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Regional Path-Dependence in Start-up Activity

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ABSTRACT

This paper studies the impact of an existing industrial structure in a region on the number of start-ups in this region. The aim is to detect path-dependencies in the regional industry structure. To this end we study empirically the regional factors that influence start-up rates. The approach deviates from the huge literature on start-up rates by studying each 2-digit industry separately, including the employment in other industries into the analysis and distinguishing between factors that provide founders and factors that influence their likelihood to start a firm.

KEYWORDS: industrial dynamics, regional industry structure, start-ups, entrepreneurship, path-dependence.

JEL classification: R11, L26, R30

1. Introduction

Economic literature on various topics provides us with evidence that industries are not independent of each other. Studies on innovation processes show that most innovations are conducted together with suppliers or customers nowadays (Lundvall 1988 and Johnsen et al. 2006). In addition, spillovers between firms have repeatedly been found to play a role for the innovativeness of firms (Jaffe et al. 1993 and Brenner & Greif 2006). Some of these interdependencies take place within industries, while some of them connect industries with each other. Furthermore, some case studies of local clusters show that the emergence of local clusters depends sometimes crucially on the already existing industrial structure in the region (Sorenson & Audia 2000 and Klepper 2006).

From all these findings we can conclude that the development of start-up activities in an industry in

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geographic space depends on the spatial distribution of the same and other industries. Most of the literature, however, discusses the dependence on the existing activity only within the same industry. The literature does not provide comprehensive information about to what extent interdependence between industries plays a role and which industries depend on which other industries. Answers to these questions are important for understanding the path-dependence of the industrial structure in regions. Furthermore, policy makers who intend to influence the development of regions, for example by bringing a certain industry to a specific region, should be aware of such path-dependencies and require knowledge about the interdependencies of industries.

This paper aims at providing some insights into the path-dependence of regional industry structures. As mentioned above this path-dependence is based on a number of processes, among them spillovers in innovation processes, advantages of proximity in cooperation, and a faster industrial development due to diversifying firms and spin-offs. Besides regional determinants in general, we will focus on the effect of other industries on the start-up activities in a region. These start-up activities are of specific importance for the industrial development in a region because they increase the firm population and often add innovative firms to the scene, which leads to a renewal of the competitive base.

Regional start-up activities are frequently studied in the literature. The standard empirical approach is to conduct regressions with the number of start-ups as dependent variable and a number of local variables, such as GDP, employment rate, and technological infrastructure, as independent variables (e.g. Reynolds 1994, Garofoli 1994, Audretsch & Fritsch 1999, Steil 1997 and Nerlinger 1998).

Our approach deviates from the standard approach in three features. First, we conduct the analysis for each 2-digit industry separately. Usually all start-up activities or at least all manufacturing start-up activities in a region are studied within one regression. An exception is provided by Audretsch and Fritsch (1999) who build, at least, classes of industries that are studied separately. We have to conduct a separate study for each industry because we aim to identify the connections between industries.

Second, we consider the employment in other 2-digit industries as independent variables in the analysis of an industry. This is not done in the literature. Some approaches in the literature include the employment in the industry itself as an independent variable (van Praag 1996). We go beyond that and include also other industries in order to find out whether there are dependencies between industries.

Third, we distinguish between independent variables that influence the likelihood of potential founders to start a firm in the studied region and independent variables that provide potential founders to the region. We use a standard neg-bin regression with random effects, but define the number of observations (details are given in Section 2) also in dependence of the independent variables.

The paper proceeds as follows. In Section 2 we discuss the possible mechanisms that lead to a dependence between industries and deduce some hypotheses. Section 3 contains a description of the empirical methods applied and the data used. In Section 4 the results of the regression analyses are presented and discussed. Section 5 concludes.

2. Theoretical considerations on regional path-dependence

Path-dependence in regional development has been repeatedly discussed on a theoretical level in the literature (for a recent review see Martin & Sunley 2006). Arthur's (1987) paper can be seen as the starting point of this strand of literature. The basic argument is that firms benefit from co-

locating with other firms in the same industry. This causes the number of firms and/or their size to increase faster in regions that contain more firms of a specific industry. This process has been repeatedly discussed and modelled since Arthur's work and its implications are comprehensively studied (see, e.g., Krugman 1991, Fujita & Thisse 2002 and Brenner 2004). It is shown that such processes can lead to the emergence of local clusters. However, these approaches do not address the question of interactions between industries, except for the approach by Brenner (2004, Section 2.2) who nevertheless does not analyse this interaction in detail.

