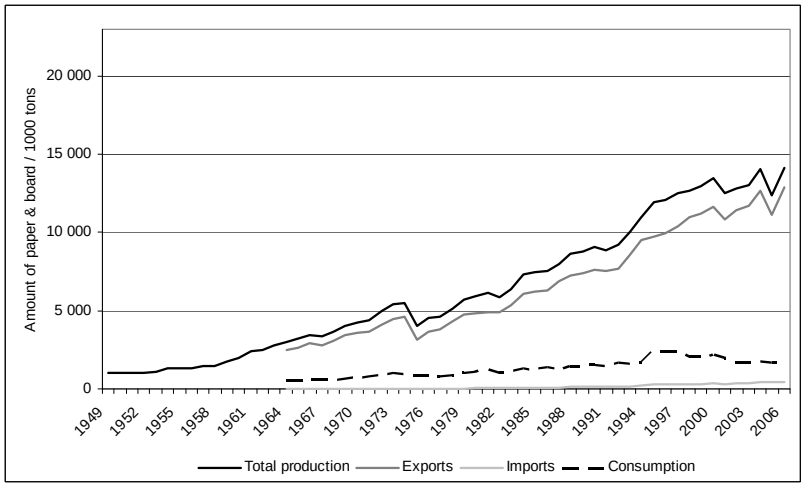

Figure 5-5: Amount of paper and board produced by the Finnish paper and pulp industry (1949-2006) and amounts of paper and board exports, imports, and total consumption in the Finnish market (1964-2006).

As **Figure 5-4** indicates, the number of employees in the industry increased from 17 000 thousand in 1950 to 43 000 thousand in 1974, reaching the highest level of employment in the history of the industry. Mostly, the number of establishments increased due to investments by the firms in new paper machines (cf. Heikkinen 2000; Jensen-Eriksen 2007). On the other hand, the number of pulp-related establishments remained at the same level during the whole period. This development is related to the fact that starting from the early 1960s, Finnish paper and pulp firms started to integrate forward in the value chain, from pulp production to the production of different grades of paper (Peterson 1996; 2001; Lamberg &

Ojala 2006). In particular, the focus of the industry soon became the production of different types of printing and writing papers (as will be discussed later). In contrast to the other figures, the number of firms in the industry actually continued to decrease during the period.

In addition to the growth of paper consumption in Western European markets, several important trends and factors affected the evolution and growth of the industry during the period. First, the development resulting in the gradual liberalization of trade among European countries enabled the Finnish industry to export paper products to Western Europe without too high tariffs (Heikkinen 2000). In particular, membership of EFTA in 1961 enabled Finnish firms to continue to export paper to their most important paper export country, the United Kingdom (Jensen-Eriksen 2007). Further, the free trade agreement with EEC in 1973 also resulted in (almost) free trade with, for example, Germany (an earlier member of the EEC)[19] (Jensen-Eriksen 2007). The paper and pulp industry was heavily involved in the process of negotiating the EFTA membership and the EEC agreement (Heikkinen 2000; Jensen-Eriksen 2007).

Second, in order to retain the competitiveness of the industry, currency devaluation was often used (Heikkinen 2000; Jensen-Eriksen 2007). For example, in 1957 the currency was devalued by 28 percent and 1967 by 33 percent. Although devaluations were not only carried out due the needs of the paper and pulp industry, the role of the industry during the period was highly important to the Finnish economy. Third, common sales organizations still remained highly important for the Finnish firms. For example, almost every Finnish paper firm was a member of Finnpap, which took care of the sales of paper (Heikkinen 2000).

Fourth, a characteristic of the Finnish industry already from the early twentieth century were different "spheres", of which almost all the paper and pulp firms were members during this period (Näsi et al. 2001; Näsi & Sajasalo 2006). These spheres centered either on banks or the state, and were important owners of many of the paper industry firms. The largest paper industry firms were often considered to be flagships of the spheres, and membership was one of the reasons why such huge investments in paper production technology were possible in Finland during the period, which was otherwise characterized by a lack of available capital (Näsi et al. 2001; Jensen-Eriksen 2007). Fifth, during this growth period, the paper and pulp industry firms started to worry about the availability of wood (Peterson 2001; Jensen-Eriksen 2007). Already in the early 1960s, felling in Finland exceeded new growth, and timber prices started to increase. As

[19] The last tariffs were, however, removed only in 1984.

Peterson (2001) describes, the raw material position in the industry changed dramatically during the first half of the 1960s. This resulted in regulation, increased silviculture, and partially in the regulation of new investments in the industry through co-operation between the central organizations of the forest industry and the Bank of Finland. The regulation system remained in effect until the end of the 1980s (Jensen-Eriksen 2007). Additionally, these worries initiated development processes aimed at more efficient use of wood. Further, Peterson (2001) suggests that over-exploitation of forests was one of the reasons why Finnish firms started to focus more on high value-added paper products, such as different types of printing and writing papers.

Finally, issues related to environmental protection became important from the early 1960s onwards (Jensen-Eriksen 2007). One important factor contributing to this was the water law enacted in 1962. The pollution of water had already been a concern for some decades, and when the production of the industry increased, the level of water pollution increased substantially. For example, according to research conducted in 1955-1956, the share of the paper and pulp industry of the total sewage water loading in Finland was as high as 75 percent (Jensen-Eriksen 2007). Starting from the late 1960s, the paper and pulp firms started to invest in more environment-friendly production technologies. Although the investments were not always seen to be positive from the perspective of the industry, their results started to be seen already from the beginning of the 1970s. The positive link between the level of discharges and the amount of production broke down: although the amount of production still continued to grow, the amount of discharges started to decrease considerably (Jensen-Eriksen 2007).

The first oil crisis in 1973 and the world-wide recession that followed hit the Finnish industry hard. The paper production of the industry in 1975 dropped more than 1.5 million tons from the 1974 figures. However, the next year the paper production was already growing, although it took until the end of the 1970s before the production figures were at the 1974 level. The next growth period continued until the beginning of the 1990s, when the next recession hit Finland and also the industry[20]. During this period, Finnish paper and board production increased from 4 million tons in 1975 to 9 million tons in 1990, as **Figure 5-5** indicates. The growth rate was, however, considerably lower than before, as was the growth rate of the GDP in Western Europe (on average 2.1 percent per annum), by far the most important export market for the Finnish paper industry.

[20] Except for a few years in the beginning of the 1980s.

As **Figure 5-2** indicates, during 1975 and 1990 the industry concentrated significantly: the number of firms dropped from 30 to less than 20 in 1990. Despite the fact that the period starting from 1985 has often been considered as the most active phase of concentration in the industry (Moen & Lilja 2001; Näsi et al. 2001), it is evident that many firms disappeared much earlier. However, as the industry still consisted mostly of small and medium-sized firms in the 1970s (Peterson 2001), the acquisitions and mergers in the late 1970s and 1980s were not as visible as they were later. The mergers and acquisitions were considered necessary in order to achieve economies of scale[21] in a continuously increasing competitive environment.

As **Figure 5-3** and **Figure 5-4** show, the number of employees and establishments started to decline during the period. However, it seems that the development was different for the establishments and employees related to paper and pulp production. The number of employees working in paper establishments continued to increase during the period, whereas the number of employees working in pulp establishments decreased considerably. This change does not, however, necessarily imply a change from pulp focus to paper focus (although this development took place as well). For example, it may imply the growth in productivity in pulp production.

With regard to important factors affecting the evolution of the industry during the period, devaluation of the Finnish currency was still used as a method to increase the competitiveness of the industry. Liberalization of trade continued further. The trade related to paper products among Western European countries was customs duty free as late as 1984 (Heikkinen 2000; Kuisma 2008). During the period, the paper sales of the industry were still taken care of by the common sales organization, Finnpap. The largest Finnish paper industry firm at the time, state-owned Enso-Gutzeit, however, resigned from the organization in 1986. Still, the history of the sales organization continued until 1996, when Finland's EU membership rendered the association illegal and the continued concentration development of the industry unnecessary (Heikkinen 2000).

Paper and pulp industry firms were still arranged into four spheres during the period. Actually, mergers and acquisitions mostly took place among firms in same spheres: smaller firms were integrated to the "flagship" firm of the sphere in question (Näsi & Sajasalo 2006). The spheres lost their importance in the early 1990s due to the severe recession affecting the functioning of the banks. Finally, the regulation system for new investments

[21] Achieving economies of scale was important taking into consideration the nature of paper products mostly as bulk.

was in effect for the whole period. The system expired in the 1990s (Näsi & Sajasalo 2006).

The severe recession in Finland in the early 1990s also affected the Finnish paper and pulp industry, although its effect on the production figures was far less dramatic than the effect of the first oil crisis. Additionally, the production figures of the industry started to grow in 1992, after only a one-year decline in total production. The growth of paper and board production continued almost until the end of the period of analysis, the total production being over 14 million tons in 2006. Examining **Figure 5-2**, **Figure 5-3**, and **Figure 5-4** reveals that despite the growth in the total production, the industry continued to concentrate. The total number of employees and the number of establishments also decreased significantly. In particular, employment related to pulp production and the number of pulp production establishments decreased considerably.

Although the concentration development of the industry at the end of the 1980s had made many of the Finnish firms among the largest in Europe, the concentration process continued at an accelerating pace during the 1990s (Moen & Lilja 2001). The process culminated in 1995 in a merger of the two largest firms, United Paper Mills (UPM) and Kymmene. After this merger, in essence the industry consisted of three large firms (also among the top 10 largest paper industry firms in the world), UPM, Enso-Gutzeit (which merged with the Swedish Stora in 1998), and M-Real. There were a few smaller firms, such as Ahlstrom and Myllykoski, which also had large market shares in the segments they focused upon.

The Finnish industry also internationalized considerably after the late 1980s, although the largest paper and pulp firms had already had international subsidiaries for a long time (Huolman 1992; Sajasalo 2003). Contributing factors to this development were the implementation of the free trade and the European Community (EC) decision in 1985 to complete the unification of the common market by 1992. New types of raw materials, such as the replacement of virgin fibres by recycled paper in the newsprint sector, as well as the use of new species of short fibre pulp in fine papers, also encouraged Finnish firms to internationalize. Additionally, the need to achieve economies of scale and the increasing competition in the European markets were behind the internationalization development (Moen & Lilja 2001; Kuisma 2008).

In general, the 1990s and the first years of the 21st century were an era of considerable growth for the large Finnish firms. Ojala et al. (2006) state that the period was the era of strongest growth ever for the large Finnish forest industry firms they analyzed. The firms were not, however, very profitable. As suggested by Ojala et al. (2006), the profitability of forest

industry declined throughout the post-war period (see also e.g. Artto 1993; Artto & Juurmaa 1998; 1999; 2001).

Finally, considering the changes in the product range of the Finnish firms, **Table 5-1** indicates the share of the main paper types of the total paper and board production at six time points. Additionally, **Figure 5-6** presents the development of the production of two paper product groups this study is particularly interested in: the amount of production of newsprint and printing & writing paper in comparison to the total paper and board production since 1950. During the period, significant changes took place in the product portfolio of the Finnish industry. First, the share of newsprint and printing & writing papers of the total production increased from 50 percent to over 70 percent in 2005. The change in the production amount of newsprint and printing & writing papers was even more significant. Clearly, newsprint lost its importance as the most important paper grade within the Finnish firms: its share of production declined from 40 percent in 1950 to only 4 percent in 2005. At the same time, printing and writing papers clearly became the most important paper grade. Their share of production increased from 10 percent in 1950 to 67 percent in 2005. Thus, with regard to the paper products, the Finnish firms clearly became increasingly dependent on the markets for these types of papers. What is also evident is the fact that the Finnish firms integrated successfully vertically forward into more value-added products (what many of the printing and writing papers can be considered to be).

As a conclusion, the Finnish paper and pulp industry has experienced significant growth since the 1950s. Currently, Finland is the sixth largest paper producing country in the world. The growth of the industry has also had a central role in the growth of the Finnish economy in general. The industry has until very recently held a special role in the country: what has been important for the industry has also been important for the state and the country. Currently, the industry specializes in paper grades used in printing and writing, the share of which has consistently increased since 1950.

Table 5-1: The share of the main paper and board grades of the total paper and board production in Finland in cross-cutting years 1950-2005.

	1950	1960	1970	1980	1990	2000	2005
Newsprint, %	40	39	31	23	14	10	4
Printing & writing, %	10	12	23	39	54	62	67
Household & sanitary, %			2	2	2	2	2
Kraft paper & board, %	9	15	28	21	12		
Fine cartonboard, %			6	11	12		
Packaging materials, %						23	25
Misc., %	41	34	10	4	6	3	2
Total, %	100	100	100	100	100	100	100

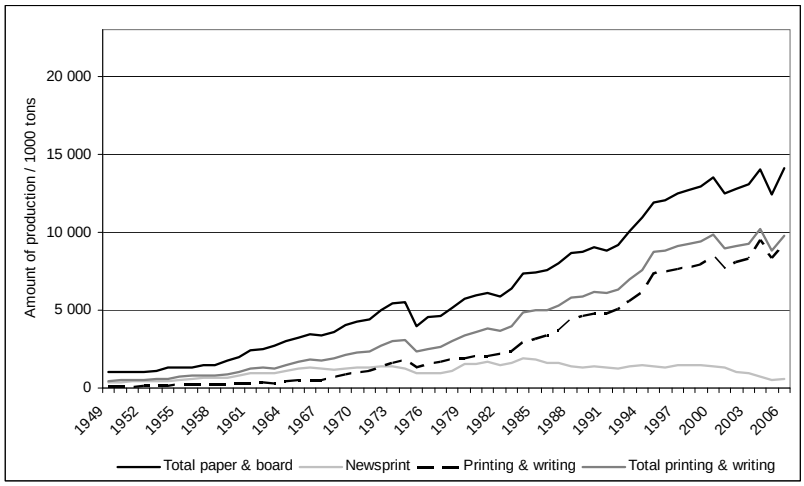

Figure 5-6: Production of total paper and board, newsprint, and printing & writing papers by the Finnish paper and pulp industry, 1949-2006.

5.4. Printing and publishing industry in Finland

The art of printing spread to Finland rather late, and it was not until the printing house of the University of Turku was established in 1642 that an increase in printed literature became evident (Nykänen 2005). The printing activity, however, remained rather low until the beginning of the nineteenth century, and it took years for technological development in printing to arrive in the country (Landgren 1992). The growth of the industry began just at the end of the nineteenth century, stimulated by an overall growth in the Finnish economy. Although the founding of printing houses was restricted (they were only allowed to be founded in large cities) before the Freedom of the Press Act of 1919 (Landgren 1992), at the end of the century there were already almost 100 printing houses, as **Figure 5-8** indicates, and their number was growing fast.

The First World War and the Civil War in Finland, however, interrupted the growth of the industry, but only for a few years (Landgren 1992). The period between the wars was again a time of growth for the industry, and the number of establishments grew steadily. The war years and the period of reconstruction that followed, however, postponed necessary investments and stalled the progress of the industry. For example, shortage of capital characterized the industry for the whole 1940s. However, in the 1940s, the

production figures and profitability of the industry rose as sales and net profits grew (Landgren 1992).

Turning to the analysis period of this study, **Figure 5-7** presents a chart of important environmental, economical, technological, and evolutionary trends that have contributed to the evolution of the industry since 1950. **Figure 5-8** presents the number of establishments in the industry (printing, publishing, and total printing and publishing), **Figure 5-9** the number of employees, **Figure 5-10** the value of production of the industry, and **Figure 5-11** the level of the GDP in Finland after 1950. As **Figure 5-10** illustrates, since 1950, the printing industry grew rather steadily until the recession in the mid 1970s. In particular, the years 1950-64 were an economic success for the industry, although the rate of growth was slightly lower than that of Finland's entire industry (Landgren 1992). The number of establishments also increased during the period, exceeding 300 in the early 1970s. The period was also a time for considerable growth in the number of employees: their number increased from 10 000 in the beginning of the 1950s to over 18 000 in the early 1970s. Additionally, as **Figure 5-9** indicates, the publishing side of the industry also grew during the period, although the development was rather unstable (characterized by large ups and downs in the figures).

From 1960 onwards, important changes started to take place in the industry. In general, the 1960s started a large-scale technological change in the industry, which has continued until the current date. First, printing houses started to invest in offset printing machines, and during the 1960s and 1970s offset replaced letterpress as the main printing method. Already in 1980, almost every newspaper in Finland was printed by offset (Landgren 1992). Phototypesetting then revolutionized the typesetting process (Marshall 1983). Second, television made its breakthrough in the 1960s, and the color television that was introduced in the early 1970s hardened the competition between the printing media and other media (Landgren 1992). The introduction of television was also one of the factors behind the large scale technological change in the printing industry. The demand for graphic material in newspapers and periodicals increased, and the role of color printing became increasingly important for the printing and publishing industry when competing against the new media.

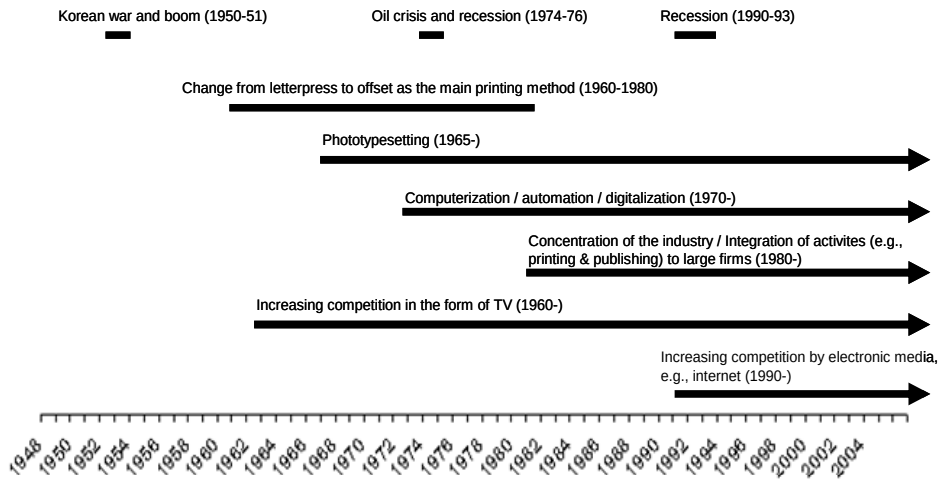

Figure 5-7: Chart of the evolution of the Finnish printing and publishing industry, 1950-2005.

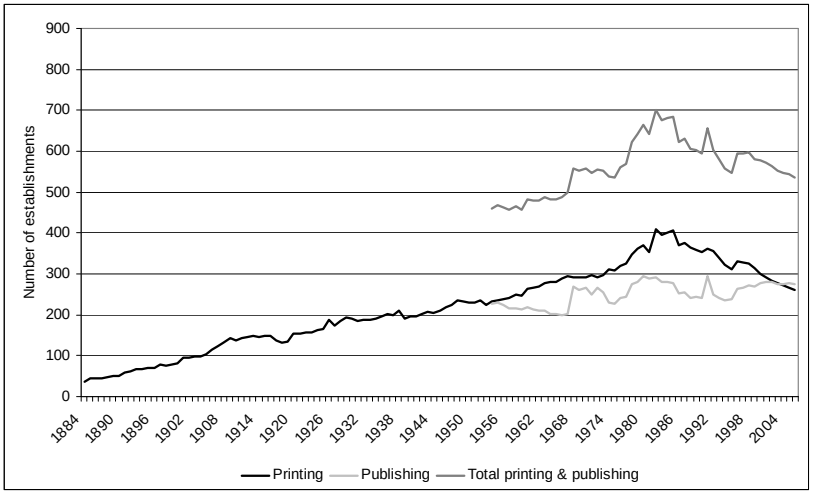

Figure 5-8: Number of establishments (note the definition for an establishment) in the Finnish printing and publishing industry, 1884-2006 (figures for publishing available from 1954 onwards).

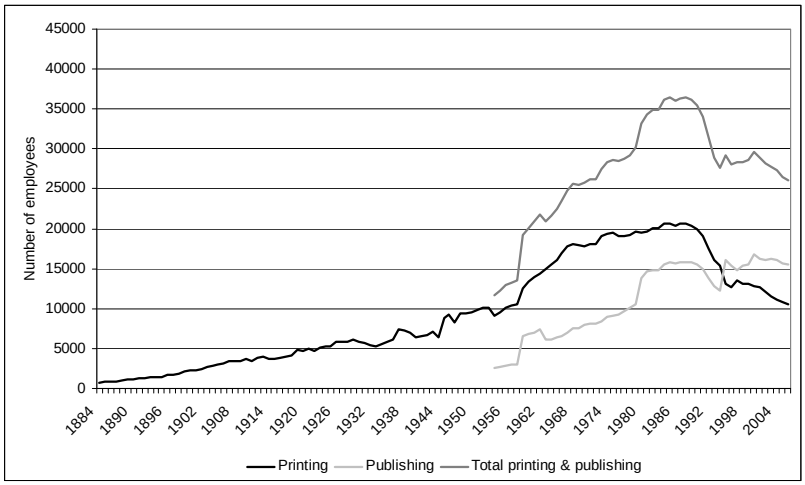

Figure 5-9: Number of employees in the Finnish printing and publishing industry, 1884-2006 (figures for publishing available from 1954 onwards).

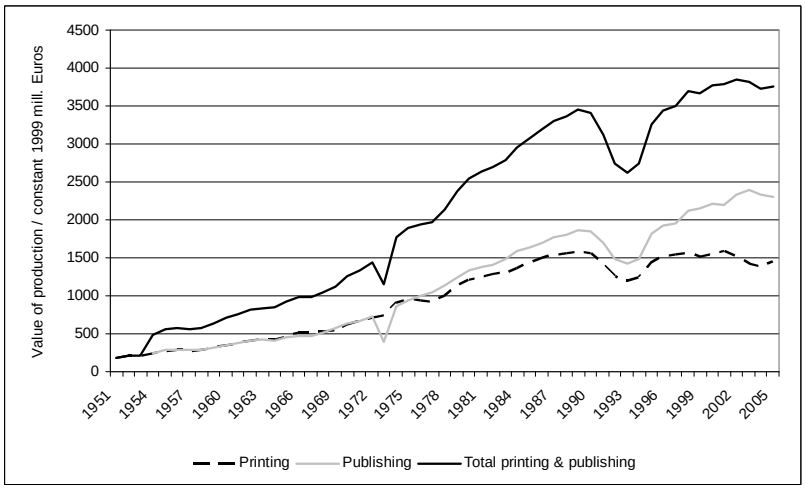

Figure 5-10: Value of production of the Finnish printing and publishing industry (figures for publishing available from 1954 onwards) in inflation-adjusted constant 1999 million Euros, 1949-2006.

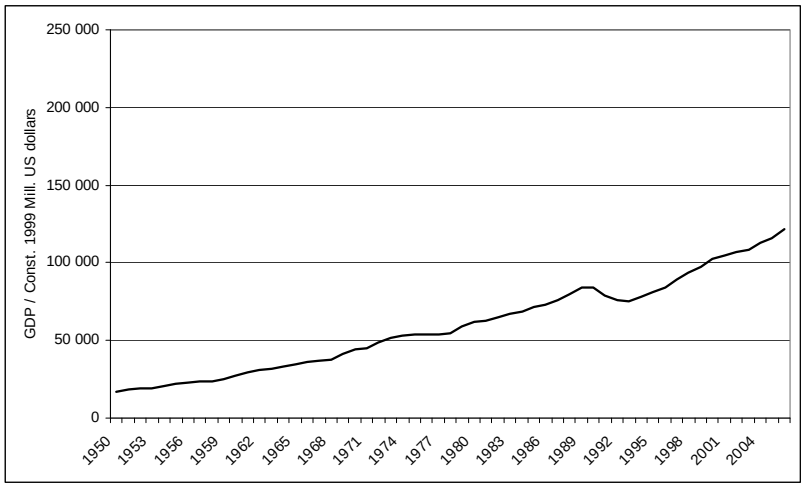

Figure 5-11: Gross domestic product (GDP) of Finland in constant 1999 million US dollars (converted at Geary Khamis PPPs), 1950-2005.

The recession after the first oil crisis affected the growth of the printing industry by decreasing the total output of the industry for a few years. However, the industry was again growing at the end of the 1980s, and the growth phase continued until the beginning of the 1990s. In comparison with the growth rates of other industries in Finland, the rate of growth of the printing industry was at least equal (Landgren 1992). Despite the growth in output, the development with regard to printing establishments was different. Although the number of printing establishments grew quickly until the early 1980s, reaching the all time high of 400 in 1982, during the second half of the 1980s the number of establishments started to decrease rapidly. In the publishing side of the industry, the number of establishments, however, remained rather stable. With regard to the number of employees, in the printing side of the industry their number increased a little. In the publishing side, in contrast, their number increased considerably, particularly in the late 1970s.

The considerable growth in the output of the industry becomes understandable when considering the growth in publishing. First, during the period 1965-1985, the number of newspaper titles increased from 238 to 418. The growth in the number of titles was very rapid, especially in the early 1980s (from 298 to 418). In the second half of the 1980s, however, the number of newspapers started to decrease: from 418 to 385 in 1989. The circulation figures of newspapers also grew during the period, from 1.62 million in 1965 to 3.12 million in 1985. Second, the magazine segment of the industry also grew significantly during the 1970s and 1980s: from 2 147 titles in 1965 to 4 520 in 1985. (Landgren 1992)

The rapid technological change in the industry continued from 1974 to 1990. In particular, the change from letterpress to offset continued, as did the change from metal setting to phototypesetting. The computerization of the industry also started. In general, the new production technology resulted in larger production units (Landgren 1992). The largest firms now operated in several segments of the printing and publishing industry. Already in 1988, the ten largest printing and publishing firms produced 32 percent of the total revenues of the industry and employed 32 percent of the employees (Landgren 1992). However, the number of small and medium-sized firms still remained considerable.

The recession of the early 1990s, which hit hard the whole Finnish economy, also had a negative effect on the Finnish printing and publishing industry, as **Figure 5-10** indicates: the output of the industry decreased by more than 20 per cent during the recession. Similarly, the number of printing establishments decreased, as did the number of employees in the industry. The recession was also the end of the growth phase of the printing side of the industry: after the recession, the industry did not grow. The output stagnated in the late 1990s, and both the number of establishments and employees decreased considerably. The publishing side of the industry did, however, grow somewhat during the period after the recession.

One important factor contributing to the development of the industry during the recession and the period after that was the decline of the newspaper segment of the industry. Already during the recession, the number of newspaper titles started to decline considerably. The worst year was 1992 when the total circulation of newspapers decreased by 330 000 (Ojala et al. 2006). Although the circulation still continued to decrease for the rest of the 1990s (Tapper 1997), the decline stopped during the first years of the 21st century (Österlund-Karinkaita 2004). In general, after the late 1990s the internet and electronic media became hard competitors for the traditional printed media. The increasing competition also produced further polarization and concentration in the printed media. Currently, the newspaper segment of the industry is dominated by a few large dailies, but at the same time, small local newspapers, which still have a large readership also have a strong role (Tapper 1997; Österlund-Karinkaita 2004). The role of printed media in general is still strong in Finland, however, compared to many other European countries.

Finally, **Figure 5-12** presents information of the consumption of the Finnish printing and publishing industry of printing and writing papers (including newsprint and other printing and writing papers) during the research period. The figure presents consumption both in absolute and per capita terms. The consumption figures have been calculated on the basis of

statistical figures for production of printing and writing papers by the Finnish paper and pulp industry and their imports to and exports from the country[22]. As the figure indicates, the consumption of printing and writing papers by the industry in both absolute and per capita terms has increased considerably during the research period. Most of the increase in consumption did, however, already take place before the 1980s. For the whole 1980s, the consumption remained rather stable, decreased during the recession period in the early 1990s, and increased to its highest level ever during the years after the recession (in the end of the 1990s, printing and writing paper consumption was some 700 000 tons and 140 kg/capita). During the last years of analysis, the consumption decreased in both absolute and per capita terms.

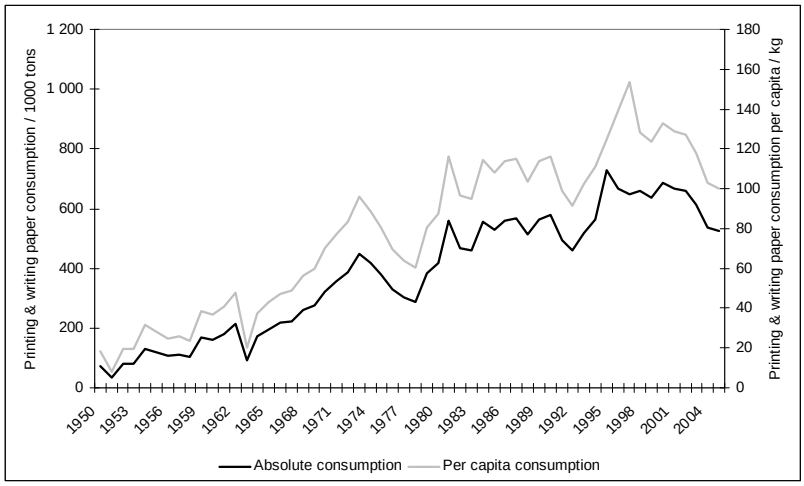

Figure 5-12: Printing and writing papers consumption of the Finnish printing and publishing industry in absolute and per capita terms, 1950-2006.

As a conclusion, the Finnish printing and publishing industry has, grown considerably since 1950. After the recession of the early 1990s, the growth of the printing side of the industry ended, however, and it has been the publishing side of the industry that has generated the further growth of the industry. The industry has also experienced a significant technological change since the 1960s, revolutionizing the field. Since the 1960s, electronic media, first in the form of television and later in the form of the internet, in particular, have become important competitors for the traditional printed media and the printing and publishing industry in general.

[22] For more specific explanation with regard to the calculations, see section 5.12.

5.5. Paper and pulp industry in Sweden

The actual beginning of paper making in Sweden can be traced back to 1612 when a handpaper mill was established in Uppsala (Rydberg 1990) The beginning of the industrial paper production only took place in 1832 when the first "modern" paper machine started its production (Sjunnesson 1997). During the nineteenth century, the growth of the industry was slow, however. The south east part of the country became the center of paper production; in this part of the country the industry was dominated by small paper mills (Rydberg 1990; Melander 1997). The northern coast of Sweden, in contrast, became the centre of pulp production (Rydberg 1990).

As can be noted in **Figure 5-15**, the industry statistics of Sweden imply that there were already almost 120 pulp establishments in the country in 1914, the maximum number of establishments during the time period the figures cover. The number of paper establishments had also almost reached its overall maximum level and was over 70 at the time. As Rydberg (1990) states, the pulp producers in the Northern coast were mainly interested in supplying international markets. The US, UK, and Germany became the large markets for the Swedish pulp production. The paper mills in the Southern part of the country, in contrast, produced a diversity of paper grades which were mainly sold in the domestic market. During the early twentieth century, it was actually pulp that was the main product of the industry, and most of it was exported to Western countries.

The capacity of the industry increased significantly during the time period between the two world wars (Melander 1997). Despite this increase, the number of establishments (in particular related to pulp) decreased. **Figure 5-16**, presenting the number of employees in the industry from 1911 onwards, suggests, however, that the number of employees both in paper and pulp establishments increased. Additionally, paper and board production increased significantly during the time period. Although Sweden did not actively take part in the world wars, the industry suffered as a result of both conflicts, due to the fact that much of the production of the industry was exported (Rydberg 1990).

Figure 5-13 presents a summary of important environmental, economical, technological, and evolutionary trends contributing to the evolution of the industry during the period of analysis of this study. Additionally, the aforementioned **Figure 5-15**, **Figure 5-16**, and **Figure 5-17** present the number of establishments and employees, and the total production of paper and board with their exports, imports, and

consumption, respectively. Further, **Figure 5-14** presents the number of firms operating in the industry from 1950 onwards.

As the production figures reveal, the time period from 1950 (characterized by a devaluation of the Swedish currency by 30 percent (Rydberg 1990) and the Korean war) until the first oil crisis and the recession following that, was a time of considerable growth in the paper and board production of the industry. The production increased from one million tons in 1950 to 5.5 million tons in 1974. The most important contributing factor to this growth was the growing demand of paper in Western Europe, the main market area of the industry. As described in the Finnish case above, the demand for paper grew on average by 5-6 percent in the area annually. **Figure 5-16** also reveals that the number of employees in the industry grew during the period, reaching its maximum level of 53 000 in the early 1960s. However, towards the end of the period, the number of employees working in pulp establishments decreased significantly.