A comprehensive description of how one industry might influence the location of another industry is provided by Klepper (2006). Especially for the case of television receivers he shows how the location of firms that produce them is crucially influenced by the location of firms that produced radio receivers and diversified partly to the new technological field. Other case studies add to this picture (see, e.g., Buenstorf & Klepper 2005 and Buenstorf & Fornahl 2006).

All this evidence comes from case studies. In the following we will put together the various insights from case studies and some empirical results on entrepreneurship and location choice in order to build a theoretical, conceptual framework for our analysis and provide some hypotheses that will be tested.

We are interested here in mechanisms that cause the location of one industry to have a positive or negative effect on the location of another industry. Negative influences of one specific industry on another industry are not discussed in the literature and seem to be not existent or rare, although they might be theoretically possible, for example if the industries rely on exactly the same or very similar resources like specialised human capital. Hence, we focus our discussion on two influences: general negative influences of industries on the location of further industries in the region and positive influences, meaning that one industry is more likely to locate where a certain other industry is already located.

The former general negative effect is caused by negative local externalities. A strong economic activity in a region leads to high costs there, such as high wages and rents. This decreases the attractiveness of the region for further economic activities, especially for industries that do not benefit from the existing economic activity. Hence, high employment numbers in some industries in a region might make the region unattractive for other industries.

The latter positive effect will be studied below in detail to figure out how one specific industry can influence the start-up rate in a specific other industry. Such a causal relationship can lead to path-dependence in regional industry structures.

Before we analyse the details of such a relationship, we have to define what the location of an industry means. The activity in an industry can be measured, for example, by the amount of sales, the number of employees or the number of firms. This activity is found to be highly concentrated in space for most industries (Ellison & Glaeser 1997 and 1999): A large part of the total activity in an industry can be found in a few regions. We call the spatial distribution of the activities in an industry its location.

The activity in an industry in each region is given by the number of firms and their size (measured by their sales, employees or turnover). Hence a variable that influences the location of an industry has either to influence the number of start-ups, the number of closures, the number of firm movements between regions, or the growth of firms in regions. The number of closures and the growth of existing firms are both related to the success of the existing firms. Hence, to understand the influence of one industry on the location of another, we might study how one industry's location affects the success and profits of firms of another industry in these locations.

This paper, however, focuses on the influence of factors on the number of start-ups and leaves the topic of the effect on the success of existing firms to further studies. The number of start-ups in an industry and region can be influenced by the activity in another industry in this region in several ways. First, other industries might attract founders to start their firm in this region instead of in

another region. Second, potential founders in the region might be motivated to start a firm by the existence of other industries in the region. Third, some of the potential founders might come from firms of other industries in the same region. We will discuss these three mechanisms separately in the following.

2.1 Location choice by founders

The literature on local clusters often talks about the agglomeration of a whole value chain in one region (Porter 1998). It is argued that a co-location with suppliers and/or customers is advantageous for a firm. Often suppliers and customers are classified into a different industry class. Hence, it seems to be natural that founders should try to locate in proximity to the location of supplier and customer industries.

However, the literature on start-ups tells us that approximately two thirds of all founders start their firm at the location in which they worked or studied just before founding or in which they have grown up (Schmude 1994 and Cooper & Folta 2000). Most founders make their location decision on the basis of personal reasoning (van Praag 1996 and Fornahl & Graf 2003). Many founders do not even think about where to start their firm. Nevertheless, the small part of founders that think about the location of their start-up might be inspired by the location of suppliers and customers. Therefore, we state the following:

Hypothesis 1: Founders might be attracted to regions in which suppliers and/or customers are located. However, this effect can be expected to be rather weak because founders rarely move to other regions.

This impact of other industries on the location of start-ups in the studied industry could be modelled as follows. There is a certain number of founders who are not bound to a specific region. The probability that they choose a certain region as the location for their start-up depends on the activity in supply and customer industries in this location. However, we expect this model to have less explanatory power because it captures only a small part of start-ups.

2.2 Influences on start-up decisions

The second mechanism that we want to discuss is the effect that the proximity of other industries might have on the decision of a potential founder to start a firm. Let us assume that there is a potential founder who plays with the idea to start a firm. The existence of firms in other industries might influence her decision in two ways.

First, the existence of suppliers and customers in the region might help the entrepreneur to evaluate existing opportunities and the perspectives of a new firm. The uncertainty decreases and the entrepreneur might be more willing to start a firm. Especially customers that allow the founder to discuss and/or evaluate sales perspectives might be helpful. The literature does not provide us with estimates of the strength of this mechanism. However, founders often have worked in a firm before they start an own firm and have collected experience with customer and markets during their own work (Shane 2000, Buenstorf & Klepper 2005). Therefore, they do not only rely on the information from customers and, hence, the effect of this mechanism can be expected to be rather weak.

Second, the existence of other firms in the region implies that successful examples of founding firms are present. Fornahl (2007) describes how successful founders function as role models for further founders and how they positively affect them in their founding decision. It can be expected that in a region with a high start-up activity people are more likely to put their plans of starting a firm into practice. People are much more influenced by positive examples in their close social and regional environment such as their family, friends, and colleagues (van Praag 1996 and Fornahl 2007). Since friends – due to, for example, common studies – and especially colleagues are often

active in the same subject, start-ups in the same technological field are more influential than start-ups in other technological fields, on average. Hence, we should find an effect of the number of successful start-ups in technologically related industries on the start-up activity in an industry.

In the empirical study below we use the number of employees to measure the activity in industries in the region. This number is often dominated by large firms, which usually exist for a long time. Hence, this number does not reflect the number of successful start-ups very well. There might be a positive relationship between the number of employees in an industry and the number of successful start-ups in this industry. However, we only expect a weak impact of the number of employees in technologically related industries on the start-up rate in an industry in the same region.

The above two mechanisms lead to the following hypothesis:

Hypothesis 2: Potential founders are more likely to start a firm in regions in which suppliers, customers, and/or firms in technologically related industries are located. However, this effect can be expected to be rather weak.

The mechanisms behind this hypothesis are based on the argument that potential founders make their founding decision on the basis of the local circumstances. This implies that they consider only the region in which they are already located as a potential location for their start-up. As mentioned above this holds for most founders. Hence, we can model these mechanisms by determining the local population of potential founders and defining a probability for each potential founder to start a firm dependent on the activity of other industries in the region. The local population of potential founders is discussed in the next subsection.

2.3 Sources of founders

Many founders have worked in firms before they start their own firm. Most often they worked in firms that belong to the same industry as their start-up. For example, Klepper & Sleeper (2005) show for the U.S. laser industry that spin-offs have a high likelihood to enter into markets that are closely related to those served by their parent firms (see also Buenstorf 2005 or Buenstorf & Klepper 2005). However, also quite frequently they start their firm in a technologically related industry (e.g. Buenstorf 2006) or they start a supplier firm for the firm in which they have previously worked (e.g. Patrucco 2005). It is less likely that they start a customer firm to the firm in which they previously worked but still this might occur in some cases (e.g. Buenstorf & Klepper 2005, Buenstorf 2005). Hence, many founders of start-ups have worked before in firms that have supplied such kind of firms, that have bought from such kind of firms or that are technologically related to the start-up.

This implies that firms in other industries are a relevant source of founders in a region. Again, we use the argument that most founders do not consider other regions as possible locations for their start-up. Thus, the number of potential founders in a region is mainly determined by the sources of founders that exist in the region. Of course, firms are not the only sources of potential founders. Universities and public research institutes are other important sources. Furthermore, some founders do not have a visible connection to the industry or technology, so that we have to regard the population of a region also as a source of potential founders. However, we expect that, besides researchers at universities and public research institutes, workers in firms in the industry or in related industries have a higher probability to found a firm in the industry.

We formulate the following hypothesis:

Hypothesis 3: The employees in industries that are technologically related to the studied industry or that contain supplier or customer firms to the studied industry constitute a significant source of potential founders. This should be most pronounced for the industry itself.

This can be modelled by adding the number of employees in these industries to other sources of potential founders. Often a start-up rate is defined in relation to the total population in a region. If we add other sources, such as industry employment, university employees and researchers at public institutes, each source has to be multiplied by a different coefficient because the different sources contribute with different probabilities. Finally, we add to these sources the number of employees that might move to the region from other locations.

3. Empirical data and method

Above we have comprehensively discussed the issue we are dealing with in this paper and have deduced some hypotheses. In this section the empirical procedure is described. First, the empirical method is explained (Section 3.1). Then, the data that is used is presented (Section 3.2).

3.1 Empirical method

The aim of this paper is to examine the relationship between industries, especially the impact of the employment in one industry on the start-up activities in another industry. Above the mechanisms behind such an impact are discussed. They imply that we have to describe the number of start-ups in an industry and region as the product of the number of potential founders and their founding probability, which both depend on the number of employees in other industries in the region and other factors.