During the period, the structure of the industry started to change considerably (see Peterson 1996; 2001). These changes were due to the increased competition in particular with regard to pulp (at the time the most important product grade of the Swedish industry). In the 1950s, competitive pressures came especially from North America (Melander 1997). First, North American pulp producers began to acquire control over the paper producing companies of Western Europe and invested in new pulp mill capacity. Second, the American paper mills started to integrate vertically, and to an increasing extent purchased their pulp from the geographically closer Canadian producers. Thus, Sweden (and also Finland) lost their leading positions as pulp exporters to Canada, and the North American firms started to export paper to Europe (Melander 1997).

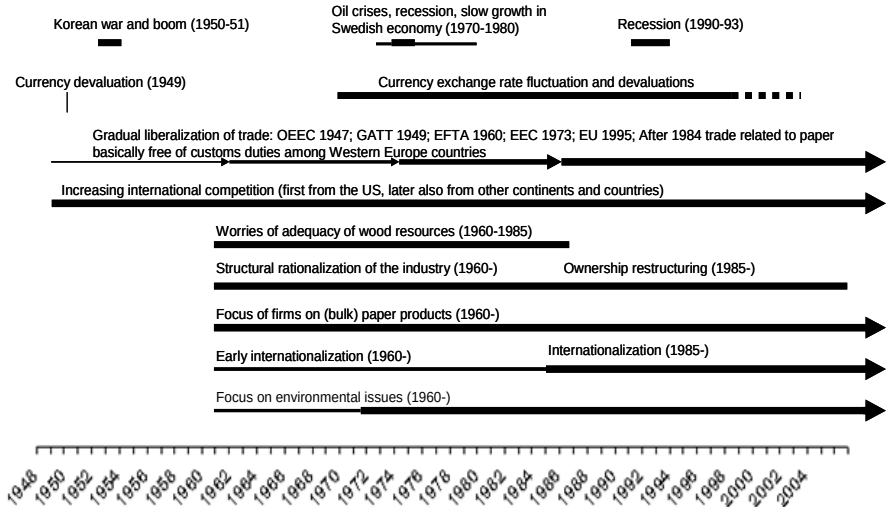

Figure 5-13: Chart of the evolution of the Swedish paper and pulp industry, 1950-2006.

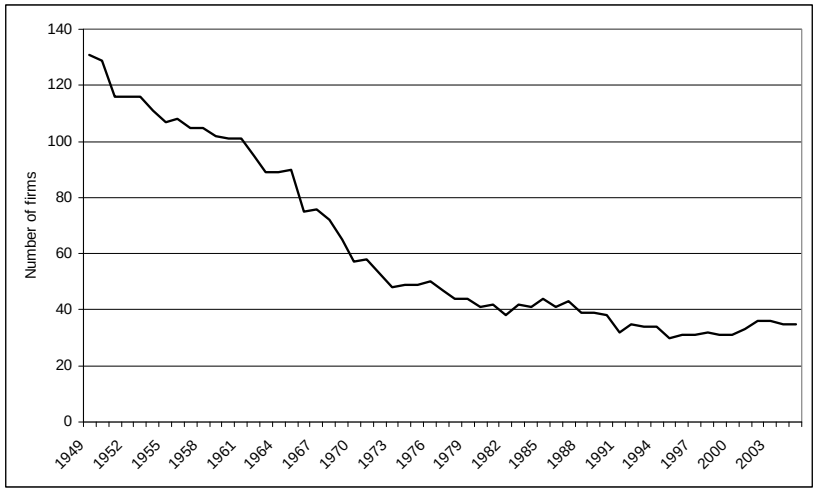

Figure 5-14: Number of firms in the Swedish paper and pulp industry, 1949-2006.

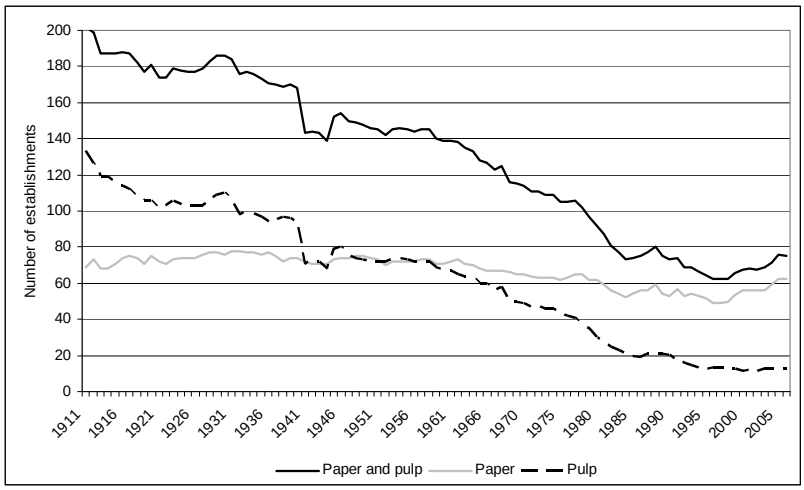

Figure 5-15: Number of establishments (note the definition for an establishment) in the Swedish paper and pulp industry, 1911-2006.

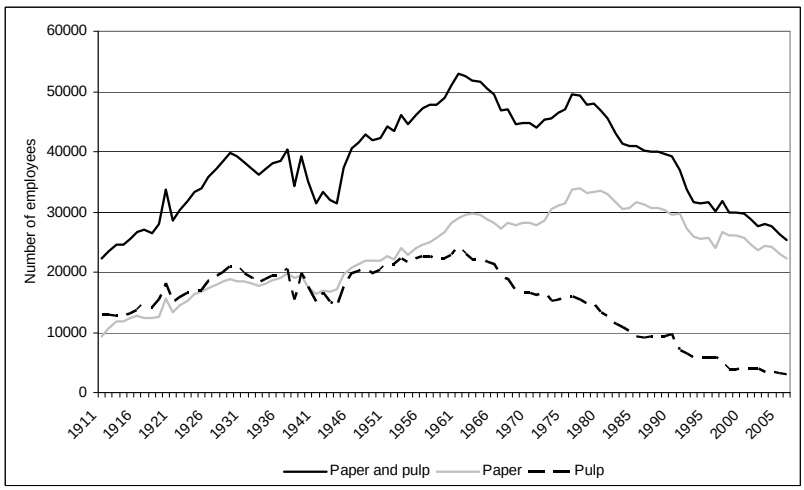

Figure 5-16: Number of employees in the Swedish paper and pulp industry, 1911-2006.

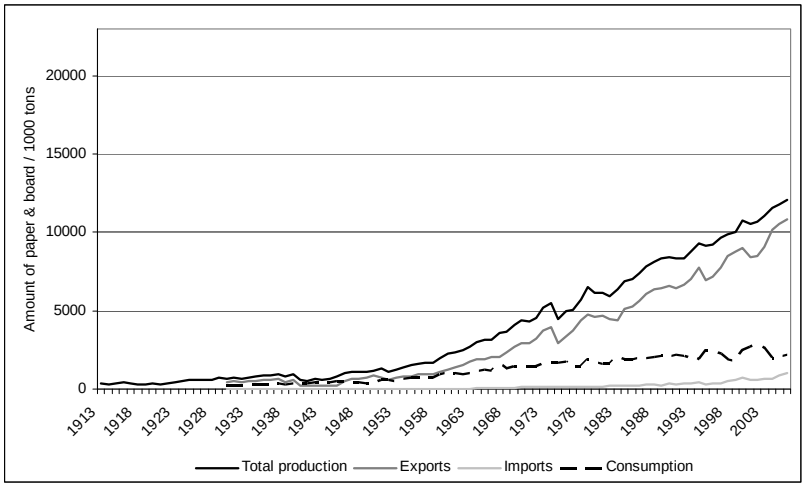

Figure 5-17: Amount of paper and board produced by the Swedish paper and pulp industry (1913-2006) and amount of paper and board exports, imports, and total consumption in the Swedish market (1930-2006).

The consequence of this trend, combined with the growing anxiety about insufficient raw-material resources starting in the late 1950s and a heightened cost awareness, was the change of the orientation of Swedish firms from rather small-scale paper and pulp production to a large-scale perspective and to larger production units (Rydberg 1990; Peterson 1996; Melander 1997). Additionally, the focus on pulp production was changed to the production of paper grades that in Western Europe could only be produced in limited volumes; first and foremost kraft paper, fluting and newsprint (Peterson 1996; 2001). **Figure 5-14** and **Figure 5-15** also clearly reveal the change in the structure of the industry. First, during the time period from 1950 to 1973, the number of firms in the industry decreased considerably: from 130 firms in 1950 to less than 50 firms in 1973. Secondly, the number of establishments decreased from 150 to little bit over 100 in 1973. In particular, it was the number of pulp establishments that decreased during the period.

In addition to the structural change, the liberalization of trade had also an important effect on the evolution of the industry (in a similar vein to the Finnish industry). In particular, membership of EFTA enabled Sweden to continue exporting paper products to the United Kingdom, an important export market for the industry (Melander 1997). Further, many Swedish firms began to internationalize in the 1960s either by investing in pulp production abroad (e.g. in 1964 SCA came to an agreement with a Canadian pulp mill with a capacity of 250 000 tons), or acquiring converting firms in Western Europe (e.g. SCA acquired four converters producing corrugated board in 1963 and 1964) (Melander 1997). Finally, issues relating to the

environment became increasingly important during the 1960s. In particular, the pollution of air and water, which had been observed for years, became the center of attention. The stricter anti-pollution legislation enacted in 1969 forced the industry to start to investigate extensive efforts to reduce pollution. During the next decades, the industry strongly invested in environmentally-friendly technology. According to Melander (1997), although the increased investment costs due to environmental legislation were seen to aid the restructuration of the industry because the new demands made it too expensive to refurbish old mills, the investments in non-profitable operations such as protecting air and water were not seen to increase the industry's competitiveness in an international perspective.

The oil crisis and the following recession hit the industry hard, decreasing the production of paper and board by one million tons between 1974 and 1975. However, due to a sharp rise in exports, the volume of production already exceeded the production levels of 1974 by 1978. The second oil crisis and its consequences during the late 1970s and early 1980s affected the demand of paper in the West European markets, causing the production of the Swedish industry to drop again. Additionally, the unstable, slow growth of the Swedish economy during the whole of the 1970s affected the industry negatively. It was not until the two devaluations of the Swedish currency in 1981 and 1982 and the growing demand in the West European market that the course of the industry turned to a more positive direction (Melander 1997). As a result, the industry grew considerably during the 1980s. The output of the industry increased by 2.5 million tons.

The structural change of the industry continued for the whole period. Although the number of firms no longer decreased, as **Figure 5-14** indicates, **Figure 5-15** reveals how the number of pulp establishments continued to decrease considerably. The change of the focus of the industry from pulp to paper continued. Contributing factors to the change where, first, the fact that in particular North American competitors were now able to compete successfully with Nordic producers in the pulp markets. Second, as Melander (1997) describes, pulp production was seen to be especially vulnerable to currency change fluctuations. In general, fluctuations in the currency exchange rate were seen as a considerable problem for the industry, starting from the beginning of the 1970s. Third, worries about the availability of wood resources since the 1960s affected the change (Peterson 1996; Melander 1997; Peterson 2001). In the 1960s and early 1970s, the worries were related to forecast or actual shortage of wood (felling exceeded the growth of forests in one year, 1974) but later the problem became that of too low a level of felling. The problems related to wood, however, started to fade in the second half of the 1980s after the volume of felling increased.

The earlier structural rationalization of the industry changed into ownership rationalization in the 1980s. Further, the free trade agreement with EEC finally resulted in a totally free trade area within West European countries in 1984, and the announcement in 1985 of the formation of a single market by 1992 contributed to the increasing internationalization of the industry. For example, during 1987 and 1988, Swedish firms acquired twelve firms within the EEC, mainly covering product areas such as tissue, paperboard and corrugated board. As the result of these developments, in the end of 1980s, the independent firms in the industry could be divided into three groups: large internationals (Stora, SCA, and Modo), medium sized firms, specializing in a few products, and very small niche firms. (Melander 1997)

The growth of the 1980s turned to a recession in the Swedish economy in the beginning of the 1990s. Although this recession hit the Swedish economy hard, it did not have a very severe effect on the paper and pulp industry because the demand in export markets did not decrease considerably. Greater decreases in exports during the period took place in 1995 and 1996 and in the beginning of the 21st century, affecting the production figures negatively. Overall, during the period, the production of the industry still grew from 8.5 million tons in the beginning of the 1990s to over 12 million tons in 2006. The number of firms remained at a similar level for the whole period, varying from 30 to 36, as **Figure 5-14** illustrates. The number of establishments also remained at relatively the same level, but the number of employees continued to decline (see **Figure 5-15** and **Figure 5-16**). In general, the structure of the industry remained as it was at the end of the last period. The greatest change was the merger between the Swedish Stora and Finnish Enso in 1998.

The formation of the singe market in Western Europe in the beginning of 1990s and the EU membership of Sweden in 1995 contributed to a further internationalization of the industry during the period. Similar to the Finnish industry, new types of raw materials also encouraged the firms to internationalize. Finally, achieving economies of scale was seen to be extremely important and contributed to the internationalization development.

With regard to changes in the product portfolios of the Swedish firms, **Table 5-2** presents the share of the main paper and board grades of the total production in certain cross cutting years since 1950, and **Figure 5-18** the volume of production of newsprint and printing & writing papers since 1915. As the figure and table indicate, the largest change during the research period took place in the share of the production of printing and writing papers: their share increased from 11 percent in 1950 to 26 percent

in 2005. Additionally, the share of newsprint decreased somewhat. The total share of different types of packaging materials and total printing and writing papers of the total production, however, remained at a relatively similar level for the whole research period.

Table 5-2: The share of the main paper and board grades of the total paper and board production in Sweden in cross-cutting years 1950-2005.

	1950	1960	1970	1980	1990	2000	2005
Newsprint, %	28	27	24	25	25	24	22
Printing & writing, %	11	15	14	16	22	26	26
Household & sanitary, %		0	3	3	3	3	3
Kraft paper & board, %	29	35	44	39	33		
Fine cartonboard, %		0	7	9	9		
Packaging materials, %						46	48
Misc., %	32	23	8	8	8	1	1
Total, %	100	100	100	100	100	100	100

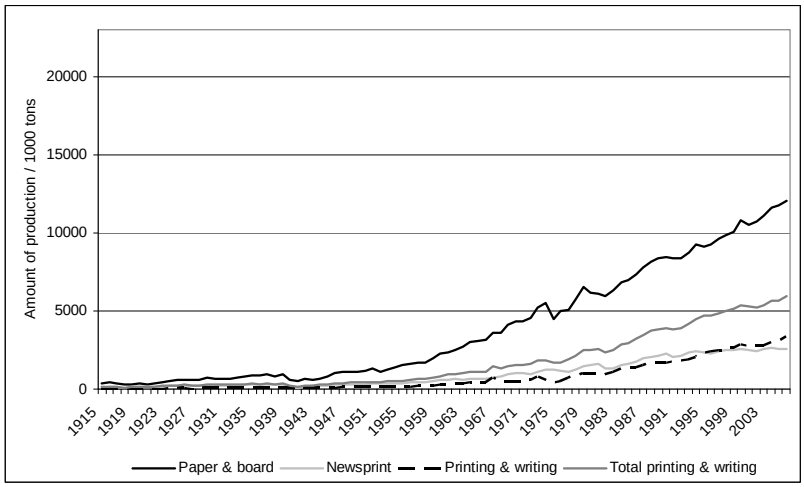

Figure 5-18: Production of total paper and board, newsprint, and printing and writing papers by the Swedish paper and pulp industry, 1913-2006.

As a conclusion, the Swedish industry has been characterized by a considerable growth during the last fifty years. Currently, Sweden is the seventh largest producer of paper and board in the world. As in the case of the Finnish industry, the growth of the industry has been a complex process, contributed to at least by an abundance of wood resources, growing export markets in Western Europe, change of the focus of production from pulp to bulk paper grades (in particular newsprint and kraftliner), structural rationalization of the industry, and internationalization of the largest firms. Although the industry has also been important for the Swedish economy as a whole, its role has not been as central as in the Finnish case.

5.6. Printing and publishing industry in Sweden

The first printing press arrived in Sweden already in 1482, only few decades after the press was invented (Nykänen 2005). However, during the next almost 400 years, the growth and development of the industry was slow, although faster than for example than in Finland, due to the higher standard of living in the country. The first newspaper in Sweden (Aftonbladet) was established in 1830 and the first mass-market newspaper (Dagens Nyheter) in 1864 (Hulten 2004). Both these newspapers are still published: Dagens Nyheter is today the leading morning newspaper in the country, while Aftonbladet has become the dominant afternoon tabloid paper. In general, during the late nineteenth century, the number of printing establishments increased considerably, and as **Figure 5-19** indicates, there were already over 400 printing establishments in the country by the early twentieth century. The number of employees was also growing, reaching the level of 10 000 in 1913, as indicated by **Figure 5-20**.

In general, the development of the printing industry was positive during the first half of the century, although the two world wars and the Great Depression affected the industry negatively. This was despite that Sweden was not actively involved in the wars. The value of the production of the industry grew seven-fold during the first half of the century. The number of establishments in the industry increased from 400 to almost 800 by 1950, and the number of employees increased from 10 000 to 30 000. With regard to the newspaper segment of the industry, the number of titles reached its maximum level in 1920 (some 240 titles) and decreased slowly especially after the Second World War (the circulation of the newspapers did, however, increase until 1980) (Hulten 2004).

Figure 5-19 presents the number of establishments in the industry during the analysis period of this study[23]. **Figure 5-20** then presents the number of employees (categorized as in **Figure 5-19**), and **Figure 5-21** the value of production of the industry in constant 1999 million Euros (again categorized as before). Finally, **Figure 5-22** presents the level of GDP in the country from 1950 onwards. Differing to the other narratives, I do not present a separate evolutionary trend chart for the industry because the Swedish industry has followed very similar evolutionary patterns as that in Finland, for example with regard to economical and technological trends, and the increasing competition from other media.

[23] What is important to note when interpreting the figure is that newspaper publishing is included in the printing establishments for the whole period, and it is only from the mid-1990s that the statistics also cover other publishing establishments (such as magazine publishing).

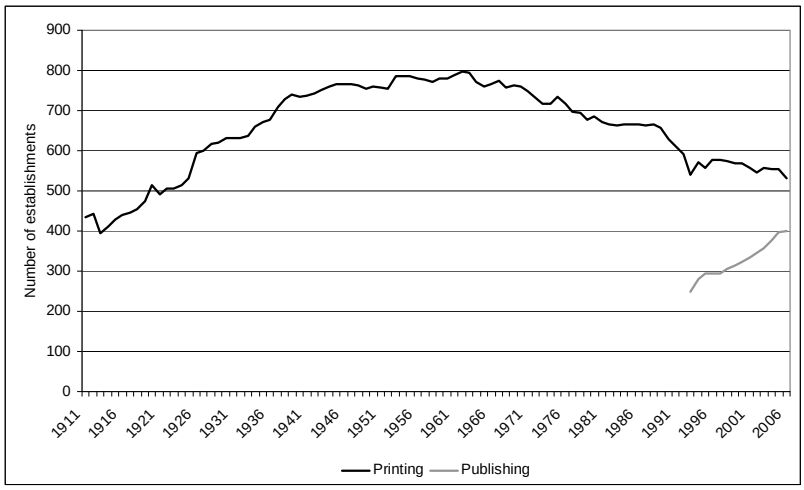

Figure 5-19: Number of establishments (note the definition for an establishment) in the Swedish printing and publishing industry, 1911-2006. Publishing of newspapers is included in printing for the whole period. Figures for other types of publishing are available from 1993 onwards.

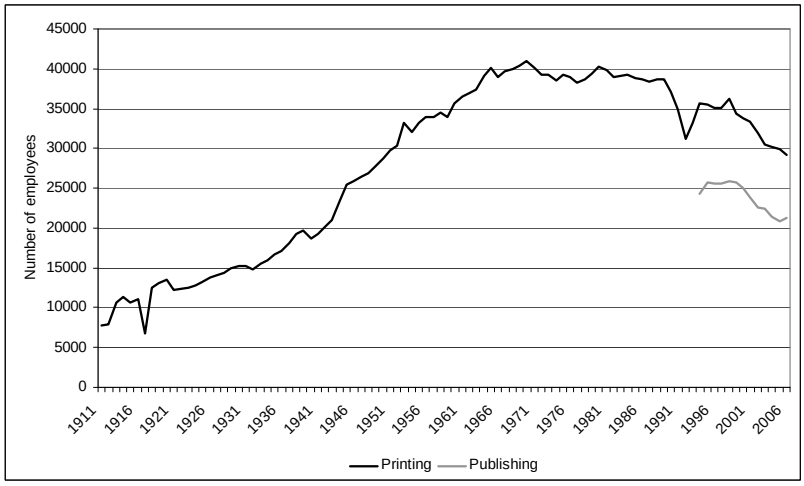

Figure 5-20: Number of employees in the Swedish printing and publishing industry, 1911-2006. Publishing of newspapers is included in printing for the whole period. Figures for other types of publishing are available from 1993 onwards.

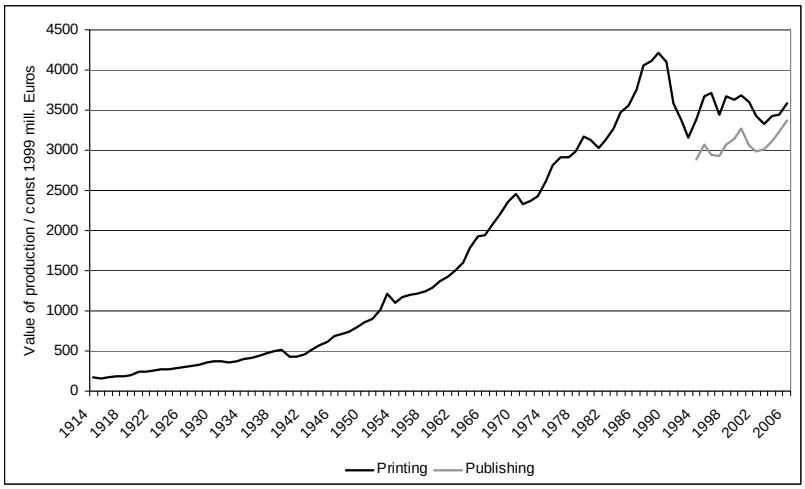

Figure 5-21: Value of production of the Swedish printing and publishing industry in constant 1999 million Euros. Publishing of newspapers is included in printing for the whole period. Figures for other types of publishing are available from 1993 onwards.

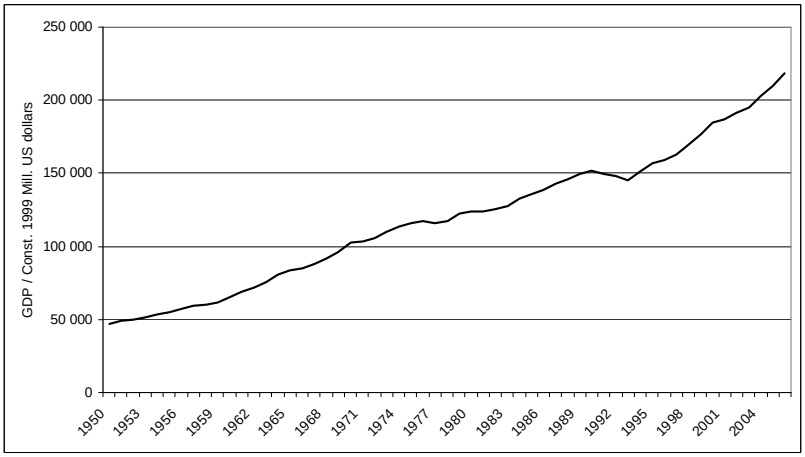

Figure 5-22: Gross domestic product (GDP) of Sweden in constant 1999 million US dollars (converted at Geary Khamis PPPs), 1950-2006.

The time period from 1950 to the recession and slow growth period starting from the early 1970s was generally a time of growth for the industry: the value of production of the industry saw an almost 2.5 fold increase. The number of printing and publishing establishments, however, remained stable during the 1950 and after that declined slowly. The number of employees still grew during the 1950s, reaching its maximum level of a little over 40 000 in the mid-1960s. Since then, the number of employees remained stable until the end of the period. As in the Finnish industry, the technological revolution started to affect the industry from the beginning of the 1960s and onwards. Offset replaced letterpress as the main printing method, and phototypesetting changed the type-setting process. In the

Swedish case, these changes can be noted in the employment figures: the new technology reduced the labor-intensivity of the industry, and thus enabled a reduction in the number of employees and the growth of the total output of the industry at the same time (i.e. the productivity of the industry grew).

Public service television was introduced in Sweden in 1957, and especially picked up from the 1960s. This challenged the printed media industry by hardening the competition between printed media and other media (Gustafsson & Hulten 1997). The decline in the titles of newspapers continued. In the 1970s the Swedish state introduced a support measure for weak newspapers facing dominant rivals, in order to protect plurality in the press (Hulten 2004). The direct support system is still in place in very specific conditions, and although it is of declining importance to the press as a whole, it is still critical to a number of individual publishers.

The 1970s and early 1980s was an era of slow growth and recession in the Swedish economy. During the rest of the 1980s, the growth of the economy, in contrast, was strong. These trends are also reflected in the development in the value of the production of the industry during the 1970s and 1980s. Although the value of the production in general almost doubled during the period, the 1970s and 1980s were a time of unstable growth characterized by periods of decline in output. The rest of the 1980s was an era of considerable growth. The number of establishments declined slowly during the period. The number of employees, in contrast, remained fairly stable during the 1970s and 1980s. One of the main factors contributing to this development was the continuing technological change. For example, computerization and automation of production processes enhanced the productivity of the industry considerably and reduced the need of employees. Additionally, as in the Finnish case, the technological change of the industry resulted in concentration and integration of the production activities.

The recession of the early 1990s hit the Swedish industry hard, as indicated by **Figure 5-21**: the value of the production of the industry decreased by over 20 percent. In a sense, the industry never fully recovered from the recession. Although the value of the production grew somewhat during 1993-1995, during the late 1990s and the early 21st century the value of the production of the industry remained fairly stable and never reached the production levels of the late 1980s. The same applies to the development in the number of establishments. The figures dropped significantly during the recession and never reached earlier levels. The number of employees also dropped during the recession and increased

somewhat in the two years after the recession, but after that declined considerably.

The decline in the newspaper segment of the industry is one of the factors contributing to the recent developments of the industry. Since 1980, when the consumption of the newspaper copies peaked, with 580 copies per 1 000 inhabitants, the consumption of newspapers dropped considerably, being 475 copies at the beginning of the twenty-first century (Hulten 2004). Some of the segments of the industry also grew during 1990-2005. For example, the periodical and magazine market has been expanding recently, despite the growing competition with the electronic media and the internet since the late 1990s. The hardening competition has, however, resulted in a concentration of the industry. For example, in the beginning of the 21st century, the six largest press publishers accounted for 60 percent of the total turnover of the industry (Hulten 2004).

Finally, **Figure 5-23** presents the absolute and per capita consumption figures of printing and writing paper consumption by the Swedish printing and publishing industry during the research period. As the figure indicates, the paper consumption did increase considerably during the research period. Similar to the Finnish industry, however, most of the increase in consumption already took place before the 1980s. Since then, both the absolute and per capita consumption figures have remained rather stable. In absolute terms, the consumption varied between 900 000 and 1.1 million tons during 1980 and 2005 and consumption per capita was some 120 kg for the respective time period.

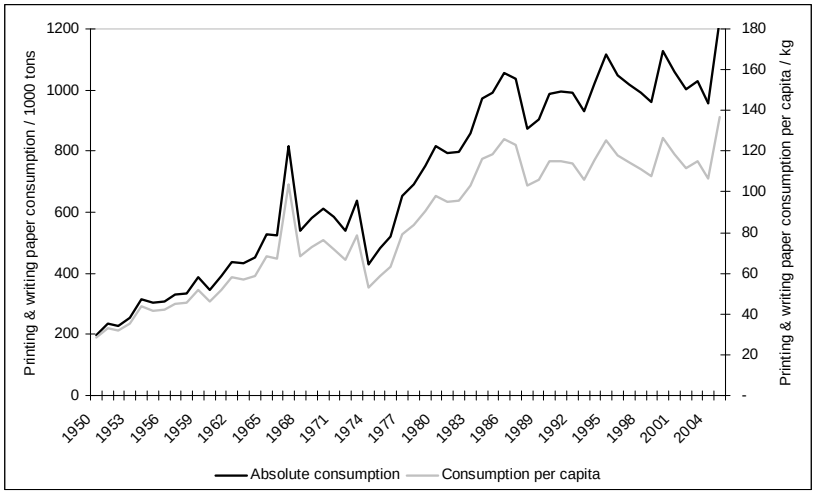

Figure 5-23: Printing and writing papers consumption of the Swedish printing and publishing industry in absolute and per capita terms, 1950-2006.

As a conclusion, the evolution of the Swedish industry has proceeded in a very similar manner as that of the Finnish industry. The industry grew strongly until the late 1980s, but thereafter its value of production has remained stable. The industry has experienced considerable technological change since the 1960s, which has greatly increased the productivity of the industry. Different forms of electronic media have, since the 1960s, hardened the competition between the printed media and other media. In particular, it has been the newspaper-related segment of the industry that has suffered.

5.7. Paper and pulp industry in the UK

As with the other counties examined, the history of paper making in the UK is also long. The beginning of paper production in the country can be traced back to 1490 (Coleman 1958; Hills 1988). The modern paper industry started in 1804, when the first Fourdrinier machine in the world was installed in the Frognal mill in Hertfordshire (Hills 1988; Owen 2000). During the first half of the nineteenth century, the British industry grew considerably, and according to Magee (1997), in 1850 the UK had the world's largest and most technically advanced industry. The industry was also the leading exporter in the world, although its expansion was driven mainly by demand in the home market.

In the second half of the century, growing competition started to appear from the US and Germany, and after 1861, when the customs and excise duties on paper were removed, the UK paper market came under attack from imports (Owen 2000). Nevertheless, despite import competition (at the end of century also from the Nordic countries and Canada), the demand in the country was sufficient to sustain a large and expanding domestic industry until the beginning of the First World War (Hills 1988; Owen 2000). In total, the paper production of the industry grew from 87 000 tons in 1858 to over one million tons in 1912 (thus, there was more than a 12 fold increase in production), as **Table 5-3** indicates (Hills 1988).

Table 5-3: Production of paper and board by the UK paper and pulp industry, and the amount of imports, exports, and consumption of paper and board in the UK market in certain cross-cutting years, 1858-1945 (figures from Hills 1998).

Year	Production / 1000 tons	Imports / 1000 tons	Exports / 1000 tons	Consumption / 1000 tons
1858	87	41	6	122
1875	162	61	3	220
1885	369	340	18	691
1895	543	543	59	1027
1907	887	451	17	1321
1912	1085	508	69	1524
1924	1317	713	242	1788
1930	1691	1054	239	2506
1935	2286	1086	198	3174
1938	2541	1046		3596
1945	1322	344		

The pressure of import competition eased after the First World War. This was mainly due to an increasing protection of UK industries from exports by customs duties (Owen 2000). The growth of paper consumption in the country in the inter-war period (the consumption of paper increased from 1.8 million tons in 1924 to 3.6 million tons in 1938) and the decrease in the share of imports enabled the UK paper industry to grow significantly until the Second World War, as also indicated by **Table 5-3** (Owen 2000). The combination of tariffs and cartels insulated paper makers from competitive pressure during the inter-war years and preserved a structure (i.e. small, privately owned firms, mainly operating from a single mill) which was out of line with the changing economic conditions of the world paper industry (Wray 1978).

Considering the analysis period of this study, **Figure 5-24** first presents an evolution chart of the industry during the research period. Next, based on industry directories and the UK Office of Statistics, **Figure 5-25** presents the number of firms in the industry since 1950. **Figure 5-26** then presents the number of employees in the industry, **Figure 5-27** the total production of paper and board, imports, exports, and total paper and board consumption during the analysis period, and **Figure 5-28** the GDP of the country.