The problem that we face is that the dependent variable is a count variable of events for which we assume to be able to predict the probability. Hence, we use a neg-bin regression. It is obvious that we are not able to include all local factors that might influence the likelihood of people to start a firm in the set of independent variables. Therefore, we include random effects in the regression.

Fixed effects cannot be used because most independent variables are stable or change very little. Furthermore, we pool the number of start-ups for all years of observation in order to minimise fluctuations and maximise significance. This implies that we can use the values of the independent variables from one specific year, usually the year before the period in which the start-ups are counted.

We deviate from the standard neg-bin regression in two aspects. First, we explicitly define the number of potential founders $P_{i,r}$ that might start a firm dependent on various independent variables. We assume a linear function and write

$$P_{i,r} = A_i + \sum_k \left(s_k \cdot v_{k,r} \right) \quad (1)$$

The value A_i denotes the total number of start-ups that occur in the studied industry i in whole Germany. s_k is the coefficient that determines to what extend the variable k contributes to the number of potential founders. $v_{k,r}$ is the value of variable k in region r. If all coefficients s_k equal zero, the number of potential founders would be A_i. This corresponds to a case in which all founders decide about where to locate independently from there previous location (see Section 2.2). The start-up activity in a region would then not depend on any source of potential founders within the region.

If founders have a tendency to start firms in the region in which they have been before, as is repeatedly found in empirical studies (Schmude 1994, Cooper & Folta 2000, and Fornahl & Graf 2003), some coefficients s_k have to be positive.

We are aware of the fact that we introduce one degree of freedom because an increase in the number of potential founders has statistically a very similar effect as multiplying the start-up probability in the model with a certain value. Therefore, we use A_i as the basis number of potential

founders (without a coefficient), so that the coefficients in Equation (1) can be interpreted in relation to this number. As a consequence, $s_k v_{k,r}$ can be interpreted as the number of potential founders that are generated in region r by variable k in comparison to the number of founders that might move to the region.

As a second deviation from the standard neg-bin regression, we use a non-linear specification of the start-up probability which is defined in our approach by

$$p_{i,r} = \frac{1}{1 + \exp\left[c - \sum_k \left(a_k \cdot v_{k,r}^{\alpha_k} \right) \right]} \qquad (2)$$

Each variable k enters the standard logit function with two parameters, a coefficient a_k and an exponent α_k. This allows for different forms of the impact of local variables on the start-up probability.

The regression is conducted numerically[2]. Because a high number of independent variables are included, we use a significance level of 1%.

3.2 Empirical data

The independent variable is the number of start-ups in the studied industry. We use the 2-digit industry classification WZ93 of Germany, except of distinguishing the pharmaceuticals industry from the rest of the chemical industry. The industries that are studied are listed in Table 1 together with the total number of start-ups in Germany between 1999 and 2005 in the respective industries. The data on the number of start-ups is based on the 'IAB Establishment Register' – also called the 'German Social Insurance Statistics' (Fritsch & Brixy 2004). The data is obtained for each 3-digit industry and each *Kreis* (administrative district).[3]

Although the data is available on the level of administrative districts, we conduct our analysis on the level of *Arbeitsmarktregionen* (AMR, labour market regions). Labour market regions take the commuting of employees into account and are therefore more likely to reflect the above issue of founders starting their firm in the same region adequately. There are 270 labour market regions in Germany.

Industry code	**Industry name**	**Total number of start-ups**
DA15	Food products and beverages	11,186
DA16	Tobacco products	9
DB17	Textiles	1,484
DB18	Wearing apparel; dressing and dyeing of fur	1,877
DC19	Leather and leather products	415
DD20	Wood and wood products	5,390
DE21	Pulp, paper and paper products	682

[2] A non-linear neg-bin regression with random effects and the number of potential events depending on the independent variables is not available in the standard statistic tools, such as R and STATA, so that the regression is programmed and conducted in C++. The likelihood is maximised with the help of an evolutionary strategy. Pre-tests have shown that the obtained maximal likelihood changes only slightly (never more than by 0.5) after 150,000 calculation steps, so that we run 150,000 steps for each regression.

[3] Whenever there are one or two start-ups in a region and industry in a year, the data that we use contains a special mark because anonymity restrictions in Germany do not allow to obtain data about whether there are one or two start-ups. In these cases we assume that with 50% probability there was one start-up and with 50% probability there have been two start-ups. Since we use a likelihood maximisation approach this is no problem in the further analysis.

Industry code	Industry name	Total number of start-ups
DE22	Publishing, printing and reproduction of recorded media	9,564
DF23	Coke, refined petroleum products and nuclear fuel	77
DG24 without DG24.4	Chemicals and chemical products	1,293
DG24.4	Pharmaceuticals, medical chemicals and botanical products	423
DH25	Rubber and plastic products	3,220
DI26	Other non-metallic mineral products	3,866
DJ27	Basic metals	999
DJ28	Fabricated metal products, except machinery and equipment	21,245
DK29	Machinery and equipment n.e.c.	8,953
DL30	Office machinery and computers	733
DL31	Electrical machinery and apparatus n.e.c.	2,492
DL32	Radio, television and communication equipment and apparatus	1,736
DL33	Medical, precision and optical instruments, watches and clocks	7,850
DM34	Motor vehicles, trailers and semi-trailers	1,107
DM35	Other transport equipment	932
	Total	92,938

Table 1: Industries that are studied and the number of start-ups.

Let us consider the independent variables that are included in the analysis. Independent variables enter the above model at two places: they might contribute to the number of potential founders or they might influence the likelihood of a potential founder to start a firm. They might also enter at both places at the same time.

The core aim of the paper is to examine the effect of other industries. To this end, we include the number of employees in other industries in the region as an independent variable. Three kinds of other industries are of interest: Industries that are technologically related, supply industries and customer industries. For each studied industry we obtain the supply industries as those industries that produce at least 3% of all inputs that the studied industry uses according to the Input-Output table for Germany from 2000 (German Statistical Office). In the same way, all customer industries are defined as those industries that take at least 3% of the output of the studied industry that does not go to the end consumer. Technologically related industries are defined as those industries that have at least a 3% overlap in the patent classes in which they patent. To this end, the shares of patents from two industries that go to each patent class are multiplied and than added. If the sum is above 0.03, we define the two industries as technologically related. The concordance between 44 technological fields and 44 industrial sectors which is used in the analysis was designed by Schmoch et al. (2003) based on patenting data from 1997 to 1999 filed at the European Patent Office.

This provides us for each industry with a number of other industries that can be expected to have an impact on the start-up rate according to Hypotheses 1 to 3. The number of industries that have each of the three relationships are listed for all studied industries in Table 2. According to Hypotheses 1 to 3 these industries might influence the number of potential founders as well as their probability to start a firm. Therefore, all these industries are used as potential local variables in Equations (1) and (2).

Industry	total number of industries considered as factors	Number of industries that are		
		supplier industries	*customer industries*	*technologically related*

		Number of industries that are		
DA15	8	3	3	3
DA16	7	5	0	3
DB17	19	5	5	10
DB18	13	3	2	8
DC19	12	6	3	6
DD20	15	4	3	9
DE21	11	4	4	6
DE22	15	7	4	7
DF23	12	2	7	4
DG24 without DG24.4	10	3	3	6
DG24.4	8	4	2	3
DH25	12	4	3	9
DI26	16	6	2	10
DJ27	14	3	4	10
DJ28	12	3	5	9
DK29	13	5	4	9
DL30	11	4	3	6
DL31	12	4	4	6
DL32	11	5	5	5
DL33	15	8	4	6
DM34	9	4	0	7
DM35	12	5	3	6
Total	**267**	**97**	**73**	**148**

Table 2: Number of industries that are related to each studied industry.

In addition to these related industries, the industry itself can be expected to have an impact on the number of start-ups in this industry. Most founders come from firms that operate in the same industry. Furthermore, for most industries the same industry is the most important supplier and customer. Finally, the literature on local clusters repeatedly states that firms benefit strongly from the co-location with other firms of the same industry. Hence, we include the employment number in the industry itself in both Equations (1) and (2) as an independent variable. Data on the employment numbers in each industry and region are obtained from the IAB for the year 1999.

Further variables that might influence both the number of potential founders and their likelihood to start a firm are the total population in the region [TOTPOP] (obtained for 2000 from INKAR 2002), the number of employees at public research institutes[4] [PUBRES], the budget of the universities and technical colleges in the region [UNI] and the number of students at a university or technical college [STUD] (both obtained for 2000 from the German Statistical Office). These are the standard factors that are discussed in the literature as sources of potential firm founders. They are used here in both Equations, (1) and (2), assuming that they might provide potential founders and might influence the decision to start a firm. In order to control for spatial autocorrelation, we also include the number of start-ups in the same industry in all neighbouring regions as a factor in both equations [SPATCOR].