In general, during the period from 1950 to 1973, the UK economy grew steadily, as did the paper consumption of the country. Thus, a foundation for the growth of the paper industry was in place. During the 1950s, the output of the paper industry grew rather steadily but the situation started to change in the 1960s. Although the output of the industry still increased by one million tons, the share of imports of the total consumption started to increase considerably, covering 40 percent of the total consumption in

1970. As **Figure 5-25** also indicates, the number of firms decreased steeply during the period. The number of employees, however, still grew during the 1950s, reaching its maximum level of 88 400 in the early 1960s, but started to decline considerably thereafter.

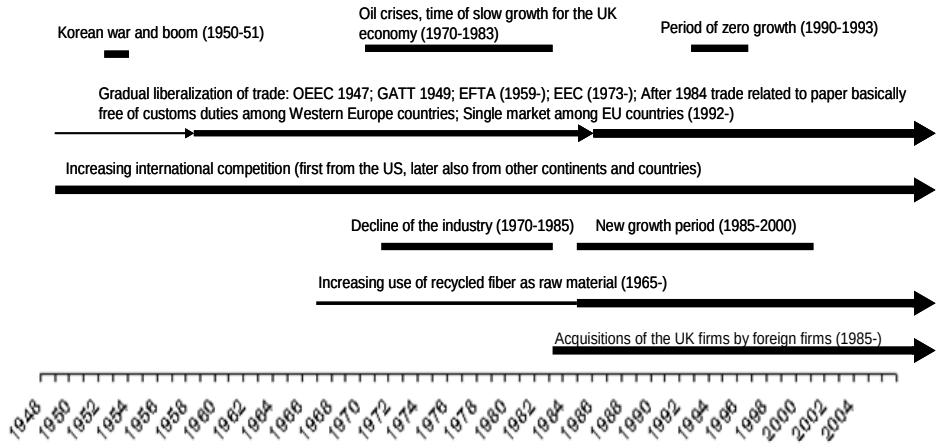

Figure 5-24: Chart of the evolution of the UK paper and pulp industry, 1950-2005.

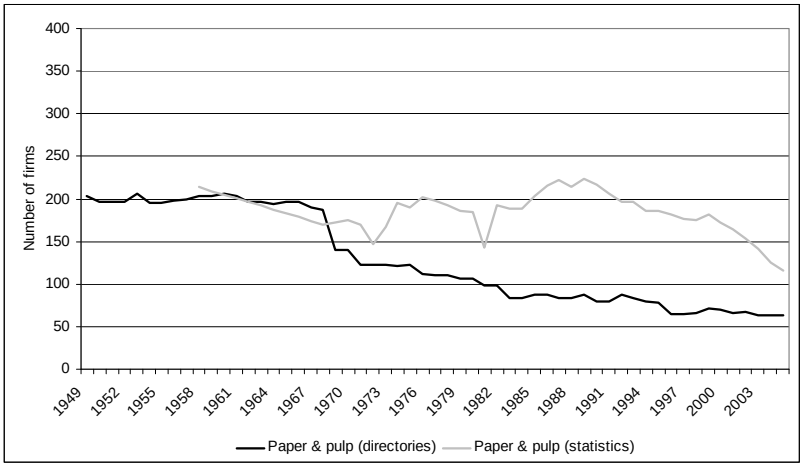

Figure 5-25: Number of firms in the UK paper and pulp industry based on (i) industry directories (Phillips paper trade directory; 1949-2006) and (ii) official statistics of the UK (1958-2006).

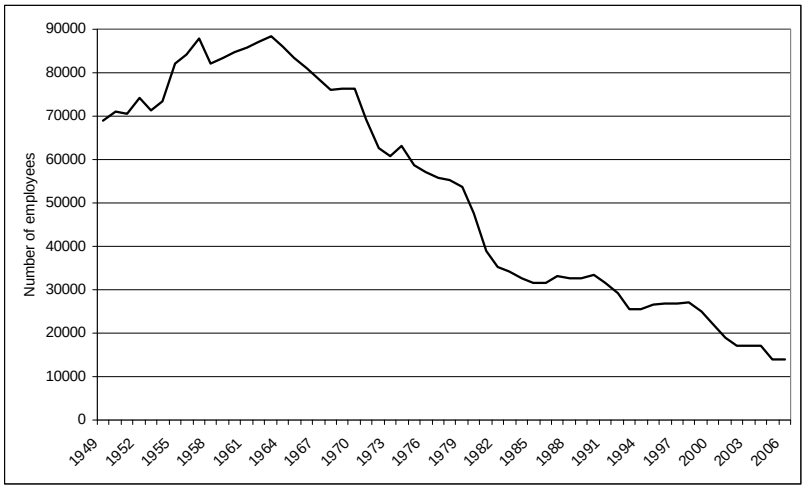

Figure 5-26: Number of employees in the UK paper and pulp industry, 1949-2006.

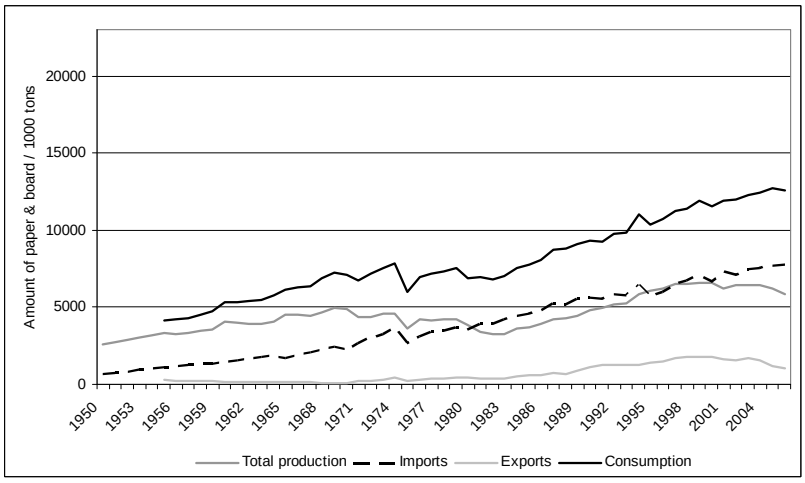

Figure 5-27: Amount of paper and board produced by the UK paper and pulp industry (1949-2006) and amount of paper and board exports, imports, and total consumption in the UK market (1956-2006).

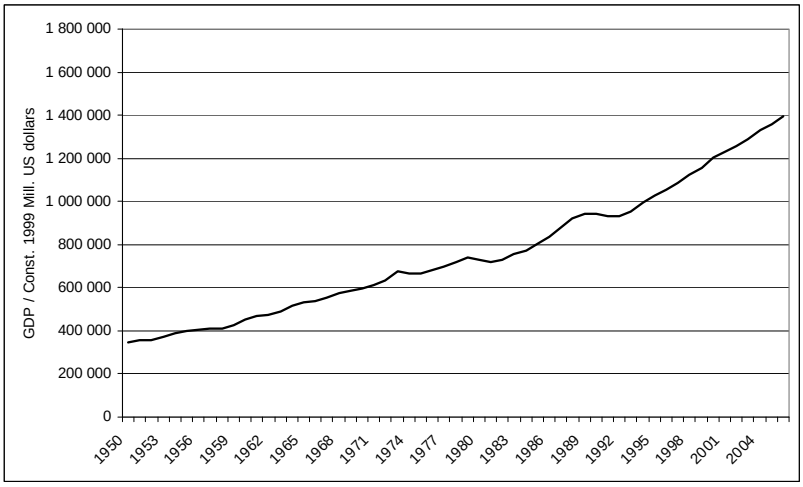

Figure 5-28: Gross domestic product of the UK in constant 1999 million US dollars (converted at Geary Khamis PPPs), 1950-2006.

One of the main factors contributing to the development described above was the tariff policy of the country (Hills 1988; Owen 2000). During the 1950s, the paper imports to the country were controlled, and thus, the industry remained somewhat protected from competition coming from outside the country. The papermakers basically enjoyed a seller's market for the most of the 1950s (Owen 2000). The situation changed, however, in 1959 when the country decided to join the European Free Trade Association (EFTA). This also resulted in a reduction in tariffs with regard to paper industry products. Because the Nordic countries also became members of the association, the UK paper industry ceased to be protected (Hills 1988; Owen 2000). The immediate impact of EFTA was not as disastrous, however, for the UK industry since the demand for paper in the UK remained strong for most of the 1960s.

The 1970s and the early 1980s became disastrous for the industry, despite the hopes for the industry that entry into the EEC in 1973 would bring some relief, since the Nordic producers would have to surmount the EEC's common external tariff (Owen 2000). But the tariff was not sufficient to have a significant effect, and the UK paper manufacturers found themselves under an attack even on a new front, from German, French, and Dutch producers (Owen 2000). Additionally, when the decreased protection of the industry by tariffs was combined with the oil crisis and the slow growth in the UK economy, the industry declined at a high rate during the 1970s and early 1980s.

As **Figure 5-27** indicates, the total output of the industry dropped from almost 5 million tons in the beginning of the 1970s to 3.2 million tons in the beginning of the 1980s. At the same time, the import penetration increased

to 60 percent. The number of firms in the industry (according to the trade directory) also decreased from 130 in the early 1970s to less than 70 in 1985. Additionally, the number of employees halved during the 1970s from over 60 000 to almost 30 000. Some of the firms survived, however. According to Owen (2000), the survival strategies of the firms continuing their operations were to switch into high-value-added paper grades, using waste paper as a substitute for imported pulp, and exploiting home-grown timber resources (see also Wray 1978).

The economic growth of the country accelerated after the early 1980s, resulting in a growing consumption of paper. Even during the slow growth period of the UK economy in the early 1990s, paper consumption continued to grow. Starting from the middle of the 1980s, the paper industry also started to grow again. The total output of the industry increased from 3.2 million tons in 1983 to over 6 million tons in 1995, after which the output of the industry stagnated until the end of the period of analysis. Despite the growth of the UK industry, the level of import penetration remained at 60 percent until the end of the period. After the middle of the 1980s, the number of firms in the industry stabilized to some 70 and even increased during the rest of the period. The number of employees still continued to decrease, although at a slower rate than earlier.

Although the growth in paper consumption was one of the factors affecting the new growth of the industry, Owen (2000) argues that one of the main antecedents behind the growth were the acquisitions of the UK paper industry firms by large paper and pulp industry firms originating in North America and the Nordic countries. This ownership restructuring of the industry continued until the end of the 1990s. In 1997, only three of the 15 principal paper producing firms were owned by the UK based firms. Thus, most of the production capacity was owned by foreign firms, including UPM, SCA, International Paper, and Smurfit. In addition to the infusion of capital and technology by foreign firms, Owen (2000) mentions that another important factor affecting the growth was the technical advances in the use of waste paper as a substitute for imported woodpulp, decreasing the dependence of the country of overseas pulp production. It was actually already at the end of the 1980s when waste paper had become the most important raw material for the UK paper mills (Hills 1988). As a final factor, Owen (2000) lists changes in the domestic political and economic environment, making the UK a more attractive location for foreign investors.

With regard to the changes in the product portfolio of the UK industry, **Table 5-4** presents the share of the main paper product types at certain cross-cutting years, and **Figure 5-29** the total paper and board production,

the production of newsprint and the production of printing and writing papers. As the table and figure show, there are no clear trends in the changes in the share of the different product types. In general, the share of the printing and writing papers in total varies between 34 and 51 percent, the household and sanitary papers between 6 and 13 percent, and the packaging materials between 35 and 44 percent.

Table 5-4: The share of main paper and board grades of the total paper and board production of the UK paper and pulp industry in cross-cutting years 1950-2005.

	1950	1960	1970	1980	1990	2000	2005
Newsprint, %	21	17	15	9	14	17	18
Printing & writing, %	30	25	23	25	29	26	24
Household & sanitary, %			6	11	9	11	13
Packaging materials, %			43	44	42	39	35
Other paper & board, %	49	58	13	11	6	7	10
Total, %	100	100	100	100	100	100	100

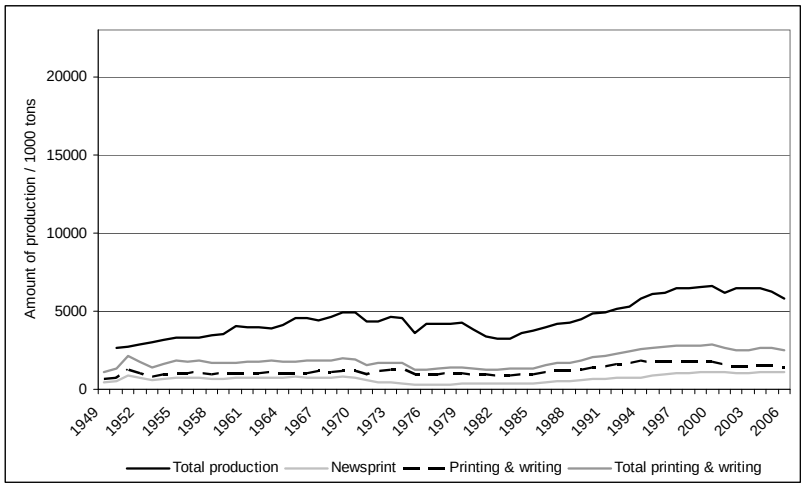

Figure 5-29: Production of total paper and board, newsprint, and printing & writing papers by the UK paper and pulp industry, 1949-2006.

As a conclusion, it is evident that during the last fifty years the UK has lost its position as one of the largest paper producing countries in the world. The period from the late 1960s to the early 1980s was especially detrimental to the industry. After the end of tariff protection, the industry was not able to compete with cheaper paper originating from the Nordic countries and North America, and also later from Germany and other European countries. The acquisitions of the UK firms by large foreign paper and pulp industry firms were an important factor in the revival of the industry after the middle 1980s. As a consequence of the acquisitions, the industry became controlled by overseas paper and pulp firms already in the middle of 1990s. The growth period of the industry ended in the end of the

1990s. For the beginning of the 21st century, the output of the industry has remained stable.

5.8. Printing and publishing industry in the UK

Although the first printing machine was invented in Germany, the UK did become the country that was in the forefront in technological development that enabled the birth of the "modern" printing and publishing industry during the early nineteenth century (Marshall 1983). For example, The Times has always prided itself on its record of innovation: the newspaper has even claimed that from the year 1748 until the present day all the chief achievements in the printing of newspapers have been either invented or first tried and fostered in what is now the office of The Times (Marshall 1983). In any case, the growth of the industry was fast during the second part of the nineteenth century, and 1896 has been considered the year in which the mass press was born in the country (Tunstall 1997).

Despite the two world wars and the Great Depression during the first half of the twentieth century, the net output of the industry doubled during the period. It was in particular the newspaper segment of the industry that flourished. Most UK newspaper sales records were actually established already in the 1940s and 1950s (Tunstall 1997). However, the massive sales of the 1940s were typically of six-page newspapers. The structure of the UK industry was rather concentrated already in the beginning of the twentieth century (Twyman 1998) although most of the firms were small in size. It has been estimated that large firms employing 200 - 1 000 workers formed less than one percent of the total number of printing firms in the UK in 1914 (Twyman 1998). In addition, an analysis of the British printing industry conducted by the British Federation of Master Printers in 1964 revealed that only 37.8 percent of member firms employed twenty-five or more people, and only 0.2 percent one thousand or over.

Turning to the analysis period of this study, **Figure 5-30** presents the main trends that have affected the evolution of the industry since 1950. Further, **Figure 5-31** presents the number of firms in the industry (the printing and publishing of newspapers and periodicals is presented separately) since 1958, **Figure 5-32** the number of employees in the industry since 1949, and **Figure 5-33** the total sales and net output of the industry since 1949. When interpreting the figures for the number of firms in particular, it is important to note that the classification and standards of the industry statistics of the UK have changed several times during the last

fifty years, and I have used scaling of the figures in constructing the time-series. Thus, although the time-series may present the overall trends that have taken place in the number of firms, nothing can be said of the absolute number of firms at certain periods.

The time period from 1950 to the early 1970s was, in general, an era of growth for the industry, and both the total sales and net output doubled during the period. The growth was especially fast in the segment related to printing and publishing of newspapers and periodicals. The share of the segment of the total output of the industry increased from 40 percent in 1950 to almost 50 percent in the end of the period. After that, the share of the segment of the total output remained at the same level until the early 1990s, after which the figures for the segment are no longer available. Further, as **Figure 5-31** indicates, the number of firms was very stable for the period (or for the period for which data is available). Similarly, the total number of employees in the industry remained stable for the whole period. The number of employees in the segment related to printing and publishing of newspapers and periodicals, however, increased by almost 50 000.

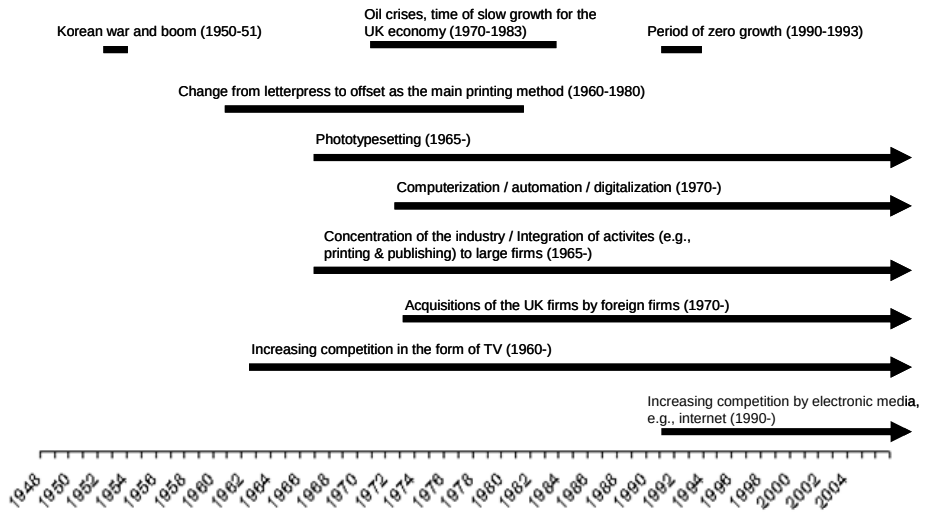

Figure 5-30: Chart of evolution of the UK printing and publishing industry, 1950-2006.

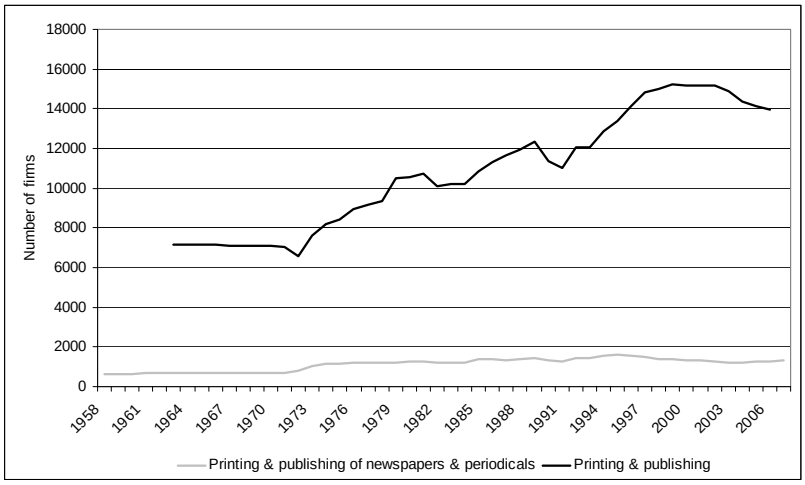

Figure 5-31: Number of firms in the UK printing and publishing industry, 1958-2006. The number of firms for the whole printing and publishing industry is available from 1965 onwards.

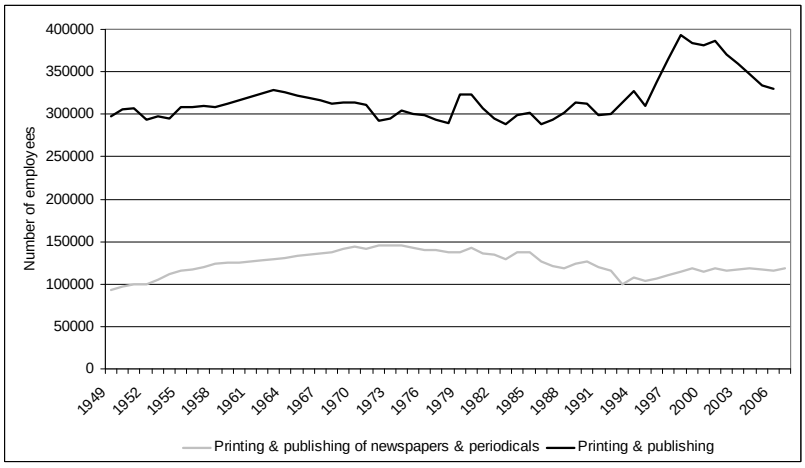

Figure 5-32: Number of employees in the UK printing and publishing industry, 1949-2006.

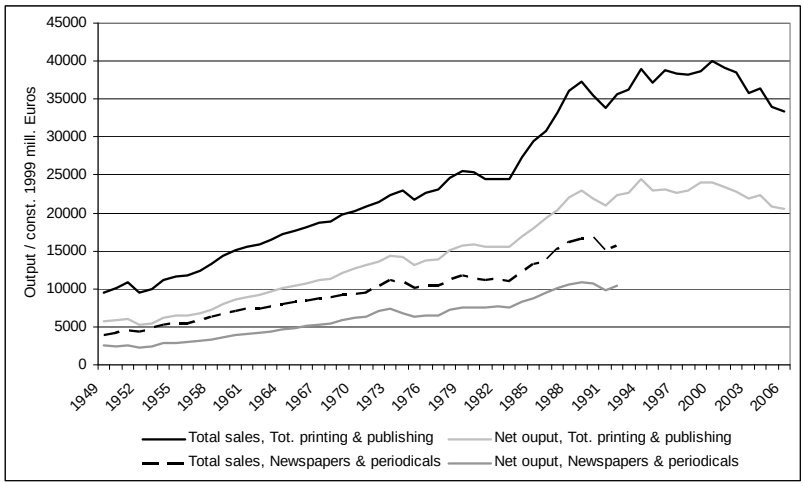

Figure 5-33: Total sales and net output of the UK printing and publishing industry in constant 1999 million Euros, 1949-2006. Figures for the total sales and net output of newspapers and periodicals are available until 1993.

As became evident in the evolutionary analysis of the Finnish and Swedish industry, the 1960s marked the beginning of rapid technological change in the industry, contributed to by the introduction of television in the late 1950s, which toughened the competition between the traditional printing media and other media. This was the case also in the UK, where the launch of a new ITV channel in 1955 is considered as the key date for television in Britain (Tunstall 1997; 2004)[24]. The concentration development of the UK industry started already in the 1960s, and according to Marshall (1983), the printing and publishing industry ranked high in the rate of market concentration already in the 1960s. For example, in the newspaper segment of the industry, six firms controlled 80 percent of all daily and Sunday newspapers by 1974. According to Ojala & Uskali (2005), the first oil crisis in 1973 was the last hit for many firms that focused solely on newspapers. The UK newspaper industry became totally controlled by eight media groups.

The 1970s and early 1980s were an era of slow growth for the industry, mostly due to the economic growth of the UK economy stagnated for almost a decade. In contrast, the rest of the 1980s was an era of considerable growth. The output of the industry increased by over 65 percent. Despite the stagnating growth in the output of the industry, the statistics suggest that the number of firms in the industry increased during the 1970s, and after a few years drop in the numbers in the early 1980s, the number of

[24] BBC had already begum a pilot television service in 1936, but even the BBC service which started up again in 1946 was still semi-experimental and subordinate to radio.

firms also continued to grow for the rest of the 1980s. The number of employees, in contrast, remained stable for the whole period. In the segment related to printing and publishing of newspapers and periodicals, the number of employees declined for the whole period, in total by almost 50 000 employees.

The technological change in the industry continued for the whole period, increasing the productivity of the industry. Additionally, the concentration development of the industry continued during the period (Fishwick 1977). As Marshall (1983) explains, the technological development of the industry resulted in two main trends in the industry: firstly, the tendency of new technologies to favor the development of large manufacturing printing and small specialized shops at the expense of the medium-sized general printer; and secondly, the restructuring of the printing industry within the much wider information industry. Also the publishing side of the industry became even more concentrated during the period. In 1983, the three largest media groups controlled 83 percent of the Sunday newspaper market and 75 percent of the national daily newspaper market (Ojala & Uskali 2005). Finally, a trend that also contributed to the evolution of the industry during the period was that many foreign firms acquired UK printing and publishing industry firms.

The period from the beginning of the 1990s to 2005 started with a recession in the UK economy, and the total sales and output of the industry dropped significantly. The rest of the decade was characterized by a slow growth in the output. Finally, during the first years of the 21st century, the industry output declined. The number of firms, in contrast, continued to grow until the end of the 1990s and declined since then. With regard to the number of employees, **Figure 5-32** indicates that after the recession in the early 1990s, the number of employees increased strongly during the mid-1990s, remained stable for the end of the decade and decreased since that time. Even in the segment related to the printing and publishing of newspapers and periodicals, the number of employees grew during the 1990s and remained stable since then.

The technological change in the industry also continued during the period, and the growth of the electronic media, in particular in the form of the internet, toughened the competition between the printed media and other media. However, it seems that the newspaper segment of the industry did not suffer much of the increasing competition. The total circulation of paid-for and free newspapers actually remained at around 170 million copies per week in 1975, 1995, and 2002 (Tunstall 2004). The increased competition, however, increased the polarization between down-market tabloid newspapers financed by sales revenue and up-market broadsheet

newspapers funded mainly by advertising. It was the mid-market newspapers which suffered the greatest sales losses already since the 1950s (Tunstall 2004). A similar kind of polarization and concentration development is still also taking place in the printing side of the industry. The large firms are growing, the small firms are managing to survive, and it is the medium-sized firms that are exiting the market (European Comission 2007).

With regard to the consumption of the UK industry of printing and writing papers, **Figure 5-34** presents the consumption of the industry by both absolute and per capita figures. As the figure reveals, the printing and writing paper consumption of the industry has increased for the whole analysis period, although most of the growth has taken place after the end of 1980s, both in absolute and per capita terms. This pattern is somewhat against the consumption patterns of the Finnish and Swedish industries. During the first years of the 21st century, the growth seems to have ceased, however. At its highest, in the early 2000s, the absolute consumption of the UK industry was some 7 million tons of paper. The per capita consumption at the same time was some 120 kg (also at its highest), corresponding to the per capita consumption in the two Nordic countries.

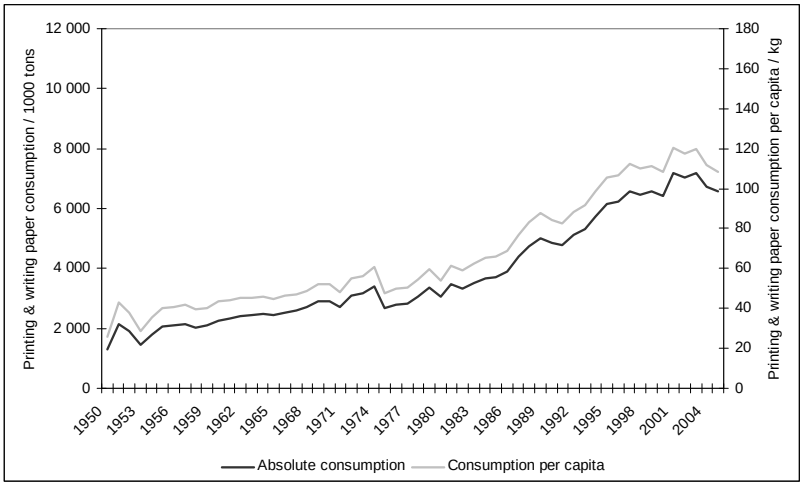

Figure 5-34: Printing and writing papers consumption of the UK printing and publishing industry in absolute and per capita terms, 1950-2006.

As a consequence, the evolution of the printing industry in the UK has followed very a similar evolutionary trajectory as its Swedish and Finnish counterparts. The main differences are related to the concentration and integration development of the industry, starting already in 1960s, and the rather strong role of foreign firms as owners of UK firms. Currently, despite the fact that there are still a large number of firms in the industry, both its

printing and publishing sides are dominated by a small number of large-sized firms.

5.9. Paper and pulp industry in Germany

The first hand paper mill in Germany was founded in 1390, and in the end of the sixteenth century there were already 190 hand paper mills in operation (Krawany 1910; Salzman 1911). However, the growth of the industry was slow until the industrialization of the country. In the course of the industrialization, Germany became the leader of the second industrial revolution with its highly competitive chemical and electric industries and its net national product triplet (Owen 2000). The paper manufacturing industry started its industrialization soon after the modern paper machine was invented, also around the beginning of the 1870s.

The growth of the industry from the industrialization to the First World War was considerable: the total paper production increased from 400 000 tons in 1875 to 2.2 million tons in 1908[25] (Turunen 2009). Germany was one of the major paper production countries already in 1875, and during the period 1875-1913, the industry accounted for some 30 percent of paper production in Europe. According to figures by Munsell & Henry (1980), in 1875 there were 423 paper mills in Germany with annual production of 182 880 tons of paper, against 274 mills with the same amount of production in the UK, and 404 mills with the production of 150 356 tons in the US.

The era after the First World War was highly unstable in Germany, characterized by hyperinflation and later the Great Depression. This also affected the German paper industry, which lost its position as the leading paper producing industry in the world. During the two world wars, the industry was also characterized by a large number of cartels, controlling much of the output of the industry (cartels were also important before the First World War). Additionally, the industry became increasingly dependent of imported pulp wood during the period (Turunen 2009).

The period of analysis in this study starts after the Second Word War, which negatively affected the German economy, and after which the country was divided to two parts, West and East Germany. The focus of the following analysis is, in particular, on the evolution of the paper industry in West Germany, due to the problems of availability of data for East

[25] The increase in the production was even higher during 1847-1875: the growth in production was 2 000 percent.

Germany. However, after the unification of West and East Germany in 1990, the data mainly covers both countries. **Figure 5-35** first presents a chart of important evolutionary trends contributing to the evolution of the industry since the 1950s. **Figure 5-36** next presents the number of firms in the industry since 1950 based on two sources: the official statistics of the country and industry directories. **Figure 5-37** then presents the number of employees in the industry, **Figure 5-38** the amount of total paper and board production, imports, exports, and paper and board consumption in the country, and **Figure 5-39** the GDP of the country.

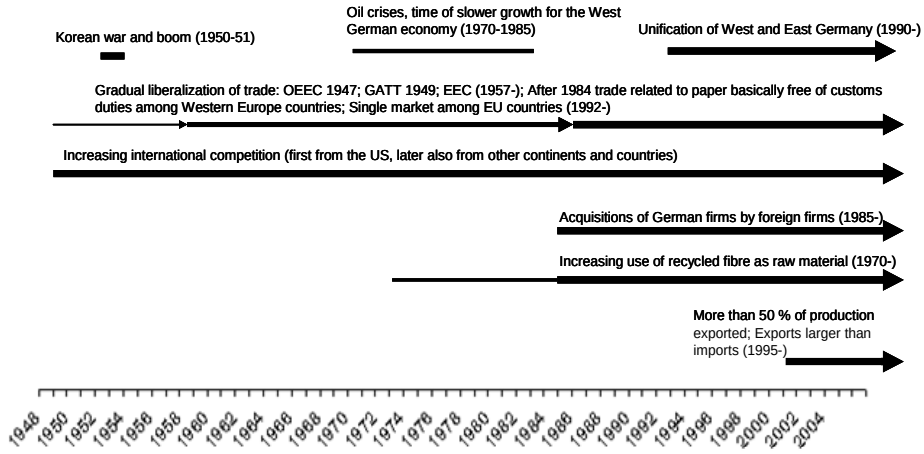

Figure 5-35: Chart of the evolution of the German paper and pulp industry, 1950-2005.

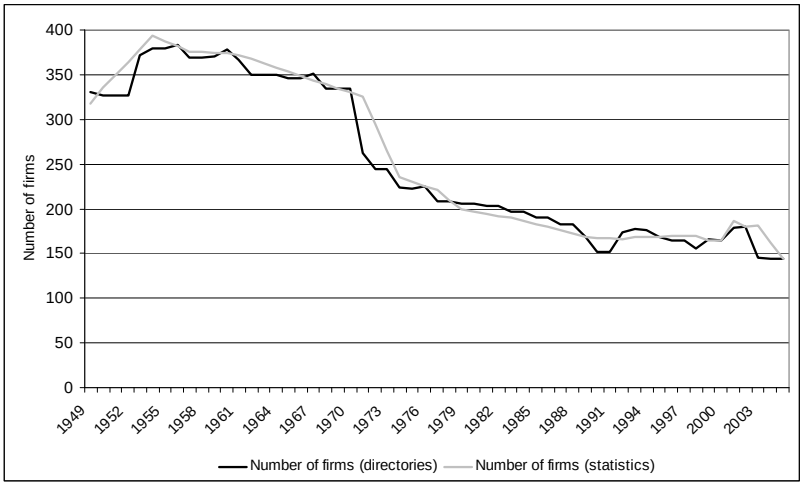

Figure 5-36: Number of firms in the German paper and pulp industry based on (i) industry directories (Phillips paper trade directory) and (ii) official statistics of Germany, 1949-2006.

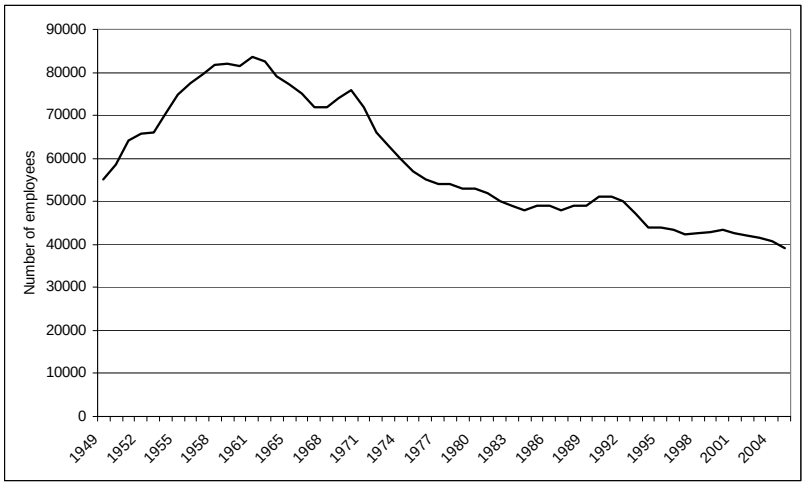

Figure 5-37: Number of employees in the German paper and pulp industry, 1949-2006.

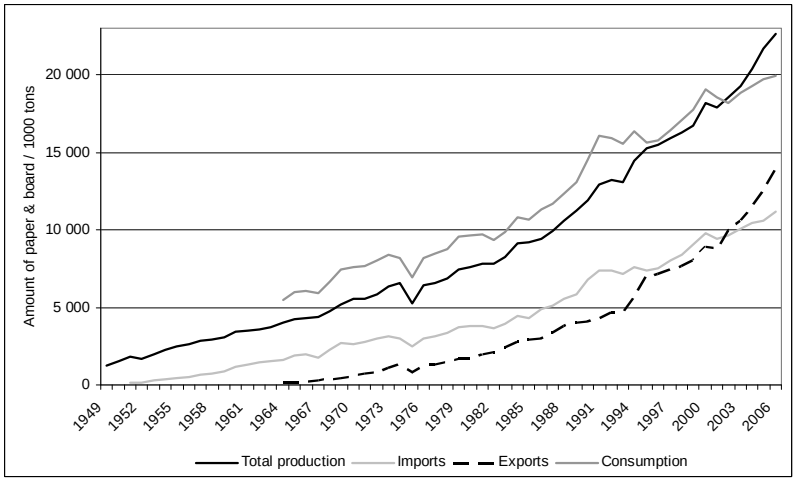

Figure 5-38: Amount of paper and board produced by the German paper and pulp industry (1949-2006) and amount of paper and board exports, imports, and total consumption in the German market (1964-2006).

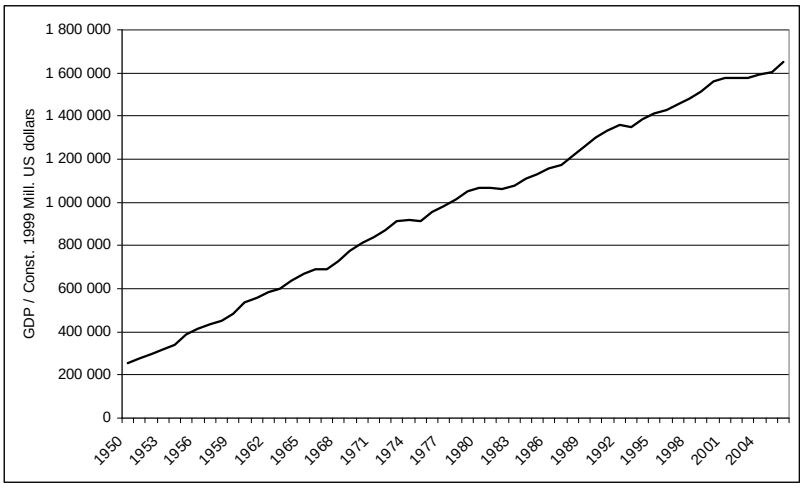

Figure 5-39: Gross domestic product of Germany, 1950-2006.

The period from the beginning of 1950 until the first oil crisis at the beginning of the 1970s was an era of high growth for the West German economy, referred to as the West German 'economic miracle' in later literature (e.g. Owen 2000; Tipton 2003). As indicated by **Figure 5-39**, the GDP of the country grew at the rate of over 5 percent per year during the period. This growth has been often attributed to Germany's excellent endowment of key natural resources, the backlog of technology which had lain fallow since the Depression, and the very rapid growth in world trade (Tipton 2003). The investment ratio in the country was also very high during the period. Much of the investments went into the production of consumer durables, especially automobiles (Tipton 2003). Additionally, the government considered promotion of competition as a high priority. The prevalence of cartels and tariffs was seen as one of the principal causes of the malfunctioning of the German economy under the Weimar Republic (Owen 2000). Therefore, West Germany was from the beginning an enthusiastic proponent of free trade, and was the pace-setter in European trade liberalization. Already during the 1950s, the average level of tariff protection was reduced from 19.6 percent to 10.6 percent. The establishment of the EEC in 1957 resulted in further reduction of tariffs (Owen 2000).

The factors contributing to the growth of the German economy during the decades after the Second World War, affected the growth of the paper industry in the country considerably. The total paper production increased from 1.5 million tons in 1950 to 6.4 million tons in 1973. Most of the paper was sold in the domestic markets. The volume of paper imports also increased during the period. In 1950, the paper imports were 6 percent of

the consumption, but in 1973 the share of the imports of the total consumption already exceeded 37 percent. The openness of the country to paper imports has been later seen as a highly positive factor for the competitiveness and growth of the industry: "The German paper industry was confronted at a very early stage with international competition in its home market and – in order to survive – was forced to invest heavily in the modernization and rationalization of the existing machines which remained after the war" (Owen 2000: 169). EEC membership in particular also allowed the industry to get hold of the growing paper consumption in the neighboring countries. Although the share of exports of the total production was still low during the period, the amount of exports was growing constantly.

As **Figure 5-36** indicates, the number of paper producing firms in the country increased during the early 1950s, most probably as a consequence of the Second World War. According to the data sources, the number of firms reached its maximum in the middle of the 1950s, and thereafter decreased. The number of employees in the industry grew until the end of the 1950s, reaching the level of 83 000, after which it also started to decline, being 63 000 in 1973. The focus of the firms in the industry was on paper production and much of the pulp was imported. For example, in 1950 almost 60 percent of the pulp used by the industry was imported (Turunen 2009). This was at least partly due to the low availability of forest resources in the country at the time. However, the trend of importing pulp has continued until the end of the analysis period.

The considerable economic growth of the country ended at the first oil crisis at the beginning of the 1970s. The growth in Germany averaged less than 2 percent per year from 1971 to 1986, and the total output actually declined in 1975, 1981, and 1982. During the time period, firms started to face higher prices for raw materials and energy, especially oil, and the relatively easy gains from exploiting the backlog of technical innovations and from shifting workers from agriculture to industry had been exhausted (Tipton 2003). In general, however, West Germany suffered much less during the period than the other western European countries or the United States. Despite the one million ton decrease in the paper and board production in 1975, the growth of the German paper and pulp industry continued until the beginning of the 1990s. In 1990, the output of the industry already exceeded 12 million tons (meaning that the production had doubled since the early 1970s). The number of firms in the industry continued to decrease for the whole period, but at a slower rate than in the early 1970s, during which more than 100 firms quickly disappeared from the industry. The number of employees also decreased during the 1970s.

During the 1980s, however, the number of employees remained at a relatively stable level and even increased somewhat in the late 1980s. Thus, during the period, the industry experienced a structural change from rather small-scale firms to larger units with higher productivity[26].

Starting from the middle of the 1980s, when the free trade area among the EEC countries was a reality and after the plans for the common market in the EEC member countries in the early 1990s were announced, the German industry became a target of an increasing number of international acquisitions. In particular, paper and pulp firms in the Nordic countries and North America wanted to secure their positions in the second largest paper product market of the world. The increasing use of recycled fiber as the raw material of paper contributed to this development. This is simply because paper from recovered fiber is most efficiently produced as close to the source of the raw material as possible (Hazley 2000). In Germany in particular, the collection of paper and the use of recovered fiber has a long history, as it not only helped conserve forest resources and reduce the imports of virgin fiber, but also placated the recycling concerns of the environmentally conscious consumers (Hazley 2000).

The growth period of the 1980s ended in the early 1990s, when the growth of the German economy, and also the growth of the paper industry stagnated. The unification of West and East Germany in 1990 was one of the factors contributing to this development. The GDP, as indicated by **Figure 5-39**, soon started to increase again until the beginning of the 21st century, during which the growth of the German economy was negligible. Similarly, the growth of paper consumption (as indicated by **Figure 5-38**) was at first slow until the middle of the 1990s, then grew considerably during the second half of the 1990s, after which growth in paper consumption was rather negligible. This development is not, however, reflected in the production figures of the paper and pulp industry. After a short zero growth period at the beginning of the 1990s, the total output of the industry increased from 13 million tons in 1993 to more than 22 million tons in 2006. What explains the growth of the total output is mainly the growth in paper exports. Since the middle of the 1990s, the industry exported more than 50 percent of its total production. Additionally, the volume of exports exceeded that of imports starting from the middle of the 1990s. Thus, since 1995, the German industry can be characterized as a net exporter of paper.

[26] However, in comparison to the structural change that took place in Finland and Sweden during the period, the change in the German industry was rather small scale (see earlier chapters but also e.g., Järvinen et al. 2009).

The trend of foreign firms entering the German paper and pulp industry continued during the period from 1990 to 2006. The increase in the number of firms operating in the industry in the early 21st century, as indicated by **Figure 5-36**, is probably an indication of this. Currently, the industry is controlled by a number of paper and pulp industry multinationals, originating in the Nordic countries and North America. The multinationals include International Paper, Sappi, Stora Enso, UPM, SCA, and Myllykoski (Hazley 2000). Already in 1997, only one of the six German firms ranked in the world's 150 largest paper firms was actually German (Hazley 2000).

With regard to the production profile of the German industry and changes that have taken place in it since 1950, **Table 5-5** and **Figure 5-40** describe the share of different type of products in certain cross-cutting years and the production figures of the total paper and board, newsprint, and printing & writing papers, respectively. As the table and figure indicate, during the period, different types of printing and writing papers became the most important product group of the industry. The share of newsprint production of the total production remained at the very same level during the time period. Similarly, particularly after 1990, the share of different types of packaging materials has remained relatively stable.

In conclusion, the paper industry in Germany has experienced a considerable growth during the last fifty years. The most important factor contributing to this development has been the growth of the economy and population in Germany. Currently, the German industry is the fourth largest in the world; the total amount of paper production of the industry exceeds 23 million tons. Despite the large home market, the industry is, however, a net exporter of paper. In 2006, it exported more than 60 percent of its production. Although the industry is still characterized by a relatively large number of firms (many of them being rather small-sized), the largest firms in the industry are owned by foreign multinational paper and pulp industry firms.

Table 5-5: The share of main paper and board grades of the total paper and board production of the German paper and pulp industry in cross-cutting years 1950-2005.

	1950	1960	1970	1980	1990	2000	2005
Newsprint, %	11	7	7	8	10	10	10
Printing & writing, %	18	23	34	38	40	41	37
Household & sanitary, %					7	6	6
Packaging materials, %					36	36	41
Other paper & board, %	71	70	59	54	7	7	6
Total, %	100	100	100	100	100	100	100

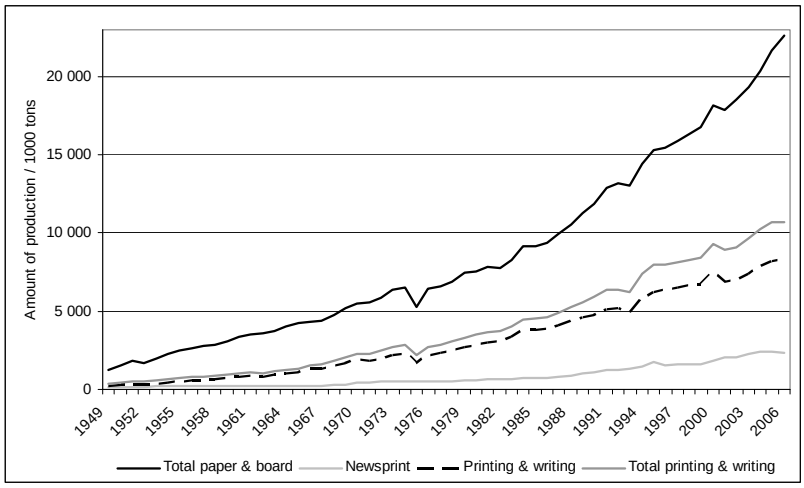

Figure 5-40: Production of total paper and board, newsprint, and printing and writing papers by the German paper and pulp industry, 1949-2006.

5.10. Printing and publishing industry in Germany

The first printing press was invented in Germany in the mid-15th century and the art of printing soon spread all over the country (Steinberg 1996). It was also Germany where the first regular newspaper started to be published at the beginning of the seventeenth century (Sandford 1976). During the nineteenth century, the industry grew considerably, and already at the end of the century there were, according to the Census of Industry of Statistics Germany, already almost 9 000 printing presses in the country, employing over 100 000 employees. Most of these were very small, however. Four thousand six hundred of the presses employed less or equal to five employees. Despite the unfavorable political climate that prevailed for much of the nineteenth century, the mass press had also already been formed in the country before the end of the century and it was particularly the newspaper industry that developed rapidly (Sandford 1976). By the end of the century, the number of newspaper publishing establishments equaled 1 750, and the number of newspaper titles was some 3 500 (Sandford 1976).

During the first half of the twentieth century, the country was hit hard by the two world wars and economic depression. Due to the differences in the methods used by Statistics Germany in counting the number of firms and employees in the industry during the period, it is, however, difficult to gain an overall picture of the evolution of the industry. Notwithstanding this, according to industry statistics, in 1907 the number of establishments in the whole printing and publishing industry equaled some 15 000, in 1925

11 700, in 1933 14 400, and in 1939 already 23 200. The number of employees equaled 170 000 in 1907, 270 000 in 1925, 240 000 in 1933, and 300 000 in 1939. As the methods and categorizations were rather similar during the 1930, it appears that at least during 1930 (after the Great Depression and before the Second World War), the industry grew considerably. This was despite a process of 'Gleichschaltung' (elimination of opposition) during the Third Reich, which affected all printing media, and many of the publishers had to leave the market (Sandford 1976).

During the first half of the century, it seems that most of the printing and publishing firms were very small in size, and the few large firms employed a large share of the employees, implying that the industry was very concentrated. For example, in 1907, 7 077 establishments (53 percent of the total) employed less than six people, and the share of 700 establishments (five percent of the establishments) that employed over 50 people of the total employment was 44 percent. Similarly, in 1933, there were 18 800 establishments (75 percent of the total) that employed less than six people and the share of 200 establishments (0.7 percent of the total) that employed over 200 people was 54 percent.

Turning to the analysis period of this study, **Figure 5-41** first presents the number of firms in the printing and publishing industry since 1950[27], **Figure 5-42** the number of employees, and **Figure 5-43** the inflation adjusted total revenue of the firms in the industry. I do not present a figure describing the general evolutionary trends that have affected the industry during the last fifty years, because, in general, the evolution of the industry has followed the same patterns as the UK industry (see **Figure 5-30**). It is also important to note that the figures cover the whole printing and publishing industry. This is because the industry statistics do not permit the division of the industry into smaller segments before the mid-1990s. Additionally, I focus only on the evolution of the industry in West Germany; notwithstanding re-unification, the figures after 1990 also cover only West Germany.

[27] These statistics cover only firms with more than 10 employees. Thus, the figures are very different from those before the Second World War.

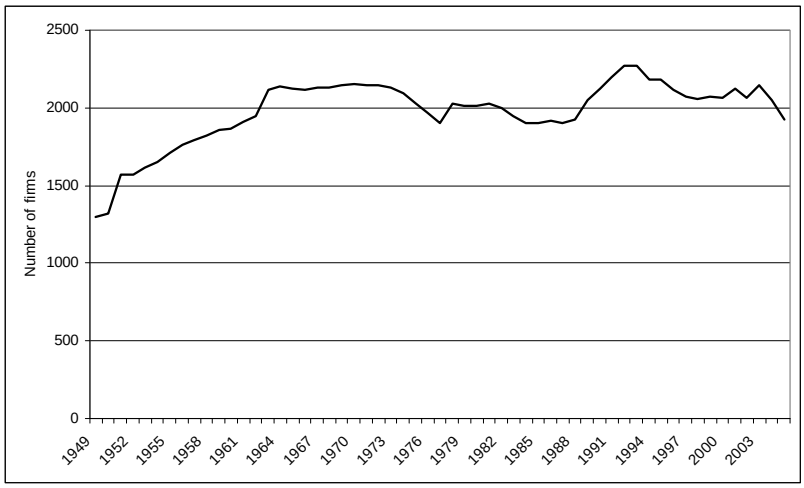

Figure 5-41: Number of firms in the German printing and publishing industry, 1949-2006.

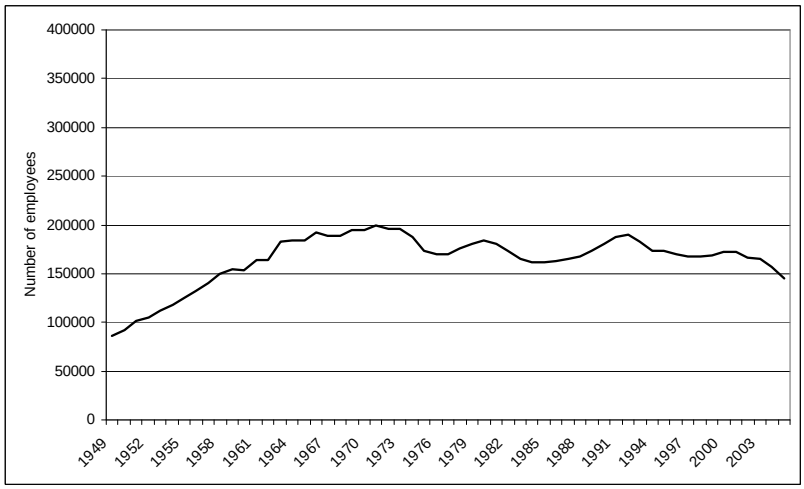

Figure 5-42: Number of employees in the German printing and publishing industry, 1949-2006.

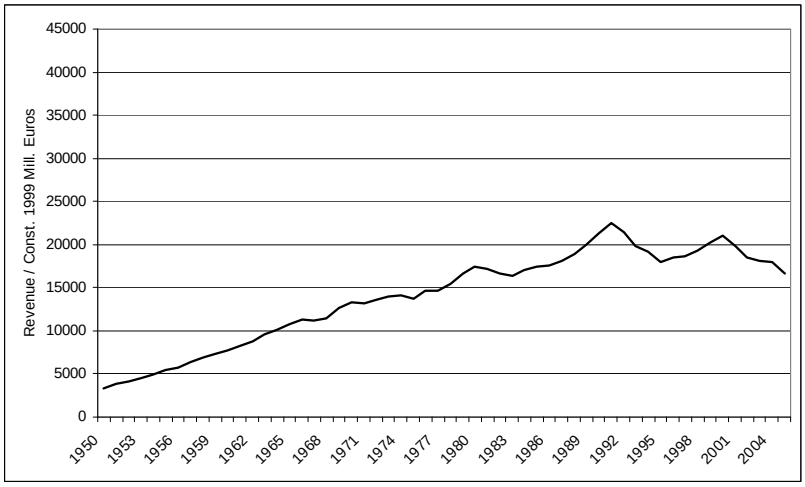

Figure 5-43: Total revenue of the German printing and publishing industry in constant 1999 million Euros, 1950-2006.

After the Second World War, Germany was divided to two parts, West and East Germany, and major changes took place in the economy and institutions of both new countries. For example, in West Germany, starting from 1945, the Allies introduced a completely new media system in the country (Sandford 1976; Meyn 1996; Kleinsteuber 1997; 2004). As a result, the current mass media of the country is almost solely a product of the post-war years. The press was to be introduced under a system of licenses, and all former newspaper owners had to be excluded from press activities. Within four years, the number of these licensed papers was 170. In 1949, when newspaper rationing ended, Germany quickly reacquired an extremely lively press (Sandford 1976; Meyn 1996; 2004). Within one year, 600 papers came into being, although the majority of circulation remained with the papers established by the occupying powers. However, many of the smaller papers were really one paper with different titles for its various local editions. Therefore, in 1954, it was possible to claim that Germany had either 1 500 papers or 225 separate 'editorial entities' (Smith 1979).

The period from 1950 to the early 1970s was an era of considerable growth for the West German economy (often referred to as the economic miracle). The growth of the economy also meant considerable growth for the printing and publishing industry, as indicated by **Figure 5-43**. Despite the early 1960s, the total revenue of the industry grew steadily and, in total, more than quadrupled during the period. Similarly, the number of firms with more than 10 employees increased from 1 300 in 1950 to over 2 100 in the early 1960s, and remained at the same level for the rest of the period. The number of employees also quickly increased during the 1950s, then

grew more unevenly during the 1960s, and reached its maximum level of 200 000 in the first years of the 1970s.

Starting from the 1960s, the development in printing technology resulted in an era of technological change in the industry (continuing until the current date). In general, the German industry was at the forefront of this technological change, because the country had already had a highly successful 'printing cluster' for a long time, covering firms manufacturing printing presses and inks, but also paper machines, among others (Porter 1990; Hazley 2000). As in the other countries, television broadcasting, which started in Germany in 1954, toughened the competition between the printed media and other media. This was also one of the factors contributing to the concentration development of the industry, starting especially from the mid-1960s onwards. According to Kleinsteuber (1997), the greatest steps in the concentration in the printing media followed the general recession in 1966-1967 and 1973-1974.

The industry statistics of the country also indicate that the level of concentration of the whole industry may have increased somewhat, starting actually already in the mid-1950s. In 1955, the share of the 130 firms employing more than 200 employees (two percent of the firms) was 30 percent of the total employment, and in 1970 the share of the 210 firms employing more than 200 employees (three percent of the firms) was 41 percent. For the whole period, however, most of the firms were very small in size[28]. The decrease in the editorial units of newspapers also gives some indication of the concentration process. As already mentioned, in 1954 there were some 1 500 papers with 225 editorial units, but already a decade later the number of editorial units was down to 183, although the number of titles had only decreased by some half a dozen. By the end of 1970, the number of editorial units had further decreased to 143, with the total number of titles reduced to 1 330. Finally, by 1975 there were only 120 independent editorial units left in the country (Smith 1979). Only the circulation of daily papers increased over the years – from 13.4 million at the end of 1954 to 18.2 million in 1974. Only one firm, Springer, had at the beginning of the 1970s a 27 percent share of the daily newspaper market of the country (Smith 1979; see also, Meyn 1996; Meyn 2004).

Following the general trend in the overall economic growth of the country during the period from the early 1970s to 1990, the growth in the revenue of the printing and publishing industry was rather unstable. Although the growth in the revenue of the industry equaled 50 percent during the period,

[28] Again it is important to note that the statistics only cover firms with more than 10 employees. If the smallest firms were also included in the figures, the number of small-sized firms would probably be much higher.

the growth was far behind the figures for the earlier period. As **Figure 5-41** indicates, the development in the number of firms was also unstable during the period, with ups and downs. The number of firms in 1990 was, however, higher than in the early 1970s, mostly due to the rapid growth in the late 1980s. Similarly, the development in the number of employees was unstable during the period. However, the growth in the number of employees in the end of the 1980s raised the figure rather close to its maximum level.

The main trend characterizing the evolution of the industry during the period, contributing considerably to the structure of the industry, was the rapid technological change. In general, the technological change favored the development of large-scale printing, and the concentration of the industry continued. Although the figures produced by industry statistics are not fully comparable with those presented for the earlier period, they suggest that in the mid-1980s the firms employing more than 200 employees had 45 percent of the total employment of the industry. In particular, the publishing side of the industry showed considerable concentration. For example, in 1989 the largest ten publishing groups represented 54.8 percent of the total circulation of newspapers in the country. As explained by Kleinsteuber (1997), the structure of the printed media was at the time characterized by a high number of titles, many strong local newspapers, only a few national papers, a great number of magazines, a dependency on advertizing incomes, and a high degree of economic concentration.

In the period from 1990 to 2005, the German economy continued to grow, although the growth rate was slower than earlier (in particular, during the first years of the 21st century). The same cannot be said of the printing and publishing industry. In the early 1990s, the total revenue of the industry decreased considerably, then grew during the rest of the 1990s, but steadily declined since then. In any case, the industry did not reach the top revenue levels of the end of the 1980s during the period. The trend in the number of firms was also downwards, despite some ups and downs. The same applies to the number of employees. The causes behind this development were the same as in the other countries: the hardening competition coming from different forms of electronic media, affecting especially the newspaper market. Otherwise, the industry was characterized by similar trends as in the earlier periods. In particular, the concentration development of the industry continued (European Comission 2007).

Finally, with regard to the printing and writing paper consumption of the German industry, **Figure 5-44** presents the consumption in both absolute and per capita terms for the considered time period. As the figure indicates, the consumption of the industry increased rather steadily until the end of

the 1980s, after which the growth rate in demand started to slow down. The consumption of the industry was at its highest in the end of 1990s and the early 2000s, being some 9 million tons. The decline in per capita consumption since the mid 1990s may be explained simply by the fact that the population of East Germany was included in the per capita figures starting from the mid-1990s. However, according to the figure, the consumption in per capita terms was its highest in the mid-1990s and equaled some 120 kg (being in line with the three other industries and countries).

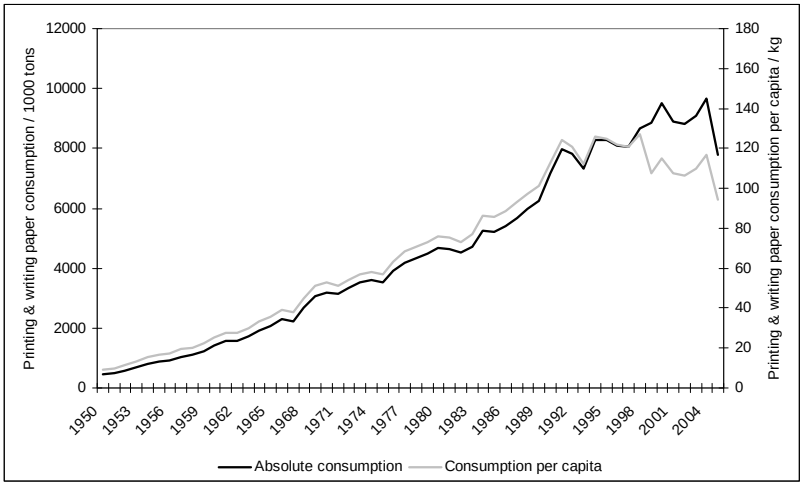

Figure 5-44: Printing and writing papers consumption of the UK printing and publishing industry in absolute and per capita terms, 1950-2006.

As a conclusion, the evolution of the German printing and publishing industry experienced considerable growth during the period of 1950-1990. Since then, the total revenue of the industry has actually declined. In general, the industry has been characterized by very similar trends as the respective industries in the three other countries: rapid technological change, considerable concentration (although most of the firms in the industry are still very small), and competition from different forms of electronic media.

5.11. Ecological interdependences between the paper & pulp and printing & publishing industries

This section commences an analysis of the ecological interdependences between the considered industries. As suggested by the framework

constructed in the theoretical part of the study, two basic types of interdependences may exist between two niche dimensions of two organizational populations: type 1 interactions between two same niche dimensions, and type 2 interactions between two different niche dimensions. The niche dimensions may be related to different types of resources, such as product markets, technology, labor, input resources, financing, or different aspects of identity. An apparent interaction between the studied industries is that of type 2 interaction between the niche dimensions related to the product market from the perspective of the paper and pulp industry, and input resource from the perspective of the printing and publishing industry. Depending somewhat on the product range of the paper and pulp industry in question, the printing and publishing industry is the largest coherent customer of the paper products manufactured by the paper and pulp industry.

Starting from the birth of both industries, the growth of one industry has reinforced the other. For example, in the late eighteenth century, and especially the first half of the nineteenth century, paper was clearly an important restricting factor in the growth of the printing industry. The first restricting factor was related to the process of paper making: before the invention of the modern paper machine in the beginning of the nineteenth century, the paper making process was a time-consuming and labor-intensive process, making it possible to produce only a rather low quantity of paper (Krawany 1910; Coleman 1958). After the invention of the Fourdrinier machine, the restrictive factor in paper making soon became the availability of the most important raw material of paper at the time, rags (e.g. Twyman 1998). The change of the raw material for paper to wood, from the mid-nineteenth century onwards, removed this restriction (Steinberg 1996). Although paper was not as important restricting factor for the growth of the printing and publishing industry during the twentieth century, the growth of the printing and publishing industry has still been highly dependent on the growth in the paper production capacity of the paper and pulp industry, contributed to by technological developments in the paper producing technology. The paper producing capacity of the industry has actually exceeded the demand of the printing and publishing industry only during the last decades (Diesen 2007).

Paper has also always been the most important cost component of the printing and publishing industry firms, although the role of other raw materials, such as printing ink or labor should not be underestimated. However, for example in 2006, paper accounted for 53 percent of the costs of the European printing industry firms (European Commission 2007). In the Finnish industry, for which data of the cost structure of the printing and

publishing firms is available for a longer period, paper formed some 90 percent of the raw material costs of the printing firms during the 1940s. Still during the 1950s and 1960, paper accounted for 80-85 percent of the total value of the raw materials of the printing firms. During the 1970s, the role of paper somewhat diminished, accounting for less than 70 per cent of the value of the raw materials. However, during the 1980s it again increased to almost 70 per cent (Landgren 1992).

Of course, the requirements of the printing and publishing industry with regard to paper grades have also had important effects on the technological development in the paper industry. For example, during the last fifty years, many technological developments related to coated papers have been based on the requirements of the printing and publishing industry (Kettunen 2002). In a sense, it may be said that with regard to many products, it has been the printing and publishing industry that has demanded certain types of paper, and the paper industry firms have then responded to the demand by developing the required technology or by modifying old processes.

From the perspective of the earlier community ecology frameworks for analyzing interdependences between organizational populations (e.g. Aldrich & Ruef 2006), the ecological interdependence between the studied industries would clearly be of a symbiotic type: it is the resource dependence related to paper that creates interaction between the industries, located one after the other in the forest industry value chain. Although I also argue that it is paper that creates by far the most important interdependence between the industries, the framework of this study suggests that there may actually be several different types of interaction between two populations. It is, for example, possible to think of several different types of type 1 interdependences that may exist between the industries. First, labor might create interdependences between the industries: if the niche dimensions of the industries related to labor overlap, this may result in competitive interaction; or if the overlap related to the niche dimension is minimal, a mutualistic interdependence might be present. Similarly, if the niche dimensions related to some common raw material of the industries, let us say for example electricity, overlap, it may result in competitive interaction. A non-overlap might then again result in mutualistic interaction.

The important question to ask, however, is whether possible interdependences other than paper have any relevance in the current research context. At least on the basis of earlier literature on the evolution and history of the considered industries, the relevance of the other interdependences in the current context may be highly questioned. Even if other interdependences may be present, it is likely that the effect of the

interdependence related to paper would overrule all of them. Thus, this study focuses on the effects of type 2 interaction related to paper.

As suggested by Proposition 3.1 in the theoretical part of the study, typical type 2 interdependences related to resources have a positive effect on the vital rates of the organizational populations in question. With regard to the current research context, this proposition should also hold due to the almost constant growth of the studied industries during the research period.

If we now consider a paper & pulp and a printing & publishing industry, linked by paper resource flow, the following causal mechanism linking the viability of the industries in the form of the vital rates emerges. In the first place, the growing demand for the printing and publishing products drives the growth of the printing and publishing industry in question and results in the growth in the resource requirements for printing and writing papers. The growing resource demand, in turn, enables the growth of the paper and pulp industry in question. The growth of the printing and writing industry, however, would not be possible without increases in the production capacity of the paper and pulp industry. Thus, the growth of the two industries can be described to be mutually reinforcing: the paper and pulp industry would not be able to grow without the growth of the printing and publishing industry and vice versa. In ecological terms, the paper & pulp industry and the printing & publishing industry linked by the paper resource flow should have positive effects on each other's vital rates, leading to the following general hypothesis:

Hypothesis 1: *A paper & pulp industry and a printing & publishing industry linked by paper resource flow affect each other's vital rates positively.*

A short note of the relevant vital rates in the current research context is in place before continuing with more specific hypotheses. At least from the perspective of the studied paper and pulp industries during the research period (the perspective from which I test the hypotheses), the rate of new firm entry cannot be considered a relevant measure of the viability of the industries: due to the phase of life-cycle of the paper and pulp industries, the entry rates of new firms have been very low for the whole research period. The same applies to the rate of mortality. Although the number of firm exits has been high in every studied paper and pulp industry, the number of actual mortality events has been very low. Again, due to the basic characteristics of the industry, most exits have been either acquisitions or mergers, not conventionally counted as mortality events. What I argue then

in section 6.1.1 is that firm growth should be the most relevant measure of the viability of the paper and pulp industries during the research period.

5.12. Specific hypotheses of the interdependences between the two industries in the four countries

In this section, I will formulate hypotheses of the interdependences between the two analyzed industries in the four countries. The hypotheses will be largely based on a descriptive analysis of the paper resource flows between the industries. The descriptive analysis, for its part, is primarily based on statistical data of the production, imports and exports of different paper grades. In particular, I assume that two paper grade groups, newsprint and printing and writing papers, form much of the resource flows between the studied industries. Although the printing and writing paper group also includes paper grades not directly used in the printing and publishing industry, it seems that at least before the mid-1980s most of the paper from these two groups went directly into the printing and publishing industry. For example, in Finland for the time period 1954-1980, for which direct data of the amount of paper consumed by the Finnish printing and publishing industry is available, the figures are actually in line with the apparent consumption figures of newsprint and printing & writing papers calculated on the basis of the production, imports, and exports of newsprint and printing & writing papers (see Landgren 1992). However, particularly after 1990, the figures most probably exaggerate the actual paper flows to some extent. This is because printing and writing papers increasingly have also started to be used outside the printing and publishing industry.

The analysis and formulation of hypotheses proceeds as follows. I will start with analyzing the interdependences from the perspective of the paper and pulp industries. As the paper flows between the industries determine the strength of the interdependences between the industries and because the industries in different countries are potentially highly dependent on each other, it is not sufficient to analyze the interactions between the industries within a country, but also between the industries in different countries. Thus, I will analyze the interactions every considered paper and pulp industry has with every considered printing and publishing industry, and on the basis of that, formulate the relevant hypotheses.

I will first analyze the potential interdependences from the perspective of the Finnish paper and pulp industry and formulate the respective hypotheses. Next, I will continue with Sweden, the UK, and Germany. After

the analyses and hypotheses from the perspective of the paper and pulp industry, I will continue with the interactions from the perspective of the printing and publishing industries. I will start with the Finnish printing and publishing industry. The respective analyses and hypotheses from the perspective of the Swedish, the UK, and German printing and publishing industries follow.

5.12.1. Finnish paper & pulp and printing & publishing industries

As described in the section about the evolution of the Finnish paper and pulp industry, the industry has always been highly dependent on exports. In general, especially after 1950, the liberalization of trade within Western Europe, opening the large markets in Germany and the UK in particular, allowed the growth of the industry. The home market demand has always been in a rather small role for the Finnish industry. Taking into consideration that printing and writing papers (including newsprint) have formed an increasingly important share of the production of the Finnish industry (over 70 percent of the total production at the moment), the same argument applies to this product group as well.

Figure 5-45, **Figure 5-46**, and **Figure 5-47** offer evidence of the importance of the export markets for the Finnish industry. As the figures illustrate, most of the printing and writing papers produced by the industry have been exported since 1920. Except for the first half of the twentieth century and the time of the Second World War in particular, the Finnish printing and publishing industry has consumed only some 10 percent of the total production of the industry. During the early 21st century, the share of production consumed by the Finnish industry even decreased clearly below 10 percent of the total production.

In general, the UK and Germany have been the most important export countries for the Finnish industry, particularly after 1950. As indicated by **Figure 5-46**, the relative share of the two countries of the total exports has varied between 30 and 40 percent for most of the research period (being even almost 50 percent in the mid-1970s). The role of Sweden as an export country has, however, always been negligible. This is understandable considering the size of the Swedish market for printing and writing papers and the large export-oriented paper industry in the country. In total, the four printing and publishing industries considered in this study have consumed over 40 percent of the total production of the Finnish industry (even over 50 in the mid-1970s) since 1950, except for the last years of the analysis.

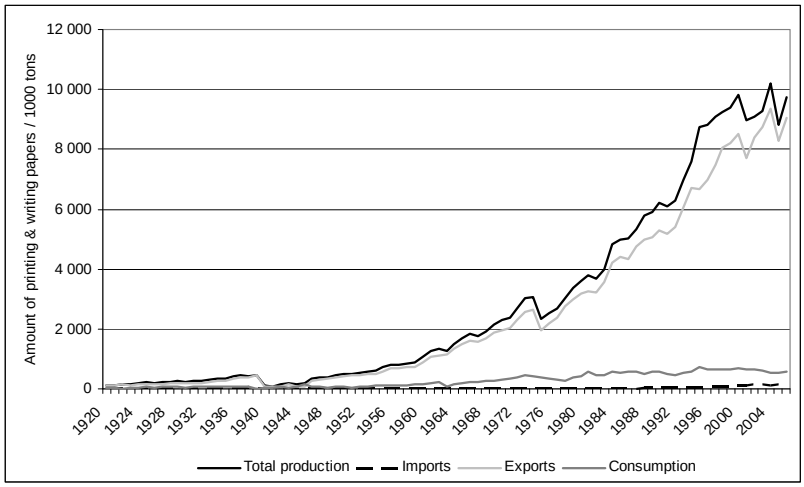

Figure 5-45: Production of printing and writing papers by the Finnish paper and pulp industry and the amount of imports, exports, and consumption of printing and writing papers in the Finnish market, 1920-2006.

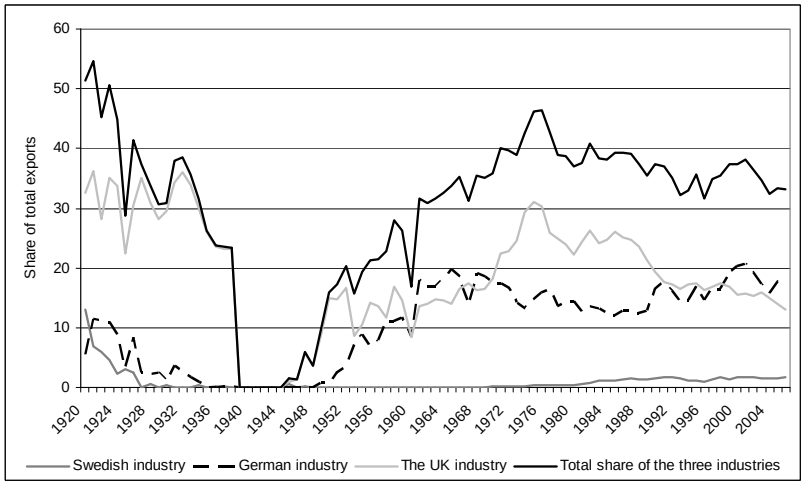

Figure 5-46: Share of the (i) Swedish, (ii) German, and (iii) UK printing and publishing industries of the total printing and writing paper exports of the Finnish paper and pulp industry, 1920-2006.

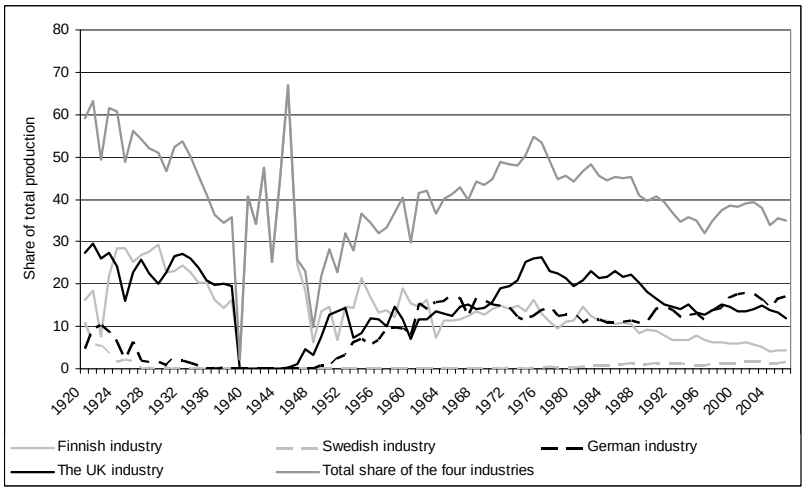

Figure 5-47: Share of the (i) Finnish, (ii) Swedish, (iii) German, and (iv) UK printing and publishing industries of the total production of the Finnish paper and pulp industry, 1920-2006.

UK printing and publishing has always been an important customer for the Finnish paper and pulp industry. The Finnish industry established a good position as a supplier of paper and pulp already during the inter-war period. After the Second World War (contributed to by the liberalization of trade), the printing and publishing industry in the country soon became the largest customer for Finnish printing and writing papers. In particular, during the 1970s and 1980s, over 20 percent of the total production of the Finnish industry was consumed by the UK printing and publishing industry. Although the share of the UK industry dropped to some 15 percent of the total production during the 1990s and the early 21st century, the UK market is still extremely important for the Finnish industry. One of the factors contributing to the decreasing share is the fact that Finnish firms started to acquire paper producing capacity from the UK market in the mid-1980s (as discussed previously), and currently produce a large amount of paper in the country. Thus, if the production capacity of the subsidiaries of the Finnish firms in the UK were considered, the role of the Finnish firms as suppliers of the UK printing and publishing industry would be even higher.

The German printing and publishing industry, the largest in Western Europe, has also been an important customer of the Finnish industry, in particular from 1950 onwards. Although Germany was a member of the other important trade association in Europe, EEC, the Finnish paper and pulp industry already established a strong position in the German printing and publishing market in the early 1970s, before the trade agreement with EEC (in a sense, the German market was even more open to Finnish paper

than the UK at the time). Starting from the early 1960s, the Finnish industry exported over 10 percent of its yearly production to the German market. During the 1960s, late 1990s and the first years of the 21st century, the German market was even more important to the Finnish industry than the UK market.

As a conclusion, it seems that although the Finnish printing and publishing industry has been an important customer of the Finnish paper and pulp industry for the printing and writing papers, the printing and publishing industries in the two most important paper exporting countries of the Finnish industry, the UK and Germany, have had a more important role for the Finnish paper and pulp industry. The role of the Swedish market has, on the other hand, been negligible[29]. Thus, when considering the ecological interdependences between the industries, it is evident that the Finnish industry has been dependent on all the three printing and publishing industries, but particularly on the German and the UK industries. Thus, I hypothesize as follows:

Hypothesis 2.1: *The Finnish, German, and UK printing and publishing industries have a positive effect on the vital rates of the Finnish paper and pulp industry.*

Hypothesis 2.2: *The effects of the German and UK printing industries on the vital rates of the Finnish paper and pulp industry are stronger than the effect of the Finnish printing and publishing industry.*

5.12.2. Swedish paper & pulp and printing & publishing industries

Similar to the Finnish industry, the Swedish paper and pulp industry has also always been dependent on paper exports. Although during the first half of the twentieth century it was actually North America that was the most important export market for the products of the Swedish industry, countries in Western Europe (Germany and the UK in particular) became the most important export markets of the industry after the Second World War. Although the share of the printing and writing papers of the total paper production of the Swedish industry has not been as high as in the Finnish industry, they have still formed some 50 percent of the total paper

[29] This does not imply, however, that the Swedish paper and pulp industry would not matter for the Finnish paper and pulp industry. In contrast, the Finnish and Swedish paper and pulp industries might be considered to have been competing on several markets, especially in Western Europe.

production. Thus, the printing and publishing industry may be considered an important customer for the Swedish industry.

Figure 5-48, **Figure 5-49**, and **Figure 5-50** offer evidence of the role of the four studied printing and publishing industries as the customers of the Swedish industry. As **Figure 5-49** first indicates, the share of exports of the total production has constantly increased since 1950. In 1950, over 50 percent of the total production was consumed in Sweden, but only 10 percent in the end of the period of analysis. Before the mid-twentieth century, however, and especially during the Second World War, the Swedish printing and publishing industry formed the most important market for the printing and writing papers produced by the Swedish industry. Since 1950, Germany and the UK became the most important export countries of the printing and writing papers. In general, Germany and the UK accounted for over 40 percent of the total exports of the Swedish industry during 1950-2005. The role of the Finnish printing and publishing industry as a consumer of the paper produced by the Swedish industry has been negligible.

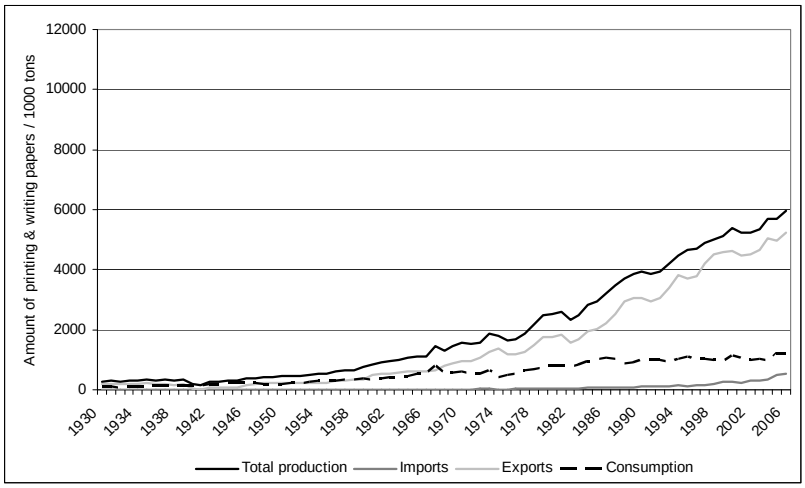

Figure 5-48: Production of printing and writing papers by the Swedish paper and pulp industry and the amount of imports, exports, and consumption of printing and writing papers in the Swedish market, 1930-2006.

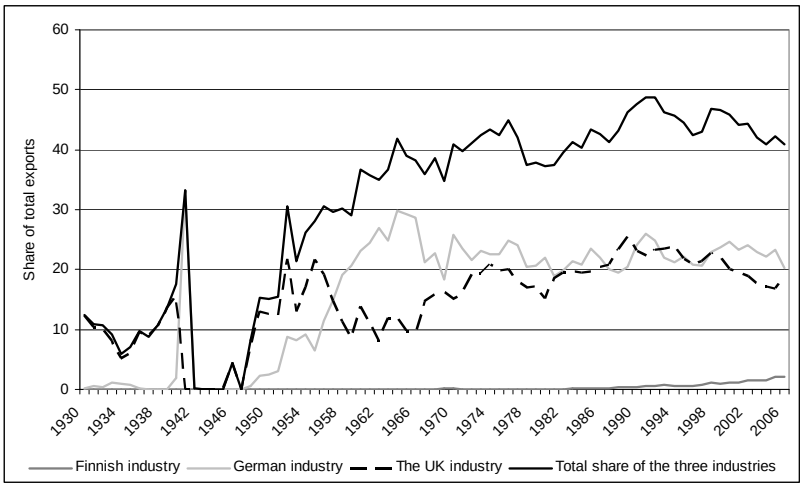

Figure 5-49: Share of the (i) Finnish, (ii) German, and (iii) UK printing and publishing industries of the total exports of printing and writing papers of the Swedish paper and pulp industry, 1930-2006.

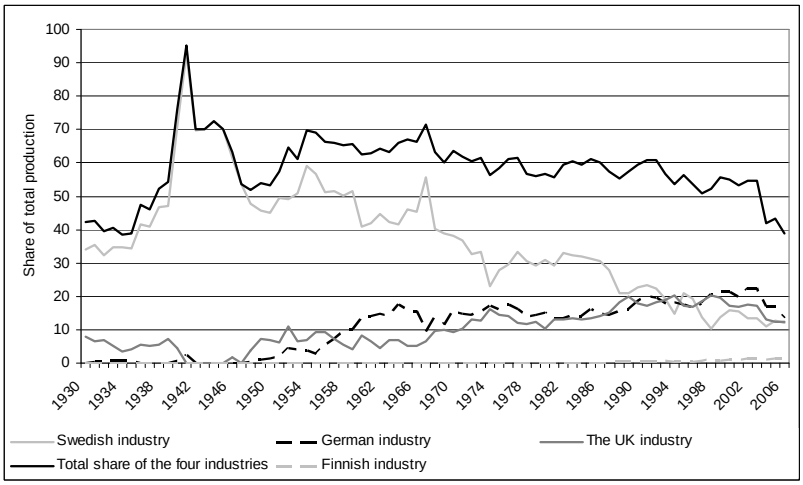

Figure 5-50: Share of the (i) Swedish, (ii) Finnish, (iii) German, and (iv) UK printing and publishing industries of the total printing and writing papers production of the Swedish paper and pulp industry, 1930-2006.

The role of the German printing and publishing industry as a customer of the Swedish paper and pulp industry strengthened quickly during the 1950s. In the early 1960s, the share of the German market was already 15 percent of the total production. Since then, the share of the German industry remained rather stable until the end of the 1980s, after which its share has increased to over 20 percent. The UK printing and publishing industry was already an important customer of the Swedish paper and pulp industry before the Second World War. After a drop during the war time, the share of the UK industry of the total production of the Swedish industry

rose to some 10 percent. Since the 1990s, its share has been some 20 percent, at the same level as the share of the German and Swedish printing and publishing industry.

Thus, although the Swedish printing and publishing industry has been the most important customer of the printing and writing paper produced by the paper and pulp industry, the role of the UK and Germany has been increasing since 1950. After 1990, the Swedish, German, and UK printing and publishing industries have had an equally important role as the customers of the industry. In general, the share of these three countries (Finland is actually also included in the figure, but its role is negligible) of the total production of printing and writing papers has varied from a little over 40 percent to 70 percent. In comparison with Finland, the role of the home printing and publishing industry has been more important especially in the 1950s, 1960s, and 1970s, but its importance has decreased steadily. As a conclusion, the analysis leads to the following hypotheses.

Hypothesis 2.3: *The Swedish, German, and UK printing and publishing industries have a positive effect on the vital rates of the Swedish paper and pulp industry*

Hypothesis 2.4: *The effect of the Swedish printing and publishing industry on the vital rates of the Swedish paper and pulp industry is stronger than the effects of the UK and German printing and publishing industries.*

5.12.3. German paper & pulp and printing & publishing industries

Figure 5-51, **Figure 5-52**, and **Figure 5-53** present statistical data of the interaction of the German paper and pulp industry with the four printing and publishing industries since 1950. As I mentioned above, Germany is currently the largest market for the printing and publishing papers in Europe, a position it established after the Second World War. As shown by **Figure 5-51**, the consumption of printing and writing papers of the German printing and publishing industry has also exceeded the production of the printing and writing papers of the German industry until the early years of the 21st century, and thus opened the market for imports (from countries like Finland and Sweden). Because the German industry has also exported much of the produced printing and writing papers abroad, accounting for over 50 percent of the total production after the mid-1990s,

imports have been in an important role in fulfilling the printing and writing paper needs of the German printing and publishing industry.

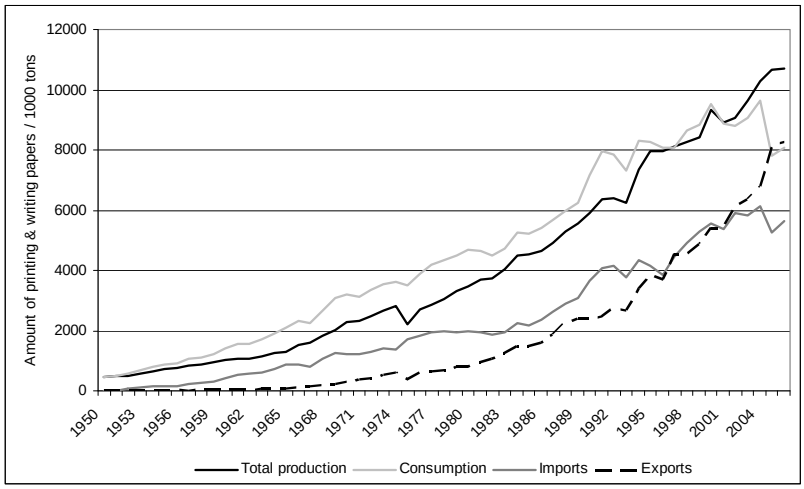

Figure 5-51: Production of printing and writing papers by the German paper and pulp industry and the amount of imports, exports, and consumption of printing and writing papers in the German market, 1950-2006.

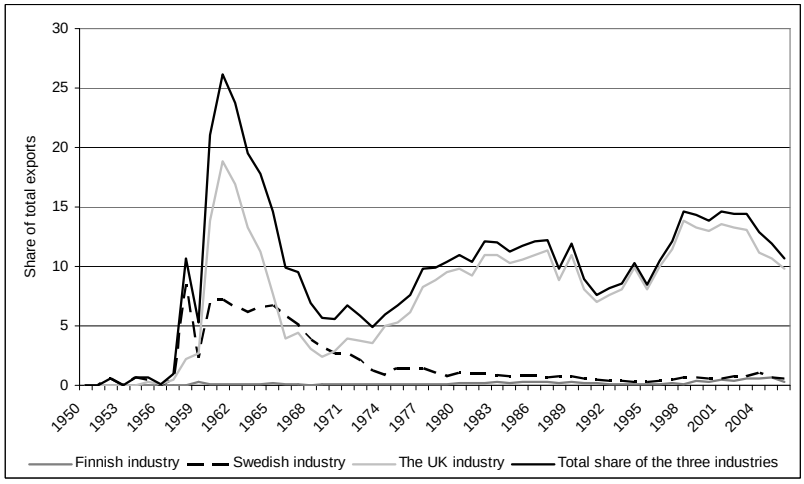

Figure 5-52: Share of the (i) Finnish, (ii) Swedish, and (iii) UK industries of the total exports of the printing and writing papers of the German paper and pulp industry, 1950-2006.

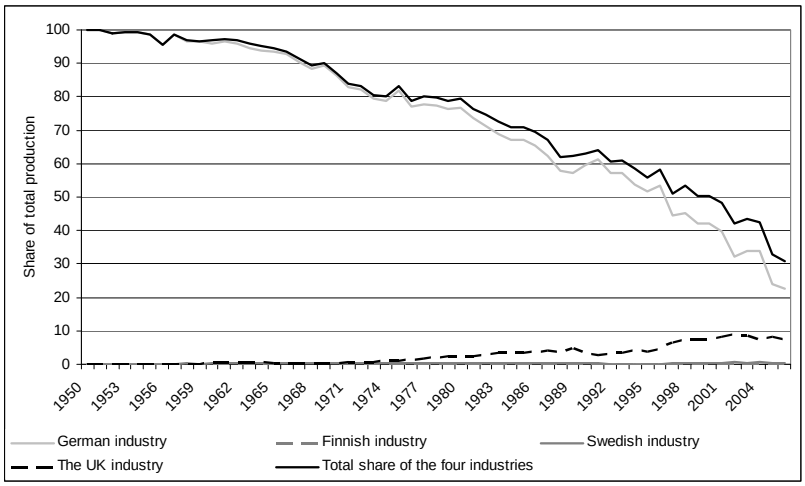

Figure 5-53: Share of the (i) Finnish, (ii) Swedish, (iii) German, and (iv) UK printing and publishing industries of the total production of the printing and writing papers of the German paper and pulp industry, 1950-2006.

As might be expected, the German printing and publishing industry has been the most important customer of the German paper and pulp industry with regard to printing and publishing papers for the whole period. The share of the total production consumed by the German printing industry has, however, decreased considerably during the last fifty years: from almost 100 percent in 1950 to 30 percent in 2005. The German printing and publishing industry is, nevertheless, still by far the most important customer of the printing and writing papers produced by the industry.

The role of the German paper and pulp industry as a supplier of the three other studied printing and publishing industries has been modest during the research period, at least in comparison to the German printing and publishing industry. In particular, the Finnish and Swedish printing and publishing industries have, for natural reasons, had a negligible role. The UK has, in contrast, had a larger role, especially starting from the 1970s[30]. The share of the UK industry of the total production of the German industry increased from one percent in the early 1970s to eight percent in 2005. One of the contributing factors to this development was the membership of the UK in the EEC from the early 1970s onwards.

Thus, the most important market for the German paper and pulp industry with regard to printing and writing papers has obviously been the German printing and publishing industry. The share of the German printing and publishing industry of the total production of the industry has, however, constantly declined during the analysis period. Of the three other

[30] Although the share of UK industry of the exports peaked in the early 1970s, the share of the industry of the total production stayed at less than one percent.

considered industries, only the UK has imported a significant amount of paper from German paper firms. However, even the role of the UK industry has been modest in comparison to the German printing and publishing industry. On this basis, I formulate the following hypotheses about the relationships between the German paper and pulp industry and the four printing and publishing industries.

Hypothesis 2.5: *The German printing and publishing industry has a positive effect on the vital rates of the German paper and pulp industry*

Hypothesis 2.6: *The effect of the German printing and publishing industry on the vital rates of the German paper and pulp industry decreases as a function of time.*

5.12.4. The UK paper & pulp and printing & publishing industries

Finally, with regard to the UK paper and pulp industry, **Figure 5-54** presents the amount of printing and writing paper manufactured by the UK industry, and the imports, exports, and apparent consumption of the printing and writing papers in the country. **Figure 5-55** presents the share of the UK and the three other printing and publishing industries of the total printing and writing paper production. The shares of the three other studied countries are combined because their share is very low in comparison to the UK industry. Additionally, I do not present a separate figure for exports to the three other countries due to the negligible volume of exports.

As discussed previously, the UK paper and pulp industry faced considerable challenges after 1950, mostly due to increasing international competition originating from the Nordic and also North American countries, which were able to manufacture paper with significantly lower costs compared to the UK paper and pulp industry. The increasing international competition was the result of the gradual liberalization of trade since the 1950s. As **Figure 5-54** illustrates, the total production of printing and writing papers by the UK paper and pulp industry decreased considerably during the 1970s and 1980s, but started to rise again during the 1990s (due to causes discussed previously). At the same time, however, the paper consumption by the UK printing and publishing industry increased considerably. Most of the paper was thus imported.

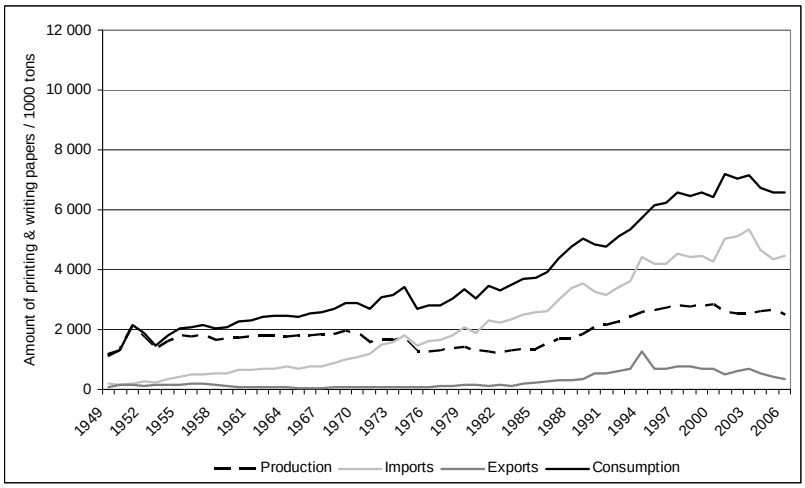

Figure 5-54: Production of printing and writing papers by the UK paper and pulp industry and the amount of imports, exports, and consumption of printing and writing papers in the UK market, 1949-2006.

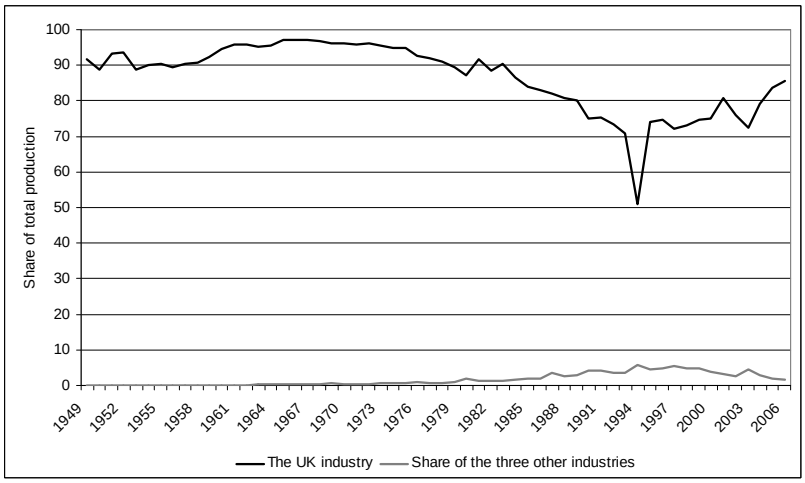

Figure 5-55: Share of the UK printing and publishing industry and the three other printing and publishing industries (Finnish, Swedish, and Germany) of the total printing and writing papers production of the UK paper and pulp industry, 1949-2006.

In general, the most important customer of the UK paper and pulp industry with regard to printing and writing papers has always been the UK printing and publishing industry. During the 1950s and mid-1980s, the industry accounted for over 90 percent of the production of the industry, and even during the rest of the period, the share of the industry remained at over 70 percent. This is, of course, understandable when considering the state of the industry, resulting in a low volume of exports. The three other considered industries (Finnish, Swedish, and German printing and publishing industries) have then understandably always had a negligible role as the customers of the UK industry.

With regard to the potential interactions between the UK paper and pulp industry and the four printing and publishing industries, the UK printing and publishing industry has clearly been the most important customer of the UK paper and pulp industry. The other three have had a negligible role as the customers of the industry. This leads to the following hypothesis.

Hypothesis 2.7: *The UK printing and publishing industry has a positive effect on the vital rates of the UK paper and pulp industry.*

5.12.5. Finnish printing & publishing and paper & pulp industries

Turning to analyzing the interactions from the perspective of the printing and publishing industries, **Figure 5-56** presents the total consumption of printing and writing papers by the Finnish printing and publishing industry, the amount of paper supplied by the Finnish paper and pulp industry, and the amount supplied by the three other studied paper industries. **Figure 5-57** then shows the relative share of the total consumption of the Finnish paper and pulp industry and the total share of the three other industries.

On the basis of the figures, it is obvious that the Finnish paper and pulp industry supplied almost 100 percent of the paper consumed by the Finnish printing and publishing industry until the early 1990s. Even from 1990 onwards, the Finnish industry has supplied over 70 percent of the consumed paper. The Finnish industry has imported only small quantities of special paper grades since the Second World War (Teollisuustilasto 1884-2006). The role of the Finnish paper and pulp industry as the only supplier of the Finnish printing and publishing industry is understandable, taking into consideration the size of the Finnish paper and pulp industry and the geographic location of Finland.

Thus, the Finnish paper and pulp industry may be considered as the only supplier of the printing and writing papers of the Finnish printing and publishing industry since 1920. The roles of the Swedish, the UK, and German paper and pulp industries as suppliers to the industry have always been negligible, even since 1990. This leads to the following hypothesis:

Hypothesis 3.1: *The Finnish paper and pulp industry has a positive effect on the vital rates of the Finnish printing and publishing industry.*

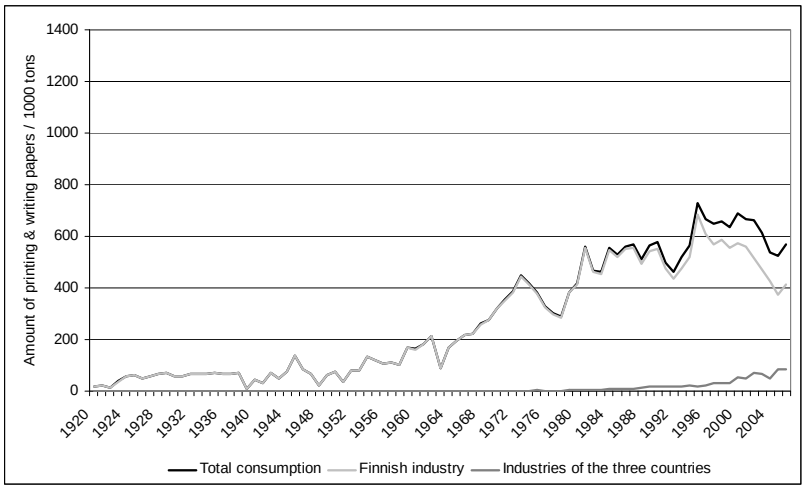

Figure 5-56: Consumption of the Finnish printing and publishing industry of printing and writing papers, and the amount of papers supplied by the Finnish paper and pulp industry and the three other paper and pulp industries (Swedish, German, and the UK), 1920-2006.

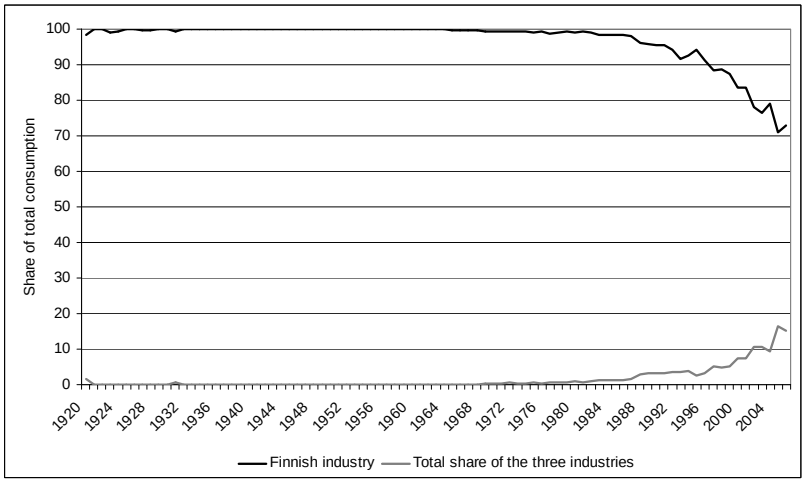

Figure 5-57: Share of the (i) Finnish and (ii) three other (Swedish, German, and the UK) paper and pulp industries of the total consumption of printing and writing papers of the Finnish printing and publishing industry, 1920-2006.

5.12.6. Swedish printing & publishing and paper & pulp industries

Similarly to Finland, the Swedish printing and publishing industry has mainly relied on the Swedish paper and pulp industry when it comes to the supply of printing and writing papers. This is clearly illustrated first by **Figure 5-58** and **Figure 5-59**. The share of the Swedish paper and pulp industry of the total consumption of the Swedish printing and publishing industry was close to 100 percent from 1930 to the early 1980s. Still, since the early 1980s, the Swedish industry may be considered to be the only

supplier to the Swedish industry. The share of the Finnish paper and pulp industry of the total consumption has, however, been increasing slightly since the early 1980s. Currently, the Finnish industry supplies some 10 percent of the total consumption of the Swedish printing and publishing industry. The role of the German and the UK industries has been negligible for the whole research period.

As a conclusion, during the analysis period of the study, the Swedish paper and pulp industry can be considered to be the only supplier of the Swedish printing and publishing industry with regard to printing and publishing papers. The role of the paper and pulp industries in the three other countries has been understandably negligible. Only recently has the share of the Finnish industry risen to 10 percent of the total consumption. Thus, with regard to the interactions between the Swedish printing and publishing and the paper and pulp industries, I hypothesize as follows.

Hypothesis 3.2: *The Swedish paper and pulp industry has a positive effect on the vital rates of the Swedish printing and publishing industry.*

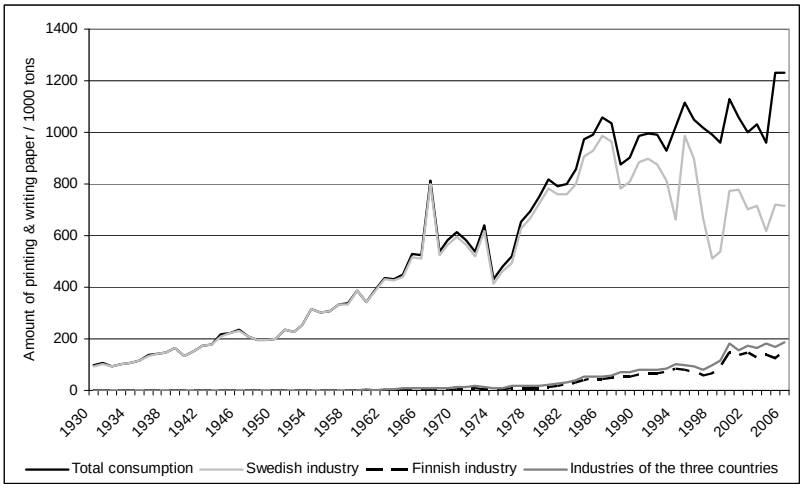

Figure 5-58: Consumption of the Swedish printing and publishing industry of printing and writing papers, and the amount of papers supplied by the (i) Swedish, (ii) Finnish, and (iii) three other paper and pulp industries (Finnish, German, and the UK), 1930-2006.

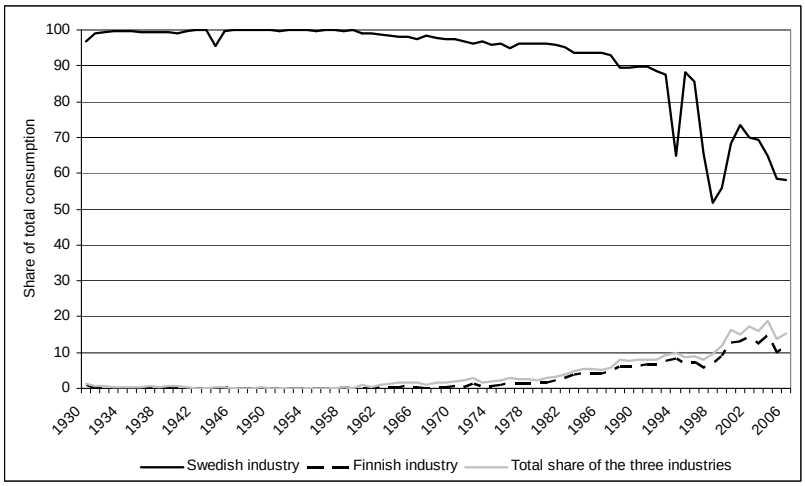

Figure 5-59: Share of the (i) Swedish and (ii) Finnish, and three other (Finnish, German, and the UK) paper and pulp industries of the total consumption of the printing and writing papers of the Swedish printing and publishing industry, 1930-2006.

5.12.7. German printing & publishing and paper & pulp industries

Figure 5-60 and **Figure 5-61** present basic statistics of the interdependences between the German printing and publishing industry and the four paper and pulp industries. As is obvious, the German paper and pulp industry has been the most important supplier of the printing and publishing industry of the country since 1950. However, the share of the industry of the total consumption has steadily decreased during the research period: in 1950, the German industry supplied 100 percent of the consumed paper, but in 2005 the share of the industry of the total consumption had decreased to 30 percent. Even in absolute terms, the amount of supplied paper by the industry has decreased since the mid-1990s.

Although the role of the Finnish and Swedish industries as the suppliers of the German printing and publishing industry has been significantly lower than that of the German paper and pulp industry, their role has increased since 1950. During the 1950s, the share of the Swedish and Finnish industries quickly increased to some 10 percent and stayed rather stable until the mid-1990s, after which especially the share of the Finnish industry has increased. In 2005, the Finnish industry already supplied over 20 percent of the paper consumed by the German printing and publishing industry.

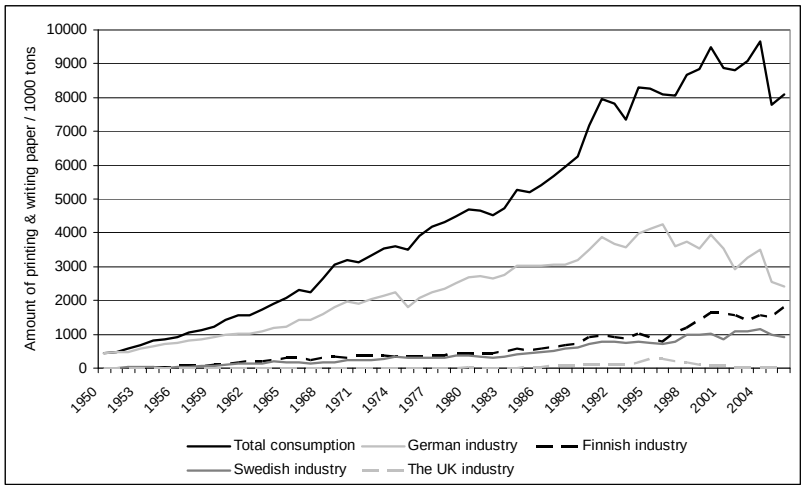

Figure 5-60: Consumption of the German printing and publishing industry of printing and writing papers, and the amount of papers supplied by the (i) German, (ii) Finnish, (iii) Swedish, and (iv) UK paper and pulp industries, 1950-2006.

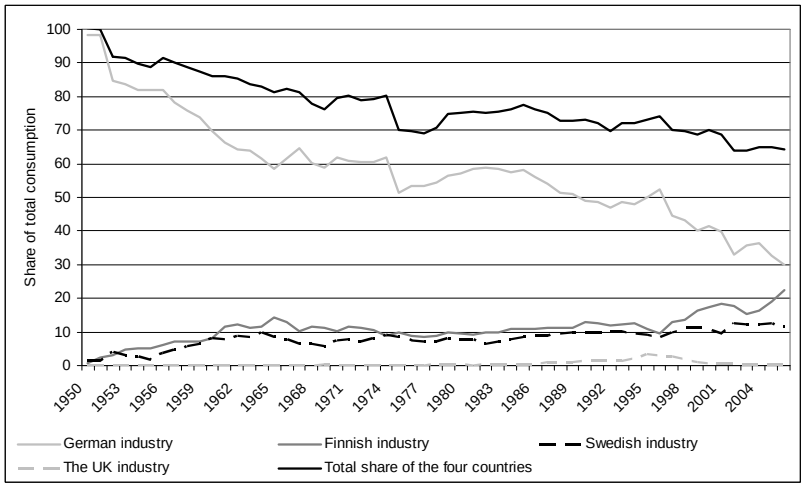

Figure 5-61: Share of the (i) German, (ii) Finnish, (iii) Swedish, and (iv) UK paper and pulp industries of the total consumption of the printing and writing papers of the German printing and publishing industry, 1950-2006.

In conclusion, the German paper and pulp industry has clearly been the most important supplier of the German printing and publishing industry since 1950, although its share of the total consumption has been decreasing constantly. The Finnish and Swedish industries have been the second and third most important suppliers of the industry, although their share of the total consumption has been significantly lower than the share of the German industry during the research period. Since the mid-1990s, especially the role of the Finnish industry has been increasing. The UK industry has never exported significant amounts of paper to the German

printing and publishing industry, for understandable reasons. In total, the four industries accounted for over 65 percent of the total consumption of printing and writing papers during the research period. On this basis, I this hypothesize as follows.

Hypothesis 3.3: *The German, Finnish, and Swedish paper and pulp industries have a positive effect on the vital rates of the German printing and publishing industry.*

Hypothesis 3.4: *The effect of the German paper and pulp industry on the vital rates of the German printing and publishing industry is stronger than the effects of the Finnish and Swedish paper and pulp industries.*

5.12.8. The UK printing & publishing and paper & pulp industries

Finally, this section presents an analysis of the interdependences between the industries from the perspective of the UK printing and publishing industry and formulates the empirically testable hypotheses of the interactions. As **Figure 5-62** and **Figure 5-63** indicate, the UK paper and pulp industry has been the most important supplier of the UK printing and publishing industry since 1950. Between 1950 and the early 1980s, however, the share of the UK paper and pulp industry of the total consumption dropped significantly: from over 80 percent to 30 percent in the early 1980s. During this phase, the UK paper and pulp industry was in a decline phase, mainly due to increasing international competition. Although the industry remained the most important supplier of paper during the rest of the period, with a share of some 30 percent of the total consumption, the Nordic countries and later Germany gained in importance.

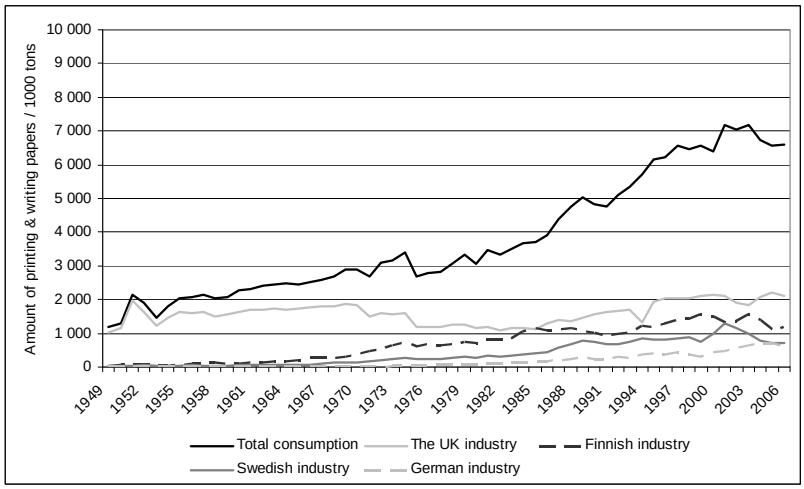

Figure 5-62: Consumption of the UK printing and publishing industry of printing and writing papers, and the amount of papers supplied by the (i) UK, (ii) Finnish, (iii) Swedish, and (iv) German paper and pulp industries, 1949-2006.

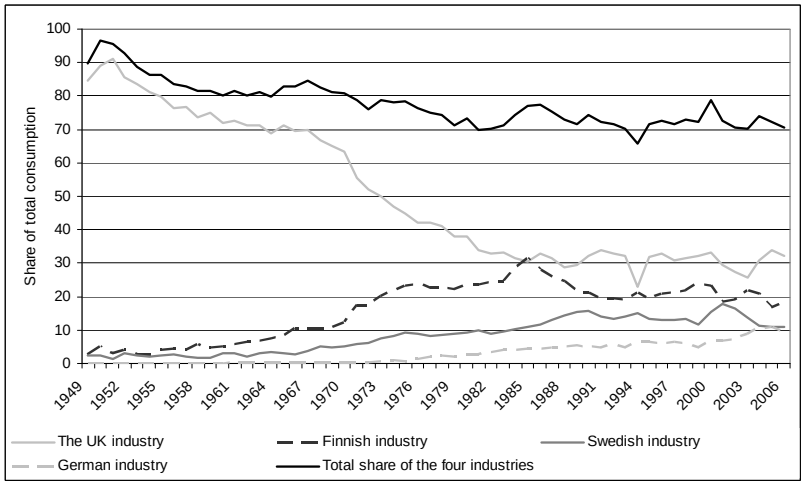

Figure 5-63: Share of the (i) UK, (ii) Finnish, (iii) Swedish, and (iv) German paper and pulp industries of the total consumption of the printing and writing papers of the UK printing and publishing industry, 1949-2006.

The role of the Finnish paper and pulp industry as a supplier of the UK industry has increased particularly after early 1970s. In the 1960s, the share of the Finnish industry increased to 10 per cent of the total consumption, and since the 1970s the Finnish industry has supplied consistently over 20 percent of the total consumption. During the mid-1980s, the share of Finland of the total consumption increased to over 30 percent, exceeding even the share of the UK industry for a few years. The Swedish industry has also been an important supplier of the UK industry since 1950 and especially after the early 1970s, when the share of the Swedish industry

increased to some 10 percent. After the mid-1980s, the share of the Swedish industry has been constantly some 15 percent. The German paper and pulp industry has also recently gained a position as an important supplier of the UK industry. During the last years of analysis, the share of the industry increased to some 10 percent. However, in comparison to Finland and Sweden, the role of the German industry has been considerably more modest for the research period, except for the few last years of analysis.

Thus, as the analysis indicates, the UK industry has been the most important supplier of the printing and publishing industry in the country during the research period. The importance of the industry has, however, decreased steadily during the research period. After the 1970s, Finland and Sweden have gained a considerable position in the UK market. In particular, Finland has been the second most important supplier of the UK printing and publishing industry since 1950 (as mentioned, the share of the Finnish paper and pulp industry even exceeded that of the UK for a few years). The role of Germany has been growing more recently. In total, the four industries have constantly supplied over 70 percent of the consumption of the UK printing and publishing industry during the research period. As a conclusion, I formulate the following hypotheses of the interdependences.

Hypothesis 3.5: *The UK, Finnish, and Swedish paper and pulp industries have a positive effect on the vital rates of the UK printing and publishing industries.*

Hypothesis 3.6: *The effect of the UK paper and pulp industry on the vital rates of the UK printing and publishing industry is stronger than the effects of the Finnish and Swedish paper and pulp industries.*

6. Quantitative Empirical Study

This chapter tests the hypotheses formulated at the end of the previous chapter by employing quantitative research methodology. In particular, my focus is on testing the hypotheses of interactions formulated from the perspective of the paper and pulp industry, for which I have been able to assemble life-history data of the firms in the four countries during 1949-2005. As the data sources and the process of constructing the life-history databases were already described in chapter 4, I will start the chapter by describing the variables used in the models. Next, I will introduce the regression model and the modeling strategy. The results of the analyses follow. In general, the methodology of the study follows earlier ecological empirical research (in particular community ecology).

6.1. Variables

6.1.1. Dependent variable

The dependent variable of the study was the rate of growth of the paper and pulp industry firms. The measure was based on the paper and board production figures for the individual firms, as reported in Phillips' paper trade directories (see section 4.3.2). Thus, the study differs from much of the earlier ecological research that has used the rate of organizational entry and mortality as the dependent variable (see section 2.2.3). Firm growth has, however, also been used as the measure of population vitality in earlier ecological research (Barnett & Carroll 1987; Banaszak-Holl 1991; Barnett et al. 1994; Barron et al. 1994; Ranger-Moore et al. 1995; Barnett, Mischke & Ocasio 2000; Barnett & Sorenson 2002; Boone et al. 2002; Barnett & Woywode 2004; Boone et al. 2004).

Unfortunately, the research context of the study, as already discussed, and issues related to the data, prevented the use of rate of organizational founding and mortality in this study. First, with regard to the rate of organizational founding, the number of new entries in the paper and pulp industry during the research period of the study, 1950-2005, was negligible in every industry included in the analysis. This was due to the phase of the life-cycle of the industries. Thus, the number of firms operating in the industry declined continuously in every studied industry for the whole research period. For example, in Finland, only 12 new entries took place during the whole period (see **Figure 6-1**). The same figure in the Swedish paper and pulp industry was somewhat higher, 36, but only a few of the entries were actually totally new firms (many of the entries were related to mergers and to entries of foreign firms in the Swedish industry).

Second, with regard to the rate of organizational mortality, the reasons why I did not employ the measure are related to both industry characteristics and problems in the data. First, the number of actual mortality events was modest in the paper and pulp industry during the research period, despite the high number of firm exits in every studied industry. Most of the exits in the industry were actually either mergers or acquisitions, not considered as actual mortality events in the earlier research on organizational mortality (Baum 1996). For example, with regard to the Finnish paper and pulp industry, only 11 exits of the 38 total exits (29 percent) were failures; the others were either mergers or acquisitions (see **Figure 6-1**, presenting the annual number of entries and exits in the industry). The low number of failures is understandable when considering the following two characteristics of the industry: the output of the industry grew continuously during the research period, and the importance of economies of scale. Acquisitions and mergers were, thus, important strategies for the paper and pulp firms to achieve economies of scale and growth.

What was even more problematic, however, was that the Finnish industry was the only one for which I was able to track down the types of exits. For the other three industries, I was only able to determine the year of the exit of a firm. Thus, when this problem was combined with the fact that the share of acquisitions and mergers of the total exits was also potentially considerable in every studied industry, running a mortality analysis would not have resulted in reliable results.

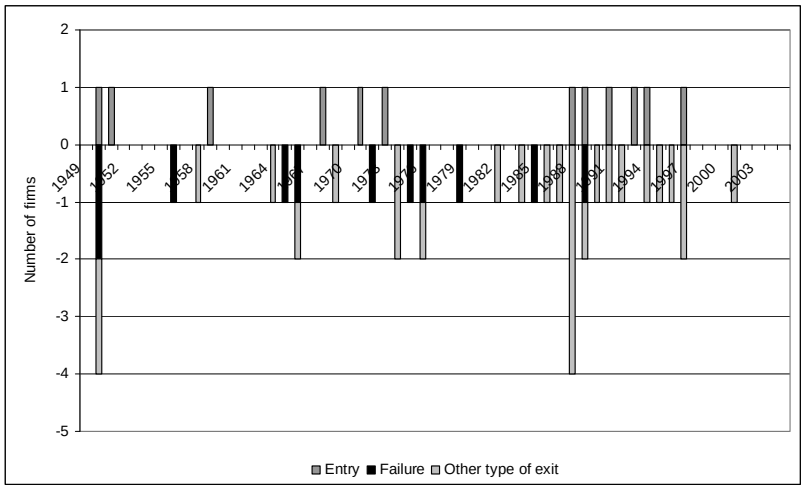

Figure 6-1: Numbers and types of entries and exits of the Finnish paper and pulp firms, 1949-2005.

6.1.2. Independent variables

To test the hypotheses of the interdependences between the two populations from the perspective of the paper and pulp industry firms, I used four different variables as measures of interdependence between the industries. One of the measures was directly related to the paper resource flow between the industries in question and three to the evolutionary characteristics of the printing and publishing industry. The first measure, *paper resource flow*, was operationalized as the annual amount of printing and writing papers supplied by a particular paper and pulp industry to a particular printing and publishing industry (e.g. from the Finnish paper and pulp industry to the Finnish, German, or UK printing and publishing industries). The values for the variable were based on statistical data of the flows of paper grades categorized as newsprint or printing & writing papers between the countries in question (retrieved from country-specific statistics of international trade between the countries). As discussed previously, the two paper grades should cover the actual paper flows between the industries well. Due to the skewed distribution of the values of the variable, the models included the values of the variable in the form of a natural logarithm.

The second measure, *paper consumption*, was operationalized as the annual consumption of printing and writing papers by a particular printing and publishing industry (in the models, the values of the variable were in the form of a natural logarithm). The values for the variable were retrieved from country-specific industry and international trade statistics and

calculated on the basis of the total production of printing and writing papers (i.e. paper grades categorized as newsprint and printing & writing papers), total imports of printing and writing papers, and total exports of printing and writing papers. Thus, the variable measured the apparent consumption of the printing and writing papers by the printing and publishing industry in question.

The third variable, *printing industry output*, was measured as the annual output of a particular printing and publishing industry (the values of the variables in the models were in the form of a natural logarithm). The values of the variable were retrieved from the industry statistics of the country in question and expressed in a monetary value. Due to differences in the statistics, the output measures were somewhat different within the countries. In the case of Finland and Sweden, the total value of production was used. In the context of Germany, the variable was based on the total revenue of the industry. Finally, the UK variable was constructed on the basis of the total sales of the industry. The fourth variable, *number of employees*, was the annual value of the total number of employees in a particular printing and publishing industry. The values for the variable were again retrieved from the industry statistics of the country in question. In the models, the original values were divided by 10 000.

Thus, as can be noted, I did not use the by far most widely used measure of interdependence, population density, as a measure of interdependence (see section 2.2.3). However, as noted by Korn & Baum (1994), any measure of the relative population size can be used as a measure of interdependence. The reason why I did not use density was mainly related to problems in the data. First, for Finland and Sweden, the data only included the number of printing and publishing establishments in the printing and publishing industry. As the evolutionary trends in the number of establishments may differ considerably of the trends in the number of firms, using the number of establishments as a measure of interdependence might have resulted in distorted results with regard to the interdependences. Second, for Germany, there were statistical data related to the number of firms, but the data only covered firms with more than 10 employees (during the specified period, only the number of firms with more than 20 employees). As many of the firms in the printing and publishing industry were actually small in size, the values for the number of firms retrieved from the statistics might have resulted in a highly distorted view of the actual number of firms in the industry. Third, the UK statistical data had the same problems that for Germany: the data covered only firms of a certain size, and changes in the principles of collecting statistics made constructing a reliable time-series of the number of firms difficult.

In addition to the four measures of interdependence, I also included several control variables in the growth models. First, with regard to firm level controls, I included *firm age* in the models (in the form of a natural logarithm). However, I was able to include the specific measure of firm age only in the Finnish data sample, as I was able to track down entry and exit years for every Finnish paper and pulp firm that had ever operated in the industry. For the firms in the three other industries, I did not know the exact entry year for many of the firms operating in the industry since 1949. For those firms that did not report their entry years in the trade directories or were founded before the year 1949 (as most of them were), I went through the database covering the firms that had operated in the Swedish, German, and UK industries in the years 1875, 1910, and 1938 (the database builds also on Phillips' Paper Directory of the World, for more information, see Järvinen et al. 2009) and checked when a particular firm, for which I did not have information about the entry year, appeared in the database for the first time. Based on this information, I then set the entry year of a firm to the year in the middle point between the year when the firm first time appeared in the database and the year it was not yet in existence. If the firm was already present in 1875, I set the entry date of the firm to 1850.

The next control variable, *pulp production*, was a dummy, indicating whether a paper and pulp firm had pulp production of its own. The values of the variable were updated annually and were based on the information in the paper trade directories. I used the control, because having internal pulp production may give a paper and pulp firm an advantage. Additionally, there are country-specific differences with regard to pulp production in the firms: Nordic firms are usually self-sufficient with regard to pulp production, whereas German and the UK firms import much of the pulp they use.

With regard to common industry-level control variables, I followed earlier ecological research and included *population density* in the models to control for the process of competition. Since I only expected competitive processes to operate in the industry, due to the phase of the life cycle of the industry, I did not include a second order density term in the models (Hannan & Carroll 1992). Following earlier ecological research, I also controlled for the effects of *industry mass*. The variable was calculated as the sum of production of paper and pulp industry firms operating in the country, minus the production of the firm in question (in the models, the values of the variables were in the form of a natural logarithm).

Finally, I introduced a few country-specific time period dummies into the models. First, in the Finnish case, I included time period dummies for the two major recession periods, during which the output of the paper and pulp

industry decreased: the recession period following the first oil crisis, 1975-1977, and the severe recession period in the early 1990s, 1991-1994. Second, in the Swedish case, I also controlled for the two main recession periods: one following the first oil crisis, 1975-1977, and the recession in the early 1990s, 1991-1993. In the models of the German paper and pulp firms, I included three time period dummies: the first for the recession period following the first oil crisis, 1975-1977; the second for the recession period of the early 1990s, 1991-1992; and the third for the period after 1990, taking into consideration the unification of the West and East Germany. Finally, I introduced two period dummies in the UK paper and pulp industry models: the first taking into consideration the recession and low growth period of most of the 1970s and early 1980s, 1974-1982; and the second for the recession period of the early 1990s, 1991-1992. In general, the control variables are in line with recent ecological research using firm growth as the dependent variable (see e.g. Barron et al. 1994; Boone et al. 2004)[31].

Table 6-1, **Table 6-2**, **Table 6-3**, and **Table 6-4** provide descriptive statistics of the variables in the four data samples. As can be noted, the correlations between some of the variables are rather high (for example, between some of the studied independent variables and population density and industry mass, and between some of the country-specific studied independent variables, like printing industry outputs in Finland and Germany), potentially resulting in multicollinearity in the models. Although multicollinearity does not result in biased estimates, it affects the variances and standard errors of the estimates: they become larger (Kennedy 1998). In order to take the problem into at least some consideration, four variables (as defined) were used in measuring the interdependences between the populations, and the studied independent variables were added step-wise to the models.

[31] In addition to the introduced control variables, I also tried including time trend variable in every model for every country (currently, the variable is only included in German models because I hypothesized that the interdependence between the industries decreases as a function of time), but since the variable has not been used as a control in earlier ecological research using firm growth as the dependent variable and the variable did not have a significant effect on the growth of the firms in any models, I decided to not to include the variable in other than German models.

Table 6-1: Descriptive statistics for the Finnish paper and pulp industry, 1950-2005, n = 997.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Ln(size)	11.307	0.066	1.0000												
2. Ln(age)	3.911	0.029	0.1100	1.0000											
3. Density	28.476	0.245	-0.3359	0.0704	1.0000										
4. Ln(mass of firms)	21.971	0.020	0.3353	0.0663	-0.6843	1.0000									
5. Pulp production	0.704	0.015	0.5591	0.2596	0.1027	0.0347	1.0000								
6. Recession 1975-1977	0.067	0.008	0.0314	0.0486	0.0073	0.1638	0.0594	1.0000							
7. Recession 1991-1994	0.052	0.007	0.1112	-0.0313	-0.3537	0.1617	-0.0159	-0.0627	1.0000						
8. Ln(paper resource flow, FI)	19.515	0.027	0.2630	0.0035	-0.7723	0.6847	-0.0267	0.0061	0.2668	1.0000					
9. Ln(paper resource flow, GE)	19.459	0.036	0.3458	0.0015	-0.8381	0.8558	-0.0352	0.0428	0.2383	0.7600	1.0000				
10. Ln(paper resource flow, UK)	19.766	0.033	0.3691	0.0411	-0.8551	0.9003	-0.0025	0.1256	0.2137	0.7864	0.9232	1.0000			
11. Ln(paper consumption, FI)	19.535	0.028	0.2601	-0.0014	-0.7835	0.6800	-0.0354	0.0022	0.2631	0.9980	0.7634	0.7866	1.0000		
12. Ln(paper consumption, GE)	21.811	0.025	0.3685	0.0100	-0.8945	0.8806	-0.0273	0.0872	0.2845	0.8008	0.9742	0.9704	0.8031	1.0000	
13. Ln(paper consumpion, UK)	21.865	0.012	0.3311	-0.0765	-0.9658	0.7127	-0.1039	-0.0849	0.3089	0.7676	0.8784	0.8812	0.7794	0.9136	1.0000
14. Ln(printing ind. output, FI)	21.051	0.026	0.3642	0.0453	-0.8580	0.8413	-0.0073	0.1098	0.2027	0.7888	0.9438	0.9598	0.7893	0.9738	0.8710
15. Ln(printing ind. output, GE)	23.210	0.015	0.3662	0.0512	-0.8162	0.9055	0.0077	0.1007	0.2692	0.7694	0.9656	0.9637	0.7663	0.9824	0.8425
16. Ln(printing ind. output, UK)	23.759	0.013	0.2733	0.0073	-0.8135	0.6946	-0.0329	0.0292	0.2697	0.9553	0.7799	0.8166	0.9596	0.8268	0.8116
17. No of employees, FI	0.254	0.002	0.3541	0.1279	-0.6905	0.8618	0.0632	0.1107	0.1534	0.7031	0.8504	0.9145	0.6938	0.8918	0.7069
18. No of employees, GE	1.678	0.008	0.2093	0.0767	-0.2856	0.7282	0.0618	0.0394	0.1523	0.3989	0.7181	0.5947	0.3889	0.6347	0.3976
19. No of employees, UK	1.274	0.004	0.0646	0.1831	0.2135	0.4331	0.1573	0.2699	-0.2987	0.0608	0.2678	0.2552	0.0454	0.2123	-0.1237

Variable	14	15	16	17	18	19
14. Ln(printing ind. output, FI)	1.0000					
15. Ln(printing ind. output, GE)	0.9688	1.0000				
16. Ln(printing ind. output, UK)	0.8109	0.7951	1.0000			
17. No of employees, FI	0.9192	0.9401	0.7225	1.0000		
18. No of employees, GE	0.5930	0.7300	0.4038	0.6595	1.0000	
19. No of employees, UK	0.2566	0.3458	0.0335	0.4331	0.7035	1.0000

Table 6-2: Descriptive statistics for the Swedish paper and pulp industry, 1950-2005, n = 2575.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Ln(size)	10.480	0.034	1.0000												
2. Ln(age)	4.005	0.021	0.0140	1.0000											
3. Density	73.158	0.627	-0.4655	0.0460	1.0000										
4. Ln(mass of firms)	21.892	0.015	0.4186	-0.0608	-0.9805	1.0000									
5. Pulp production	0.522	0.010	0.4194	0.1027	-0.0399	0.0124	1.0000								
6. Recession 1975-1977	0.049	0.004	0.0670	-0.0012	-0.1737	0.1089	0.0427	1.0000							
7. Recession 1991-1994	0.033	0.004	0.1047	-0.0068	-0.2295	0.2171	-0.0145	-0.0417	1.0000						
8. Ln(paper resource flow, SE)	20.011	0.009	0.4216	-0.0477	-0.9134	0.9242	0.0341	0.0299	0.2321	1.0000					
9. Ln(paper resource flow, GE)	18.815	0.028	0.4280	-0.0414	-0.9259	0.9380	0.0394	0.1057	0.2147	0.9051	1.0000				
10. Ln(paper resource flow, UK)	18.729	0.023	0.4570	-0.0592	-0.9561	0.9557	0.0245	0.1038	0.2643	0.8457	0.8855	1.0000			
11. Ln(paper consumption, SE)	20.079	0.010	0.4364	-0.0540	-0.9268	0.9527	0.0306	0.0153	0.2195	0.9742	0.9254	0.8951	1.0000		
12. Ln(paper consumption, GE)	21.591	0.018	0.4571	-0.0477	-0.9779	0.9842	0.0364	0.1212	0.2434	0.9293	0.9737	0.9507	0.9572	1.0000	
13. Ln(paper consumpion, UK)	21.782	0.008	0.4289	-0.0581	-0.8956	0.9191	0.0166	-0.0221	0.2481	0.8229	0.8889	0.9441	0.8996	0.9290	1.0000
14. Ln(printing ind. output, SE)	21.432	0.010	0.4551	-0.0502	-0.9809	0.9801	0.0393	0.1629	0.1940	0.9386	0.9394	0.9436	0.9417	0.9775	0.8781
15. Ln(printing ind. output, GE)	23.069	0.011	0.4445	-0.0398	-0.9675	0.9653	0.0415	0.1322	0.2419	0.9453	0.9769	0.9053	0.9431	0.9853	0.8758
16. Ln(printing ind. output, UK)	23.685	0.009	0.4534	-0.0553	-0.9610	0.9793	0.0301	0.0780	0.2533	0.9122	0.9499	0.9611	0.9474	0.9851	0.9527
17. No of employees, SE	3.614	0.007	0.1911	0.0214	-0.4896	0.4574	0.0551	0.1770	-0.1645	0.5707	0.5383	0.2922	0.4398	0.4753	0.2032
18. No of employees, GE	16.119	0.057	0.2970	0.0140	-0.7011	0.6933	0.0560	0.0796	0.1651	0.7516	0.8015	0.5422	0.6913	0.7357	0.5452
19. No of employees, UK	12.463	0.027	0.1616	0.0304	-0.4214	0.3792	0.0699	0.2632	-0.1673	0.4670	0.4684	0.1996	0.3694	0.4030	0.1250

Variable	14	15	16	17	18	19
14. Ln(printing ind. output, SE)	1.0000					
15. Ln(printing ind. output, GE)	0.9759	1.0000				
16. Ln(printing ind. output, UK)	0.9651	0.9613	1.0000			
17. No of employees, SE	0.5458	0.5963	0.3975	1.0000		
18. No of employees, GE	0.7109	0.8169	0.6704	0.8172	1.0000	
19. No of employees, UK	0.4334	0.5185	0.2989	0.8793	0.7906	1.0000

Table 6-3: Descriptive statistics for the German paper and pulp industry, 1950-2005, n = 8764.

Variable	Mean	S.D.	1	2	3	4	5	6	7
1. Ln(size)	9.252	0.019	1.0000						
2. Ln(age)	4.007	0.013	0.0399	1.0000					
3. Density	269.747	0.911	-0.4559	-0.0789	1.0000				
4. Ln(mass of firms)	22.479	0.007	0.4601	0.0409	-0.9004	1.0000			
5. Recession 1975-1977	0.033	0.002	0.0181	0.0371	-0.0994	-0.0004	1.0000		
6. Recession 1991-1992	0.031	0.002	0.1140	-0.0470	-0.1969	0.2063	-0.0332	1.0000	
7. Period 1990-	0.217	0.004	0.3648	-0.0757	-0.6451	0.7458	-0.0979	0.3393	1.0000
8. Pulp production	0.104	0.003	0.1472	-0.0053	0.0024	-0.0085	-0.0145	0.0053	0.0421
9. Time	26.056	0.167	0.4759	0.0385	-0.9276	0.9925	0.0169	0.2099	0.7683
10. Ln(paper resource flow, GE)	21.256	0.007	0.4565	0.0785	-0.8938	0.9700	0.0362	0.2051	0.6135
11. Ln(paper consumption, GE)	21.769	0.009	0.4609	0.0652	-0.8882	0.9843	0.0558	0.2006	0.6531
12. Ln(printing ind. output, GE)	23.172	0.006	0.4349	0.0877	-0.8400	0.9407	0.0739	0.2002	0.5354
13. No of employees, GE	16.519	0.028	0.2233	0.0821	-0.3587	0.5696	0.0480	0.1443	0.1553

Variable	8	9	10	11	12	13
8. Pulp production	1.0000					
9. Time	0.0021	1.0000				
10. Ln(paper resource flow, GE)	-0.0193	0.9505	1.0000			
11. Ln(paper consumption, GE)	-0.0153	0.9673	0.9926	1.0000		
12. Ln(printing ind. output, GE)	-0.0281	0.9108	0.9834	0.9825	1.0000	
13. No of employees, GE	-0.0488	0.4867	0.6764	0.6743	0.7699	1.0000

Table 6-4: Descriptive statistics for the UK paper and pulp industry, 1950-2005, n = 4134.

Variable	Mean	S.D.	1	2	3	4	5	6	7
1. Ln(size)	9.530	0.028	1.0000						
2. Ln(age)	3.831	0.017	-0.0963	1.0000					
3. Density	139.725	0.828	-0.3021	0.0661	1.0000				
4. Ln(mass of firms)	22.150	0.004	0.2912	-0.1135	-0.6246	1.0000			
5. Period 1974-1982	0.170	0.006	0.0312	0.0773	-0.2526	-0.1076	1.0000		
6. Recession 1991-1992	0.030	0.003	0.0595	-0.0504	-0.1850	0.1419	-0.0797	1.0000	
7. Pulp production	0.061	0.004	0.2261	-0.1071	-0.0804	0.0942	-0.0248	0.0141	1.0000
8. Ln(paper resource flow, UK)	21.155	0.003	0.1042	-0.1064	0.0370	0.6127	-0.5279	0.0614	0.0609
9. Ln(paper consumption, UK)	21.844	0.007	0.3248	-0.1069	-0.8868	0.8494	0.0064	0.1943	0.1002
10. Ln(printing ind. output, UK)	23.763	0.007	0.3176	-0.0754	-0.9237	0.8066	0.1386	0.2072	0.0838
11. No of employees, UK	31.480	0.035	0.2014	-0.1305	-0.2708	0.6556	-0.2175	-0.1152	0.1108

Variable	8	9	10	11
8. Ln(paper resource flow, UK)	1.0000			
9. Ln(paper consumption, UK)	0.3622	1.0000		
10. Ln(printing ind. output, UK)	0.1656	0.9565	1.0000	
11. No of employees, UK	0.6230	0.5353	0.4056	1.0000

6.2. Method

With regard to analyzing the growth of the paper and pulp industry firms, I followed the earlier ecological research on firm growth (see Carroll & Hannan 2000) and built the analysis on Gibrat's law, which claims that the sizes of firms, like those of other "naturally occurring" economic units, follow a lognormal distribution (Gibrat 1931). The main idea is the "law of proportionate effect", which holds that growth is proportional to size, and the factor of proportionality is random (Kapteyn 1903). As specified by Carroll & Hannan (2000), let S_{it} denote the size of an organization in period

t and assume that the size of each organization in each period is a multiple of its size in the previous period:

$$S_{it} = S_{i,t-1}(1 + u_{it}),$$

where u_{it} is a random growth rate. Further, according to Carroll & Hannan (2000), as size at any time depends upon the initial size, S_{io}, and the history of random growth rates, the following holds:

$$S_{it} = S_{io}(1 + u_{it}) \cdots (1 + u_{io}).$$

If the periods are sufficiently short and the growth rates are small (or if time is regarded as a continuous parameter) then the earlier equation can be well approximated by

$$\ln(S_{it}) = \ln(S_{io}) + u_{it} + \cdots + u_{io}.$$

Gibrat's model for the growth of firms assumes that the random growth rate, u_{it}, (1) is independent from period to period and among firms in each period; (2) is independent of the current size; and (3) reflects the operation of many forces, each with small effect, which means that it can be approximated by a normal distribution (Carroll & Hannan 2000). That is, Gibrat assumes that the u_{it} are independent, identically distributed, normal random variables with mean μ and variance σ^2. Then it follows that

$$\ln(S_{it}) = \ln(S_{o}) + \varepsilon_{it},$$

where $\varepsilon_{it} \sim N(\mu t, \sigma^2 t)$.

Based on this, and following earlier ecological research, I estimated a growth model of the following type:

$$\ln(S_{i,t+1}) = \theta \ln(S_{it}) + r_{it} + \varepsilon_{i,t+1},$$

with $r_{it} = \mathbf{x}'_{it}\pi$, where *i* indicates the paper and pulp firm and **x**'$_{it}$ is a vector of covariates.

I arranged the data in the form of pooled cross-sections of the paper and pulp firms for the time period of 1949-2005. Pooling of the repeated observations on the same firms, however, is likely to violate the assumption of independence from observation to observation and result in the residuals

of the model being autocorrelated. First-order autocorrelation occurs when the disturbances in one time period are correlated with those in the previous time period, resulting in incorrect variance estimates. This renders OLS estimates inefficient, and for the model of interest (with lagged dependent variable included) autocorrelation generates biased estimates (Judge, Griffiths, Hill et al. 1985). Therefore, following earlier ecological research on firm growth (e.g. Barnett et al. 1994; Barron et al. 1994; Boone et al. 2004), I decided to run fixed-effects (within-estimator) models to estimate the parameters of the covariates. As described by Boone et al. (2004), the fixed-effect regression is an appropriate method to deal with autocorrelation. The method also results in very conservative estimates, as it controls for any type of unobserved heterogeneity across the firms (Boone et al. 2004), likely to be present in the current samples. As has been the norm in earlier research, I lagged all independent variables by one year. Finally, all models were estimated using the statistical package STATA (version 11.0).

6.3. Results

6.3.1. Growth of Finnish paper and pulp firms

Starting from the growth models with regard to Finnish paper and pulp firms, **Table 6-5** presents the estimated models. Model 1 is the baseline model including the control variables, Models 2-5 add the variables for the paper resource flows to the considered industries, Models 6-9 include the variables of printing and writing papers consumption in the considered countries, Models 10-13 the variable measuring the output of the printing and publishing industries in the considered countries, and Models 14-17 the number of employees in the three hypothesized countries. In general, adding the variables related to interdependences between the industries results in higher model fit in comparison with the baseline model.

With regard to paper resource flow variables, the models suggest that when added independently, each of the resource flows have a positive and statistically significant effect (Finland 0.078, $p<0.05$; Germany 0.116, $p<0.05$; the UK 0.328, $p<0.05$) on the growth of the Finnish firms. According to Model 5, including all the three variables, the German, and the UK industries still seem to have a statistically significant, positive effect on the growth of the Finnish paper and pulp firms (Germany, 0.059, $p<0.05$;

the UK, 0.263, $p<0.05$)[32]. The effect of the Finnish variable, however, becomes non-significant. Thus, the results offer rather strong support for hypothesis 2.1. Although the results may also be interpreted to support hypothesis 2.2, suggesting that the German and the UK industries have stronger effect on the vital rates of the Finnish paper and pulp industry in comparison to the Finnish printing and publishing industry, it is also possible that the Finnish variable loses its significance due to the high level of multicollinearity (resulting in larger standard errors). However, when considering the sizes of the coefficients, it seems that in particular the size of the UK coefficient is considerably larger than the Finnish coefficient (even at the 95 percent level of confidence, the coefficients for the Finnish and UK variables do not intersect). Thus, hypothesis 2.2 can be interpreted to receive at least some support.

The variables for the total printing and writing paper consumption, when independently added to Models 6-8, indicate that the industries in the three countries affect positively on the growth of the Finnish paper and pulp firms (Finland, 0.078, $p<0.05$; Germany, 0.448, $p<0.05$; the UK, 0.652, $p<0.05$). In Model 9, including the variables for all the three countries, the effects of the Finnish and German industry retain their significance. The variable for the UK industry, in contrast, loses its significance (which again may be a result of multicollinearity)[33]. With regard to the sizes of the coefficients, the German coefficient is larger than the Finnish at 95 percent level of confidence. Thus, the results offer at least partial support for hypotheses 2.1 and 2.2.

Next, Models 10-13 include the variables about the output of the printing and publishing industries in the three hypothesized countries. First, with regard to the independent effects of the variables, the output of the printing and publishing industries seem to have positive, statistically significant effects on the growth of the Finnish firms (Finland, 0.469, $p<0.05$; Germany, 0.728, $p<0.05$; the UK, 0.898, $p<0.05$). According to Model 13, however, including the variables for the three countries, it is only the effects of the German and UK printing and publishing industries that have positive, statistically significant effects on the growth of the Finnish firms[34]. The results may, therefore, be interpreted as supporting hypothesis 2.1.

[32] I also ran models with two of the three resource flow variables included in the models. In these models, both the included variables had statistically significant, positive effects on the growth of the Finnish firms.

[33] I again ran models with two of the three variables included in the models. In these models, both the included variables retained their statistical significance, except for the model where the UK and German variables were included: the UK variable lost its significant effect.

[34] Again, in the models in which two of the three variables are included, the two variables have a statistically significant effect on the firm growth.

Although, again, the Finnish variable may lose its significance due to multicollinearity, the result may also be interpreted to support hypothesis 2.2: the effects of the German and the UK industries on the growth of the Finnish paper and pulp firms are stronger than the effect of the Finnish printing and publishing industry. The sizes of the coefficients for the German (0.685, $p<0.05$) and UK industries (1.292, $p<0.05$) are also significantly larger than that of the Finnish printing and publishing industry (they do not intersect at a 95 percent confident level), thus offering support for the hypothesis.

Finally, models 14-17 add step-wise the variables of the total number of employees in the three considered printing and publishing industries. As models 14-16 indicate, the total employment of the three industries have positive effects on the firm growth in the Finnish paper and pulp industry, when considered independently (Finland, 3.387, $p<0.05$; Germany, 0.643, $p<0.05$; the UK, 1.422, $p<0.05$). However, in Model 17, including the variables for the three considered countries, only the total employment of the Finnish industry has a statistically significant effect on the growth of the Finnish paper and pulp firms. The results offer partial support for hypothesis 2.1, but no support for hypothesis 2.2.

As a conclusion, hypotheses 2.1 and 2.2 suggested, first, that the Finnish, German, and UK industries have had a positive effect on the vital rates (in this case, the growth rate) of the Finnish paper and pulp industry, and second, that the effect of the UK and German printing and publishing industries have had a stronger effect on the vital rates of the Finnish paper and pulp industry than the Finnish printing and publishing industry. In the light of the results, hypothesis 2.1 receives rather strong support. At least when considered independently, all the four variables used in measuring the effects of the printing and publishing industries suggest that the three printing and publishing industries have had a positive effect on the growth of the Finnish paper and pulp firms.

Table 6-5: Fixed-effect (within) regression models of firm growth for the Finnish paper and pulp industry, 1950-2006. The number of firms is 37. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Constant	3.441†	5.662†	5.357†	1.157	1.164	5.662†	-2.048	-7.440†	-6.872
	(1.129)	(0.860)	(0.548)	(1.080)	(1.201)	(0.860)	(1.586)	(3.160)	(3.556)
Ln(size)	0.848†	0.827†	0.822†	0.819†	0.818†	0.827†	0.811†	0.825†	0.806†
	(0.017)	(0.017)	(0.017)	(0.016)	(0.016)	(0.017)	(0.016)	(0.017)	(0.058)
Ln(age)	0.295†	0.262†	0.231†	0.230†	0.219†	0.262†	0.212†	0.235†	0.216†
	(0.060)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Density	-0.037†	-0.030†	-0.028†	-0.014†	-0.014†	-0.030†	-0.012†	-0.008	-0.003
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.007)	(0.008)
Ln(mass of firms)	0.197†	0.033	0.022†	0.004	0.003	0.033†	0.005	0.029†	-0.293†
	(0.045)	(0.005)	(0.005)	(0.007)	(0.007)	(0.005)	(0.007)	(0.005)	(0.095)
Pulp production	0.983†	0.939†	0.919†	0.940†	0.927†	0.939†	0.953†	0.920†	0.941†
	(0.109)	(0.107)	(0.106)	(0.105)	(0.105)	(0.107)	(0.107)	(0.106)	(0.106)
Recession 1975-77	0.177	0.081	0.093	0.037	0.057	0.081	0.062	0.170	0.094
	(0.071)	(0.070)	(0.069)	(0.069)	(0.070)	(0.070)	(0.068)	(0.072)	(0.075)
Recession 1991-94	0.022	0.043	0.053	0.110	0.099	0.043	0.014	0.078	-0.006
	(0.086)	(0.084)	(0.083)	(0.083)	(0.083)	(0.084)	(0.082)	(0.083)	(0.083)
Ln(paper resource flow, FI)		0.078*			0.012				
		(0.038)			(0.039)				
Ln(paper resource flow, GE)			0.116*		0.059*				
			(0.025)		(0.028)				
Ln(paper resource flow, UK)				0.328*	0.263*				
				(0.055)	(0.063)				
Ln(paper consumption, FI)						0.078*			0.161*
						(0.038)			(0.073)
Ln(paper consumption, GE)							0.448*		0.523*
							(0.074)		(0.069)
Ln(paper consumption, UK)								0.652*	0.294
								(0.139)	(0.186)
Ln(printing ind. output, FI)									
Ln(printing ind. output, GE)									
Ln(printing ind. output, UK)									
No of employees, FI									
No of employees, GE									
No of employees, UK									
R^2	0.726†	0.802†	0.813†	0.803†	0.807†	0.802†	0.779†	0.817†	0.779†
n	1037	1037	1037	1037	1037	1037	1037	1037	1016

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

Table 6-5 (continues): Fixed-effect (within) regression models of firm growth for the Finnish paper and pulp industry, 1950-2006. The number of firms is 37. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17
Constant	-0.674	-6.467†	-8.338†	-24.278†	7.596†	7.542†	8.091†	8.664†
	(1.274)	(1.516)	(4.080)	(4.624)	(1.184)	(1.195)	(1.200)	(1.205)
Ln(size)	0.804†	0.806†	0.844†	0.790†	0.818†	0.826†	0.823†	0.815†
	(0.016)	(0.017)	(0.017)	(0.016)	(0.017)	(0.017)	(0.016)	(0.016)
Ln(age)	0.239†	0.238†	0.318†	0.269†	0.283†	0.242†	0.224†	0.247†
	(0.058)	(0.058)	(0.060)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Density	-0.017†	-0.027†	-0.031†	-0.014†	-0.030†	-0.049†	-0.061†	-0.044†
	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.007)
Ln(mass of firms)	-0.058	-0.100	-0.246	-0.075†	-0.022	0.0001	-0.037	-0.068
	(0.055)	(0.055)	(0.154)	(0.016)	(0.050)	(0.050)	(0.051)	(0.051)
Pulp production	1.010†	0.965†	0.985†	1.000†	0.975†	0.923†	0.921†	0.938†
	(0.108)	(0.106)	(0.109)	(0.107)	(0.105)	(0.106)	(0.105)	(0.105)
Recession 1975-77	0.049	0.072	0.139	-0.004	0.112	0.164	0.021	0.088
	(0.068)	(0.068)	(0.071)	(0.069)	(0.068)	(0.068)	(0.070)	(0.075)
Recession 1991-94	0.133	-0.034	-0.008	-0.048	0.082	-0.068	0.159	0.065
	(0.083)	(0.082)	(0.086)	(0.089)	(0.083)	(0.084)	(0.084)	(0.097)
Ln(paper resource flow, FI)								
Ln(paper resource flow, GE)								
Ln(paper resource flow, UK)								
Ln(paper consumption, FI)								
Ln(paper consumption, GE)								
Ln(paper consumption, UK)								
Ln(printing ind. output, FI)	0.469*			0.106				
	(0.053)			(0.102)				
Ln(printing ind. output, GE)		0.728*		0.685*				
		(0.075)		(0.159)				
Ln(printing ind. output, UK)			0.898*	1.292*				
			(0.299)	(0.293)				
No of employees, FI					3.387*			1.905*
					(0.383)			(0.567)
No of employees, GE						0.643*		0.232
						(0.076)		(0.151)
No of employees, UK							1.422*	0.430
							(0.157)	(0.368)
R^2	0.759†	0.764†	0.778†	0.735†	0.773†	0.816†	0.814†	0.795†
n	997	1016	1037	997	1037	1037	1037	1037

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

Considering the models where the variables for the three industries are included, the effect of the German industry is statistically significant in three of the four models, and the UK and Finnish industries in two of the four models. With regard to hypothesis 2.2, the results are more difficult to interpret, due, for example, to the potential problem of multicollinearity. The models including the variables for the actual resource flows and the output of the printing and publishing industries, however, suggest that it is the UK and German industries that have had a stronger effect on the growth of the Finnish paper and pulp firms than the Finnish printing and publishing industry: the effect of the Finnish industry becomes non-insignificant when the variables for the German and UK industries are added to the models. Despite the last four models, including the variable of total employment of the three industries, the coefficients of the German and the UK printing industries are also larger in size in comparison with the sizes of the coefficients of the Finnish industries. Thus, I may argue that the results offer at least partial support for hypothesis 2.2.

The control variables included in the models also offer interesting insights into the growth of the Finnish paper and pulp firms. First, firm age has a positive and statistically significant effect on firm growth in every studied model. Thus, in the Finnish industry, the oldest firms are largest in size and have been growing fastest. Second, population density shows a negative and statistically significant effect on the growth of the Finnish paper and pulp firms in most of the models. This result is in line with the earlier ecological research, suggesting that the higher the density the stronger the competition among the organizations in a population. Third, the effect of industry mass on the firm growth rate is more inconsistent: in some of the models its effect is positive and statistically significant, but in others negative and statistically significant. In a sense, taking into consideration the earlier inconsistent results with regard to the effect of the variable on the vital rates of organizational populations (e.g. Barnett & Amburgey 1990), the inconsistency in the results is not surprising. Fourth, pulp production has a positive and statistically significant effect on the growth of the Finnish paper and pulp firms in every considered model. The result suggests that the firms that also produce pulp are larger in size and grow fastest. Fifth, and finally, the period effects are consistently non-significant in all the models.

6.3.2. Growth of Swedish paper and pulp firms

Table 6-6 presents the models of firm growth for the Swedish paper and pulp industry. As in the Finnish case, Model 1 is the baseline model,

including all the control variables. Models 2-5 add step-wise the variables of the paper resource flows from the Swedish industry to the three considered printing and publishing industries. Models 6-9 include the variables of the total consumption of printing and writing papers in the three considered countries, Sweden, Germany, and the UK. Models 10-13 then add the variables of the output of the printing and publishing industries in the three countries, and finally, Models 14-17 include the variables of the total employment of the printing and publishing industries in the three countries. In general, the model fit increases considerably after adding the printing and publishing industry variables to the models.

Models 2-5 add the variables with regard to the actual resource flows between the industries. As can be noted, the effects of the German and UK printing and publishing industries are significant in the models where they are considered independently (Germany, 0.047, $p<0.05$; the UK, 0.104, $p<0.05$), but also in Model 5, which includes the three industries (Germany, 0.058, $p<0.05$; the UK, 0.144). The effect of the resource flow to the Swedish printing and publishing industry is not significant in any of the models. Additionally, the differences in the sizes of the coefficients are not significant. Thus, the results do not fully support hypothesis 2.3, and especially not hypothesis 2.4.

Next, Models 6-9 include the variables of the total printing and writing consumption in the three considered countries as measures of interdependences between the industries. As Models 6-8 suggest, when considered independently, the total consumption of printing and writing papers by the Swedish, German, and UK industry has had a positive and statistically significant effect on the growth of the Swedish paper and pulp firms (Sweden, 0.147, $p<0.05$; Germany, 0.380, $p<0.05$; the UK, 0.158, $p<0.05$). In Model 9, including the variables for the three countries, the variables for Germany and the UK remain significant (Germany, 0.312, $p<0.05$; the UK, 0.109, $p<0.05$); the variable for the Swedish industry loses its significance, however. This may again be the result of multicollinearity (the correlations between the three variables are very high), but could also be interpreted to support the view that the growth of the UK and German industries has driven the growth of the Swedish paper and pulp firms more strongly than the Swedish printing and publishing industry (and thus, not support hypothesis 2.4, in particular). The differences in the sizes of the coefficients are not significant, however (especially between Sweden and the UK). In general, the results may be interpreted to support hypothesis 2.3.

Table 6-6: Fixed-effects (within) regression models of firm growth for the Swedish paper and pulp industry, 1950-2005. The number of firms is 118. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Constant	7.956†	7.872†	8.390†	7.551†	7.112†	7.307†	7.345†	5.798†	6.046†
	(1.604)	(1.719)	(1.610)	(1.604)	(1.801)	(1.622)	(1.653)	(1.793)	(1.809)
Ln(size)	0.834†	0.836†	0.836†	0.833†	0.831†	0.835†	0.825†	0.835†	0.824†
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Ln(age)	-0.042†	-0.042	-0.046	-0.057	-0.066†	-0.049	-0.059	-0.058	-0.070†
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.033)	(0.032)	(0.033)
Density	-0.012†	-0.012†	-0.011†	-0.010†	-0.008†	-0.012†	-0.010†	-0.011†	-0.010†
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln(mass of firms)	-0.0005†	-0.003	-0.061	-0.072	-0.203†	-0.103	-0.344†	-0.057	-0.384†
	(0.068)	(0.071)	(0.072)	(0.071)	(0.081)	(0.079)	(0.089)	(0.071)	(0.093)
Pulp production	0.173†	0.172†	0.168	0.184†	0.182†	0.173†	0.182†	0.180†	0.189†
	(0.047)	(0.047)	(0.047)	(0.047)	0.047	(0.047)	(0.048)	(0.047)	(0.048)
Recession 1975-77	0.049	0.051	0.053	0.058	0.080	0.078	0.038	0.084	0.072
	(0.044)	(0.045)	(0.043)	(0.043)	(0.045)	(0.045)	(0.044)	(0.045)	(0.048)
Recession 1991-93	-0.081	-0.082	-0.083	-0.111†	-0.129†	-0.085	-0.135†	-0.091	-0.137†
	(0.050)	(0.050)	(0.050)	(0.051)	(0.051)	(0.050)	(0.051)	(0.050)	(0.051)
Ln(paper resource flow, SE)		0.007			0.070				
		(0.053)			(0.061)				
Ln(paper resource flow, GE)			0.047*		0.058*				
			(0.017)		(0.018)				
Ln(paper resource flow, UK)				0.104*	0.144*				
				(0.029)	(0.033)				
Ln(paper consumption, SE)						0.147*			0.067
						(0.058)			(0.065)
Ln(paper consumption, GE)							0.380*		0.312*
							(0.065)		(0.076)
Ln(paper consumption, UK)								0.158*	0.109*
								(0.059)	(0.066)
Ln(printing ind. output, SE)									
Ln(printing ind. output, GE)									
Ln(printing ind. output, UK)									
No of employees, SE									
No of employees, GE									
No of employees, UK									
R^2	0.774†	0.841†	0.838†	0.828†	0.821†	0.836†	0.828†	0.829†	0.820†
n	2656	2656	2656	2656	2656	2656	2575	2656	2575

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

Table 6-6 (continues): Fixed-effects (within) regression models of firm growth for the Swedish paper and pulp industry, 1950-2005. The number of firms is 118. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17
Constant	2.970	6.384†	-0.381	-2.846	9.493†	9.487†	9.636†	11.436†
	(2.268)	(1.977)	(2.017)	(2.456)	(1.674)	(1.676)	(1.677)	(1.782)
Ln(size)	0.835†	0.831†	0.826†	0.819†	0.834†	0.834†	0.833†	0.832†
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Ln(age)	-0.040	-0.039	-0.066†	-0.065†	-0.057	-0.058	-0.060	-0.063
	(0.032)	(0.033)	(0.032)	(0.033)	(0.033)	(0.032)	(0.032)	(0.033)
Density	-0.009†	-0.011†	-0.012†	-0.012†	-0.013†	-0.013†	-0.013†	-0.015†
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln(mass of firms)	-0.118	-0.082	-0.404†	-0.529†	-0.066	-0.063	-0.061	-0.140
	(0.078)	(0.075)	(0.090)	(0.098)	(0.071)	(0.072)	(0.071)	(0.074)
Pulp production	0.172†	0.179†	0.183†	0.200†	0.181†	0.182†	0.186†	0.194†
	(0.047)	(0.048)	(0.047)	(0.048)	(0.047)	(0.047)	(0.048)	(0.048)
Recession 1975-77	0.033	0.043	0.076	0.044	0.056	0.055	0.059	-0.049
	(0.044)	(0.044)	(0.043)	(0.044)	(0.044)	(0.044)	(0.044)	(0.033)
Recession 1991-93	-0.056	-0.099	-0.147†	-0.118†	-0.115†	-0.118†	-0.132†	-0.149†
	(0.051)	(0.051)	(0.051)	(0.053)	(0.053)	(0.052)	(0.052)	(0.070)
Ln(paper resource flow, SE)								
Ln(paper resource flow, GE)								
Ln(paper resource flow, UK)								
Ln(paper consumption, SE)								
Ln(paper consumption, GE)								
Ln(paper consumption, UK)								
Ln(printing ind. output, SE)	0.345*			0.365*				
	(0.111)			(0.131)				
Ln(printing ind. output, GE)		0.146*		-0.133				
		(0.072)		(0.086)				
Ln(printing ind. output, UK)			0.734*	0.756*				
			(0.109)	(0.118)				
No of employees, SE					0.011			0.032
					(0.045)			(0.087)
No of employees, GE						-0.001		0.003
						(0.005)		(0.012)
No of employees, UK							-0.013	-0.017
							(0.010)	(0.020)
R^2	0.841†	0.844†	0.822†	0.820†	0.770†	0.770†	0.769†	0.770†
n	2656	2575	2656	2575	2656	2656	2656	2656

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

Models 10-13 add step-wise the variables with regard to the output of the printing and publishing industries in the three countries. Again, the independent effects of the variables for the three industries are positive and statistically significant, as indicated by Models 10-12 (Sweden, 0.345, $p<0.05$; Germany, 0.146, $p<0.05$; the UK, 0.734, $p<0.05$). In Model 13, including all three variables, the effect of the German industry becomes highly non-significant (and even the sign of the coefficient turns to negative); the effects of the output of the Swedish and UK industries still remain positive and statistically significant (Sweden, 0.365, $p<0.05$; the UK, 0.756, $p<0.05$). Again, the three variables are highly correlated, potentially contributing to the obtained results. However, the coefficients and standard errors for the output of the Swedish and the UK industry remain stable between the models that include the effect of the individual industries and the final model. Therefore, the results may be interpreted to support hypothesis 2.3, but hypothesis 2.4 does not receive support.

Models 14-17 add the variables of total employment of the three industries to the analysis. As can be noted, none of the employment variables have a statistically significant effect on the growth of the Swedish firms. Even the signs of the coefficients for the German and UK industry (in particular) are negative. Additionally, it also seems that the fit of the model for the models including the employment variables are worse than for the models including the other three measures of interdependence. Thus, it may be speculated whether total employment is a right variable for measuring interdependences between the industries, at least in the Swedish research context.

In general, the results offer support for hypothesis 2.3, suggesting that the Swedish, German, and UK printing and publishing industries have had a positive effect on the vital rates of the Swedish paper and pulp industry (except for the total employment variable, which is not significant in any of the models). In the models that include variables for individual industries, the German and UK variables have positive and statistically significant effects in three of the four models, and the Swedish variable in two of the four models. In the models that include the variables for all three industries, the Swedish industry has a statistically significant effect in one of the four models, and the German and UK industries in two of the four models. With regard to hypothesis 2.4, suggesting that the Swedish industry should have a stronger effect on the vital rates of the Swedish paper and pulp industry in comparison with the German and UK industries, the results offer very little, if any support. In contrast, if anything, the results suggest that it is actually the German and UK industries that have had a more important effect on the evolution of the Swedish paper and pulp

industry than the Swedish printing and publishing industry. For example, Models 2-5, measuring the interdependences by the actual resource flows between the industries, suggest that the Swedish printing and publishing industry has not had a statistically significant effect on the growth of the Swedish paper and pulp firms.

Finally, with regard to the effects of the control variables, first, the effect of firm age is negative and also statistically significant in many of the models. Thus, in contrast to the Finnish paper and pulp firms, firm age lowers the growth rate of the Swedish paper and pulp firms. Second, population density has a negative and statistically significant effect on firm growth in the Swedish paper and pulp industry. As discussed above, the result is in line with earlier ecological research. Third, industry mass has a negative effect on firm growth in every model; the effect is also statistically significant in some of the models. This result suggests that the competition between the firms is stronger when the mass of the industry is larger, as is also suggested by the theory of mass dependence (the theory is not, however, supported in all earlier empirical research). Fourth, as in the Finnish paper and pulp industry, pulp production has a positive and statistically significant effect on firm growth. Finally, the recession period in the early 1990s seems to have affected the growth rates of the Swedish firms negatively, at least according to some of the models, where the variable has a statistically significant effect on firm growth.

6.3.3. Growth of German paper and pulp firms

Table 6-7 presents regression models of firm growth for the German paper and pulp firms. Model 1 is a baseline model, including the control variables. Models from 2 to 9 add the four measures of interdependence between the German paper & pulp and printing & publishing industries to the model. Since hypotheses 2.5 and 2.6 argue that the German printing and publishing industry has a positive effect on the vital rates of the paper and pulp industry, but that the effect decreases as a function of time, I model the interdependence between the industries by including an interaction term of the interdependence variable in question and time trend variable in the models[35].

[35] As in the descriptive analysis of the interdependence between the industries I noted that the role of the UK printing and publishing industry as a customer of the German paper and pulp industry increased in importance especially during the 21st century, I also ran models which included the respective paper resource flow (between the German paper & pulp and the UK printing & publishing industry),

First, as suggested by Models 2 and 3, including the paper resource flow variable and its interaction with time, the effect of the interdependence between the industries seems to be positive, but the effect decreases as a function of time: in Model 2, the paper resource flow variable has a positive and significant (0.022, $p<0.05$) effect on firm growth and in Model 3, including the interaction, the interaction of paper resource flow and time has a negative effect on paper and pulp firm growth (-0.002, $p<0.05$). Second, Model 3, where the interdependence between the industries is measured by the total consumption of printing and writing papers by the German printing and publishing industry, suggests that the positive effect of the printing and publishing industry on the growth of the paper and pulp firms decreases as a function of time. The independent effect of the variable has a positive and statistically significant effect on firm growth (0.021, $p<0.05$) and interaction has a negative and statistically significant effect on firm growth (-0.002, $p<0.05$).

Third, the results with regard to the variable of the total output of the German printing and publishing industry also support the hypotheses: the output of the printing and publishing industry has a positive and statistically significant effect on firm growth (0.022, $p<0.05$) and interaction has a negative and statistically significant effect (-0.004, $p<0.05$). Finally, the effect of the total employment of printing and publishing industry has a positive and statistically significant effect on firm growth (0.004, $p<0.05$) when modeled independently; also interaction has a negative and statistically significant effect (-0.003, $p<0.05$). Thus, both hypothesis 2.5 and 2.6 receive rather strong support.

Finally, with regard to the control variables, firm density has a consistent, negative, and statistically significant effect on firm growth, which is in line with earlier ecological research. In contrast, in some of the models industry mass has a positive and statistically significant effect on firm growth. Differing from the Finnish and Swedish (and also the UK industry) the effect of pulp production has a negative (although not statistically significant) effect on firm growth. Considering the characteristics of the industry, i.e. that the German firms have not, in general, focused on pulp production, the result is understandable. Finally, firm age and the period effect do not have statistically significant effects on firm growth in any of the models.

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paper consumption, printing industry output, and printing industry employees (related to the UK printing & publishing industry) variables. However, since I did not find that the variables had a statistically significant effect on the growth of the German firms, I do not present models in which the effect of the UK industry is taken into consideration.

Table 6-7: Fixed-effects (within) regression models of firm growth for the German paper and pulp industry, 1950-2005. The number of firms is 324. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Constant	0.881†	0.463†	0.019	0.565†	0.677	0.495†	0.755	0.888†	0.894†
	(0.043)	(0.158)	(0.358)	(0.129)	(0.379)	(0.176)	(0.438)	(0.043)	(0.043)
Ln(size)	0.911†	0.902†	0.902†	0.902†	0.902†	0.902†	0.902†	0.908†	0.908†
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Ln(age)	-0.005	-0.007	-0.007	-0.007	-0.007	-0.006	-0.008	-0.008	-0.009
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
Density	-0.0002†	-0.0002†	-0.0004†	-0.0002†	-0.0004†	-0.0002†	-0.0004†	-0.0002†	-0.0004†
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ln(mass of firms)	0.006†	0.002	0.009†	0.002	0.012†	0.003	0.002	0.004†	0.006
	(0.001)	(0.002)	(0.005)	(0.002)	(0.005)	(0.002)	(0.005)	(0.001)	(0.004)
Recession 1975-77	0.017	0.014	0.009	0.009	0.009	0.011	-0.001	0.013	0.010
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.011)
Recession 1991-92	-0.009	-0.020	-0.015	-0.021	-0.015	-0.020	-0.010	-0.021	-0.011
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)
Period 1990-	-0.018	0.006	0.011	0.008	0.016	0.006	0.024	0.001	0.009
	(0.011)	(0.012)	(0.015)	(0.012)	(0.016)	(0.012)	(0.014)	(0.012)	(0.015)
Pulp production	-0.023	-0.013	-0.012	-0.013	-0.012	-0.013	-0.012	-0.018	-0.017
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Time			0.030†		0.047†		0.086†		0.003
			(0.013)		(0.023)		(0.021)		(0.002)
Ln(paper resource flow)		0.025*	0.050*						
		(0.008)	(0.018)						
Ln(paper resource flow) x Time			-0.0015*						
			(0.001)						
Ln(paper consumption)				0.021*	0.016				
				(0.006)	(0.019)				
Ln(paper consumption) x Time					-0.002*				
					(0.001)				
Ln(printing ind. output)						0.022*	0.012		
						(0.008)	(0.021)		
Ln(printing ind. output) x Time							-0.004*		
							(0.001)		
No of employees								0.004*	0.008*
								(0.001)	(0.002)
No of employees x Time									-0.0003*
									(0.0001)
R^2	0.990†	0.996†	0.996†	0.996†	0.996†	0.996†	0.996†	0.996†	0.996†
n	8949	8764	8764	8764	8764	8764	8764	8948	8949

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

6.3.4. Growth of the UK paper and pulp firms

Table 6-8 presents the regression analysis results for the growth of the UK paper and pulp firms during 1950-2005. Model 1 is a baseline model, including all the control variables and Models 2-5 add the four measures of interdependence. As can be noted, Models 2-4, which include variables for the paper resource flow between the industries, the total consumption of printing and writing papers by the UK printing and publishing industry,

and the output of the printing and publishing industry, suggest that the UK printing and publishing industry has had a positive effect on the growth of the UK paper and pulp firms. Thus, the results are in support of hypothesis 2.7. The variable for total employment of the printing and publishing industry in Model 5 does not, however, offer support for the hypothesis: the effect of the variable is not statistically significant, but even the sign of the coefficient is in contrast to the hypothesis. Still, in the aggregate, the results can be considered to offer rather strong support for hypothesis 2.7.

Finally, considering the effects of the control variables on the growth of the paper and pulp firms, as expected, it seems that density has a negative effect on growth rates (at least according to the models where the variable has a statistically significant effect). Second, in the models where the effect of the industry mass variable is significant, the effect of the variable is positive, in contrast to the original theory. Third, as in the Finnish and Swedish industry, the firms with pulp production have higher growth rates than the firms that do not. Finally, the period effects are generally not significant; the exception is the period 1974-1982, which has a negative effect on the vital rates of the paper and pulp firms in some of the models.

Table 6-8: Fixed-effects (within) regression models of firm growth for the UK paper and pulp industry, 1950-2005. The number of firms is 180. Firm size is the dependent variable; all independent variables are lagged by one year.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.210	0.271	0.016	-0.266	-0.044
	(0.262)	(0.279)	(0.284)	(0.316)	(0.299)
Ln(size)	0.916†	0.915†	0.915†	0.914†	0.916†
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Ln(age)	-0.0003	-0.0002	-0.002	-0.001	0.0012
	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)
Density	-0.0002†	-0.0002†	-0.0001	0.00004	-0.0002†
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ln(mass of firms)	0.029†	-0.012	0.005	-0.005	0.043†
	(0.012)	(0.019)	(0.018)	(0.018)	(0.015)
Period 1974-1982	-0.011	-0.013†	-0.008	-0.012	-0.012†
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
Recession 1991-92	0.003	0.003	0.002	-0.0002	-0.003
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Pulp production	0.073†	0.073†	0.074†	0.076†	0.074†
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Ln(paper resource flow)		0.038*			
		(0.019)			
Ln(paper consumption)			0.033*		
			(0.018)		
Ln(printing ind. output)				0.051*	
				(0.019)	
No of employees					-0.002
					(0.002)
R^2	0.995†	0.995†	0.995†	0.995†	0.995†
n	4134	4134	4134	4134	4134

* = p < 0.05 (one-tailed test); † = p < 0.05 (two-tailed test). Standard errors in parentheses.

7. Discussion and Conclusion

Theoretically, this study was motivated by a lack of theory and research on how the structure and evolution of industries is affected by other industries or organizational populations. In particular, the study set out to complement earlier theory and research on community ecology, a research stream in the organizational ecology paradigm with explicit focus on population interdependences. This was accomplished by introducing a novel theoretical framework of population interdependences. Empirically, the study set out to apply the framework by examining interdependences between rarely studied symbiotically or vertically related organizational populations: paper & pulp and printing & publishing industries within four European countries – Finland, Sweden, Germany, and the UK during 1950 - 2005. The novel empirical research context offered an interesting but complex research setting to study the interdependences, as the interactions between the industries were not restricted by geographic space.

By building on different theory fragments of organizational ecology (including community ecology) and human ecology, the study introduced a novel theoretical framework of population interdependences. The framework consists of the following principles. First, a population niche is a multidimensional construct that is divisible into *N* number of dimensions based on different environmental conditions (Hutchinson 1957; Hannan & Carroll 1992). Second, the framework argues that interdependences originating from resources and identity (cf. Dobrev et al. 2006) are inherently different, and consequently, a population niche is divided in to two main parts: one related to resources and the other related to identity. Third, the framework suggests that two kinds of basic interactions may be present between two niche dimensions: (1) interdependences between two same or like niche dimensions (referred to as type 1 interdependences); and (2) interdependences between two different or unlike niche dimensions (referred to as type 2 interdependences). Fourth, the effects of the interdependences on the vital rates of the organizational populations may

vary from fully positive to fully negative (i.e. from competitive to mutualistic). Finally, 'total' or aggregate ecological interaction between two organizational populations (at time *t*), is a function of all of the sub-interdependences between all possible niche dimensions.

On the basis of the presented principles, a number of propositions of interdependences between organizational populations were formulated. The first set of propositions covered type 1 interdependences between the populations related to resources. In general, the effects of type 1 interdependences on the vital rates of organizational populations were suggested to vary from fully positive to fully negative. The second set of propositions concerned the type 1 interdependences related to identity. In general, it was proposed that the effects of these interdependences on the vital rates of organizational populations may also vary from fully negative to fully positive.

The next set of propositions covered type 2 interactions related to resources. First, it was proposed that the effects of these interactions may vary from fully positive interactions to fully negative ones. Further, it was suggested that these interactions typically have a positive effect on the vital rates of both populations. However, some contingencies, such as population decline or concentration, were proposed to result in negative type 2 interactions. Finally, dominance was suggested to be an important contingency with regard to type 1 and 2 interactions. A dominant organizational population with regard to the considered interdependence at the level of a niche dimension exerts a stronger negative or weaker positive effect on the vital rates of the other organizational population (in comparison with the effects the first has one on the vital rates of the other).

From the empirical point of view, the study examined one specific type of interdependence between organizational populations: a type 2 interdependence related to resources in the context of paper & pulp and printing & publishing industry. The results of the empirical part of the study suggested that the main interdependence between the paper & pulp and printing & publishing industries was created by a type 2 interdependence between the product market dimension of the paper and pulp industry and the input resource niche dimension related to paper of the printing and publishing industry.

In general, the interactions were suggested to have positive effects on the vital rates of the studied industries. Within the four countries, the industries were found to be interdependent on each other in complex ways. Based on the descriptive analysis of the resource flows between the industries, it appeared that the Finnish paper and pulp industry was more dependent on the German and UK printing and publishing industries than

on the Finnish printing and publishing industry. The Swedish pulp and paper industry, similarly, was dependent on the Swedish industry but also the German and UK industries. The German paper and pulp industry, in contrast, was only dependent of the German printing and publishing industry, and the strength of this dependence decreased as a function of time. Finally, the UK paper and pulp industry was only dependent of the UK printing and publishing industry. These interdependences were also verified by a quantitative analysis of the growth of the paper and pulp firms in the four countries. More specifically, I employed four variables to measure the interdependence between the industries: the actual paper resource flows, the total consumption of printing and writing papers in the countries, the output of the printing and publishing industries in the countries, and the total employment of the printing and publishing industries. The results of the analysis were, in general, in line with the hypotheses (except for the results with regard to the total employment variable).

Although I did not test the interactions from the perspective of the printing and publishing industry statistically, the descriptive analysis of the paper resource flows among the industries suggested that the Finnish and Swedish printing and publishing industries were only dependent on the respective paper and pulp industries during the analysis period of the study. The German printing and publishing industry was mainly dependent of the German paper and publishing industry; however, the strength of the dependence seemed to decrease as a function of time, and at the same time, the industry became more dependent on the Finnish and Swedish paper and pulp industries. Finally, the main supplier of the UK printing and publishing industry was the UK paper and pulp industry, but in particular from the early 1970s onwards, the role of the Finnish and Swedish paper and pulp industries became almost as important as the UK paper and pulp industry.

In the following sections, I will further elaborate upon the theoretical and methodological contributions of the study. Additionally, I will discuss the limitations of the study and suggest topics for further research. Finally, conclusions are drawn with regard to the general contribution of the study.

7.1. Contribution to theory

The study offers several contributions to earlier research. First, the theory of interdependences between organizational populations extends earlier

topical research in the field of organizational ecology. In particular, it does so by suggesting that a population niche should be considered to be a multidimensional construct, and that a niche dimension is the basic level of analysis of interdependences between organizational populations. The basic interactions between populations occur between niche dimensions. In the aggregate, all the potential interactions between different niche dimensions contribute to the total ecological interaction between populations. Based on these ideas, a number of testable propositions were formulated of the potential interactions that may exist between two niche dimensions, and of their effects on the vital rates of organizational populations. In general, the framework and propositions offer a coherent ground for future research on interactions between populations of organizations.

In comparison with earlier research, the framework relaxes an implicit assumption in much of earlier ecological research about the equality of product market and population niche (Baron 2004; Sorensen 2004), by turning the basic level of analysis of population interdependences to the level of niche dimensions. For example, in addition to product markets, labor, input resources, or financing may be a source of important ecological interactions between organizational populations, with considerable effects on the vital rates (see e.g. Sorensen 2004; Dobrev et al. 2006). Additionally, in contrast to earlier community ecology research, the framework allows multiple different types of interdependences to exist between organizational populations at the same time.

Analyzing interdependences at the level of niche dimension makes the research on population interdependences more demanding, however, due to potential for multiple different types of interdependences even between two organizational populations. On the basis of this, one can then also question whether the topic is ultimately worthy studying at all. I do, however, think that in many cases (as in the empirical research context of this study) it may be possible to reduce the number of relevant interactions so as to focus the analysis on a few or even one; what is then required is to study the co-evolution of the populations explicitly, and try to identify the most powerful interactions. When this is done, it is possible to run empirical models with a focus on the most important interaction or interactions; for example by using density as the measure of interdependence (if arguable). On the other hand, by turning to measuring resource flows between organizational populations directly, it is possible to focus on only certain interdependences and study the dynamics related to these (as was also done in the empirical part of this study). Admittedly, however, gathering longitudinal data from resource flows is difficult.

Based on the framework, the use of density as a measure of interdependence may also be somewhat problematic. As density can be considered a rather high-level surrogate measure of competition and legitimation, even in single-population contexts, using it as a measure of interdependence between multiple populations may result in ignoring the lower-level complexity present in the interactions. On the other hand, because the niches of populations that have been the focus of earlier research have often considerably overlapped, it is possible that density may be able to capture the overall trends in the interdependences between these kinds of populations. Again, it is also possible that the interaction related to one niche dimension, e.g. product markets, is so strong in comparison to the interdependences originating from the other, that these other interdependences have no actual relevance; hence density may actually be able to capture the actual interactions between the populations. In any case, I see that it would always be essential to consider all the relevant interactions between the studied populations before using density as the only measure of interaction.

Further, the framework presented also sheds light on the sometimes unexpected or non-significant results of earlier research regarding the interactions between populations. For example, Barnett & Carroll (1987) consider mutualistic interdependences they detect as somewhat "surprising", and speculate that such may be a statistical artifact due to density patterns across time. However, on the basis of the introduced framework, it is plausible that the populations studied had several different types of interdependences between their different niche dimensions, and some of these were negative and some positive. Owing to the use of density as the measure of interdependence, they were not able to detect the possible complexity present in the interactions between the populations studied. Similarly, the reason why it has sometimes been difficult to achieve statistically significant results when using density as the measure of interaction is that interdependences between the populations are complex, and density is not able to capture such complexity.

The empirical part of the study offers several contributions. First, the research context of the study is novel. The paper & pulp and printing & publishing industries have not been studied before from the perspective of organizational ecology. Research on the evolution of the two considered industries, in general, has also been rare. Thus, the systematic evolutionary narratives of the evolution of the industries in the four countries during 1950-2005 offer important insights into the evolutionary dynamics of the industries, as well as the differences in the evolution of the industries in the countries. Although more detailed histories of many of the industries exist,

the large volume of time-series quantitative data and the systematic nature of the narratives make them rather unique.

Second, the empirical results of the study increase the understanding of the interdependences between symbiotical or vertically related organizational populations; this is rarely studied in earlier research on industry evolution. Although earlier industry evolution research has offered rather accurate models of the general patterns of evolution of industries and organizational populations by focusing mostly on industry or organizational level characteristics, the results of this research (and earlier community ecology research with the focus on population interdependences in particular) suggest that other industries or organizational populations may play a considerable role in the evolution of the industry or population in question. As such, the quantitative empirical models of this study clearly showed that the evolution and growth of the paper and pulp industry in the four countries was highly dependent on the evolution and growth of the printing and publishing industries.

In a sense, the rareness of earlier evolutionary research on inter-industry or population interactions is understandable, taking into consideration the difficulties inherent in assembling the data of evolution of several industries or organizational populations: it usually requires a huge effort to compile solid datasets even from the evolution of one industry or organizational population. Even in this study, the hypotheses of the interdependences between the paper & pulp and printing & publishing industries were only tested from the perspective of the paper and pulp industries, partly due to problems related to the data.

Third, with regard to organizational ecology, but also other research areas of industry evolution, the results of the study show how evolutionary interdependences between symbiotically or vertically related industries or organizational populations do not always occur between industries or organizational populations in the same geographic space, as earlier research often implicitly assumes or suggests (e.g., Audia et al. 2006). As shown, the Finnish paper and pulp industry has actually been more dependent on the German and UK printing and publishing industries than on the Finnish printing and publishing industry. Additionally, the growth of the Swedish paper and pulp firms was shown to be highly dependent upon the evolution and growth of the German and UK printing and publishing industries. Although earlier organizational ecology research, for example, shows that populations in the same industries in different geographic locations (see e.g., Carroll & Wade 1991; Hannan, Carroll, Dundon et al. 1995; Hannan 1997; Hannan, Carroll, Dobrev et al. 1998; Greve 2002; Boone et al. 2004) may affect each others' vital rates, no earlier research has considered the

possibility that industries or populations connected by type 2 interactions but located in different geographical spaces may be dependent on each other (or further, that the effect of a population located in another geographic space may be stronger than the effect of a population in the same space). It is, however, highly plausible that these types of interdependences may also exist in other types of contexts (for example, due to the increasing internationalization of industries), and their omission might even result in making incorrect conclusions of the forces driving the evolution of a population or industry.

Fourth, the results also offer evidence of the possibility that the interdependences between the populations may change over time. In the current research context, the results of the analysis in the case of the German paper and pulp industry showed how the strength of the interdependence between the industries changed as a function of time. The effect of the German printing and publishing industry on the evolution of the German paper and pulp industry decreased as a function of time according to all the measures used in measuring the interactions between the industries. Although earlier ecological research (Audia & Rider 2010) has speculated on the possibility that the interdependences between populations may change as a function of time (Audia & Rider use inter-population effects as controls in their models), no earlier research has explicitly hypothesized about the change in the strength of the interaction.

7.2. Methodological contribution

The study also offers some methodological contributions to the field of organizational ecology, in particular. First, departing from much of the earlier ecological research, I conducted a detailed analysis of the evolutionary dynamics of the considered industries, in particular during the research period 1950-2005. This analysis was based on earlier literature on the industries, complemented by a quantitative time-series data of the evolution of the industries, mainly based on official statistics of the countries in question. Additionally, I analyzed the interdependences between the studied industries in a detailed manner on the basis of the historical narratives of the industries and the resource flows between the industries. Since the interactions between the industries are often (unfortunately) contingent on the characteristics of the industry or population in question (cf., Ingram & Yue 2008), a detailed analysis of the evolution of the industries or populations and the considered

interdependences can be considered to be essential for analyzing interdependences between any populations or industries. Although, of course, the introduced theoretical framework offers an important ground for studying population interactions, at least in the current research context, a detailed historical analysis of the evolution of the industries and the interactions was considered to be essential even for formulating the hypotheses of the potential interdependences.

The second methodological contribution with regard to organizational ecology is related to the employed measures of interdependence between the industries. As is evident on the basis of the review of earlier research on population interdependences, population density has been the most widely used measure of interdependence, due to the fact that most of the earlier research has been based on the theory of density dependence and its extensions, and that assembling data of population density is rather straightforward. However, as already suggested, population density may not be the ideal measure of interdependence between populations, given the possibility that multiple different types of interdependences may exist between populations. Thus, I decided to employ four different measures of interdependence between the paper & pulp and printing & publishing industries, which are potentially able to take into consideration the actual ecological interactions among the industries; more specifically: (1) actual paper resource flows between the industries, (2) total consumption of printing and writing papers of the printing and publishing industries, (3) total output of the printing and publishing industries, and (4) total employment in the printing and publishing industries. In particular, the actual paper resource flow between the industries can be considered to be a specific measure of interdependence related to the interaction between the niche dimensions of the product market from the perspective of the paper and pulp industry and the input resource niche dimension related to paper of the printing and publishing industry. The three other measures are then more general ones, reflecting the relative size of the printing and publishing industries (however, at least the measure of total paper consumption is strongly related to the flows of paper among the industries).

All of the measures (except for the total employment in the Swedish and UK research context) resulted in very similar implications with regard to the interdependences between the industries: the printing and publishing industries affect the vital rates of the paper and pulp industries positively. Although I did not employ density as a measure of interdependence (due to limitations related to data), I suggest that future ecological and industry evolution research, in general, may benefit from using more specific measures of interdependences. Admittedly, however, assembling specific

data of the actual resource flows or actual interactions may in many cases be rather difficult (cf., Sorensen 2004). Still, gathering data of the measures employed in this study should not be an impossible task in many research contexts (see also Audia et al. 2006).

7.3. Limitations and future research

All research has several limitations, and the same can be said for this study. I will start with limitations related to theory and continue with limitations related to the empirical part of the study. With regard to the theoretical part of the study, the theoretical framework did not consider potential type 2 interdependences between identity-related niche dimensions or between identity and resource-related niche dimensions. These interdependences were not considered because, although they may exist, no literature has covered them and generating general propositions of their effects on the vital rates of the organizational populations was somewhat impossible. In any case, theorizing on them offers the first potential avenue for further research on the topical area.

Turning to the limitations related to the empirical part of the study; limitations related to data had a potential effect on some of the results of the study. First, restrictions related to statistical data affected the research design and methodological choices of the study. For example, I was not able to gather data of population density for the printing and publishing industries for the four countries, the most widely used measure of interdependence among the industries. Although density may have not have been the most optimal measure of interdependence in the current research context, employing such as one measure may have been relevant, considering earlier research. With regard to Finland and Sweden, industry statistics only covered the number of establishments in the printing and publishing industry; as was noted from the data related to the paper and pulp industries, the trends and changes in the number of establishments differed considerably from those of the number of actual firms. Additionally, although the industry statistics for Germany and the UK offered data of the number of firms in the industries for at least a part of the research period, the figures for Germany only covered firms with over ten employees (for the paper and pulp industry, however, the figures presented in industry statistics resembled the figures based on the industry directories relatively well), and in the UK considerable changes took place in the methods of gathering firm data during the research period (additionally,

the official statistical data of the number of firms in the paper and pulp industry were not in line at all with the firm data assembled on the basis of industry directories).

A second limitation related to the statistical data is that the methods of presenting and assembling the statistical data changed in every country during the research period. Thus, for many of the presented time-series, for instance describing the number of establishments or employees in the industry, I had to use scaling of the values in order to construct comprehensive time-series for the research period. Admittedly, this may have resulted in distortions in the time-series. The scaling should not, however, have affected the relative changes taking place in the values of the variables.

As a second limitation related to the data, I was not able to identify the types of new entries and in particular exits for the paper and pulp firms in the four countries (except for the Finnish industry). Because, at least in the case of the Finnish paper and pulp industry, most of the exits were acquisitions or mergers (rather natural considering the characteristics of the industry) and not considered as mortality events in earlier ecological research, I was not able to use the rate of firm mortality as a dependent variable for the study. Thus, as I was also not able to use the other most widely used dependent variable of industry evolution in the current research context, the rate of firm entry, due to the phase of the life-cycle of the paper and pulp industry, I decided to use the rather rarely used firm growth as the dependent variable for the study. However, the rareness of firm growth as a dependent variable in earlier research may be more related to the issue that it is usually very difficult to assemble data of firm size for the whole population of firms rather than that firm growth would not be an adequate measure of industry evolution. In any case, firm growth can be considered to be a good measure of industry evolution in the context of the paper and pulp industry, taking into consideration the considerable growth of the industry during the research period. For future research, however, using the rate of firm mortality as the dependent variable would enable further validation of the results of the current research.

Continuing with the limitations related to the life-history data of the four paper and pulp industries, the source of the data (i.e. Phillips' paper trade directories) did not include size data for all the paper and pulp firms for the whole research period. In particular, with regard to the life-history data of the German and UK industries, production data for a large number of firms was missing, potentially resulting in distortions regarding the estimation of the quantitative models. Since very little data was available for firms for which production data did not exist, I was not able to assess the possible

bias caused by the deficiencies in the data. In any case, it seemed that the firms for which data was available should have been rather small in size since the production figures of paper and board based on the official industry statistics were in line with the production figures calculated on the basis of the life-history data.

Third, I was not able to assemble databases of the evolution of the printing and publishing industries in any of the four countries, and thus, I was not able to test the formulated hypotheses of the effects of the paper and pulp industries on the vital rates of the printing and publishing industry. The main causes for this were related to the heterogeneity of the printing and publishing industry and the very large number of small firms operating in the industry. Although assembling the database of at least some of the sectors of the industry would have been possible, it would have required an extremely great amount of time and work; for example because no one data source exists (e.g. industry directory) that covers all the firms in the industry. Testing the hypotheses from the perspective of the printing and publishing industry was thus left for further research.

Fourth, the presented models can be considered rather simple, at least in the sense that they include only controls for the basic variables (firm size, age, density, industry mass, and basic period effects) usually used in ecological models. As the detailed narratives of the evolution of the industries suggested, however, there may also have been a number of other antecedents that may have potentially affected the growth of the firms in the paper and pulp industries (such as competition originating from other paper and pulp industries, devaluation of currencies, technological changes, or internationalization of the industries). Unfortunately, I was not able to compile data for many of the variables and, in any case, controlling all the possible factors affecting firm growth would not have been possible. For example, further research on competitive interactions between the four paper and pulp industries (since the markets of the four industries overlap, competitive interaction should exist between the industries) would offer interesting insights into the evolution and growth of the industries.

In addition to the further research opportunities already considered, the review of earlier research on population interdependences, the introduced framework, and the empirical results offer a number of interesting areas for further research. First, as I have already set out, earlier research on organizational ecology, and on industry evolution in general, has not paid sufficient attention to type 2 interdependences (often occurring between symbiotically or vertically related organizational populations or industries), although these interdependences can be considered to be at least as important as those between like dimensions (cf. Hawley 1986). For

instance, detailed studies about populations predominantly linked by purchaser–supplier relationships or similar, might offer fresh insights into the evolution and dynamics of different types of organizational populations. Additionally, our knowledge, even of the different interdependences between like niche dimensions, is rather limited (cf. Baum 1996). In particular, considering the current framework, further research could aim at validating the propositions of the type 1 interactions between the same niche dimensions related to resources or identity. Additionally, there is no empirical research on the role of dominant populations in organizational communities: for example, how strongly do dominant populations affect populations that are dependent upon them?

A second opportunity for further research is studying different types of interdependences as such. This would offer new knowledge about what kind of interactions might be present between two populations. At present, I see that our knowledge of the possible interdependences related to the different dimensions of the niche is very limited. Although I have listed and discussed the potential niche dimensions that could matter with regard to ecological interdependences between organizational populations, it is highly plausible that the list covers only part of the dimensions that potentially affect population evolution. For example, detailed case studies of the co-evolution of different types of organizational populations or industries might be able to shed light on the potential types of interactions.

Third, further studies focusing on the links between different types of interdependences would also be required. In the theoretical framework, I only considered interactions in isolation from each other, but it is likely that the different niche-based interactions are highly interdependent. For instance, in certain contexts it may be plausible that competition in one niche dimension affects the competition in another dimension (i.e. links between niche dimensions related to technology and product markets (cf. Podolny et al. 1996)). Additionally, this type of research would also shed light on the relative strength of different types of interaction; for example, whether negative or positive interaction in one niche dimension is considerably stronger in effect than an interaction related to some other niche dimensions.

7.4. Conclusion

To conclude, this study was motivated by a lack of research on interdependences between populations of organizations and the role of

these types of interactions in the evolution of organizational populations. By building, both theoretically and methodologically, on the field of organizational ecology and community ecology in particular, this study then examined ecological interdependences between the paper & pulp and the printing & publishing industries within four European countries – Finland, Sweden, Germany, and the UK – during 1950-2005. To extend and complement earlier research on population interdependences, the study first analyzed earlier research on the topical area and introduced a novel theoretical framework of population interdependences. The framework was then applied in an empirical study of interdependences between the two industries in the four countries. Based on the theoretical framework, historical narratives of the evolution of the industries and descriptive analyses of the respective interactions, testable hypotheses of the interdependences between the industries were formulated. Life-history data of the evolution of the paper and pulp industries were then used in testing the hypotheses from the perspective of the paper and pulp industries. The final results suggested interesting and rather complex relationships between the two industries in the four countries.

The study offered a number of contributions, implications, and further research opportunities with regard to organizational ecology, community ecology, and research on industry evolution in general. Despite some limitations, the theoretical framework, for example, was suggested to offer a coherent ground for further research on the topical area, and to offer insights on the earlier research in the area. Additionally, the empirical part of the study offered important contributions with regard to evolutionary interactions between symbiotically or vertically related organizational populations, as well as methodological contributions related to further research.

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