In addition, we use eight local variables as factors that only influence the probability of potential founders to start a firm. These are the share of population in the age of 25 to 50 years (2000)

[4] Obtained for 2000 from the yearly reports of the four big research associations: the Helmholtz Association, the Max Planck Society, the Fraunhofer Society, and the Leibnitz Association.

[AGE25-50], the GDP per inhabitant (2000) [GDP], the growth rate of the GDP (1994-2002) [ΔGDP], the population density (2000) [POPDENS], the growth rate of the population (1990-2000) [ΔPOP], the unemployment rate (2001) [UNEMP] (all obtained from INKAR 2002, 2004 and 2006[5]), and the share of employment in small [SMALL] (1-19 employees) and large [LARGE] (more than 500 employees) firms in the manufacturing sector (obtained from the IAB for the year 1999). All these variables are frequently studied in the literature in the context of start-ups.

It was observed that self-employment is linked to the availability of personal financial capital (van Praag 1996, Blanchflower and Oswald 1998). Individual capital encourages foundings because potential founders can use their savings to start the firm or have a security in case their firm fails. In regional level studies, an increase in the absolute number of local inhabitants (Guesnier 1994, Davidsson et al. 1994, Keeble and Walker 1994), growth in local gross national product (Reynolds 1994, Bade and Nerlinger 2000) and regional population density (Garofoli 1994, Davidsson et al. 1994, Spilling 1996) were used as indicators for local market growth. These demand side factors should have a positive effect on the probability to start a firm.

The available empirical results for the impact of the regional unemployment rate on the founding probability are mixed. Some researchers claim that high unemployment has a positive effect on firm foundings because agents have to secure their income which leads to necessity-based entrepreneurship (Reynolds 1994, Audretsch and Fritsch 1994, Guesnier 1994). Others say that high unemployment leads to low foundings because recessions are daunting to entrepreneurs (Garofoli 1994, Steil 1997). The share of small firms in a region in most studies has a positive effect on start-up activities (e.g., Davidsson et al. 1994, Audretsch & Fritsch 1994, Guesnier 1994). Reasons for this are for example the already mentioned role model effect as well as lower barriers to market entries in those regions (Steil 1997). The same positive impact can in most studies be found for large firms (e.g., Engel & Fier 2000, Almus, Egeln & Engel 1999) because those firms provide an incubator function, serve as customers for new start-ups and start-ups profit from outsourcing activities of large firms.

4. Results and discussion

In Section 2, three hypotheses have been formulated. All of them state that the start-up rate in an industry and region depends on the activities of other industries in this region. This implies that the developments of industries are not independent from each other, which causes a path-dependence in the industry structure in regions. Similar findings are reported by Braunerhjelm and Carlsson (1999), while Steil (1997) reports no dependence of start-up activities on the industry structure for East Germany which is probably caused by the restructuring processes of the East German economy after re-unification.

According to the three hypotheses, the employment in supplier, customer, and technologically related industries should play an important role for the start-up activity in a region. These sources, together with universities and public research institutes, should dominate the number of founder that are attracted from elsewhere to the region, reflected in the model by A_i.

In the following we will discuss four topics separately. First, we examine the results for all factors except the employment in the various industries (Section 4.1). Second, the impact of the employment in the industry on the start-up rate in the same industry is discussed (Section 4.2). Third, we examine what kind of relationship between industries causes them to have an impact on the start-up rate of each other (Section 4.3). Fourth, we depict the relationships between industries in order to grasp the structure of industrial path-dependence (Section 4.4).

[5] In a few cases we had to deviate slightly from the idea to take all variables from 1999 or 2000 because the values have not been available for this year.

4.1 Important factors for founding activities

In the literature on founding activities and the causes for differences between regions a number of factors is repeatedly stated (e.g. Reynolds 1994, Garofoli 1994, Audretsch & Fritsch 1999, Steil 1997, Nerlinger 1998), which are also included in this approach. The number of industries in which each of them has a significant (1%-level) impact is listed in Table 3.

Factor	positive impact on founding probability	negative impact on founding probability	source of founders
population	**6**	0	**16**
employment in public research institutes	0	0	1
budget of universities	1	**4**	1
number of students	**3**	**3**	0
spatial correlation (start-ups in neighbouring region)	0	**6**	**3**
share of population with an age between 25 and 50	**2**	**9**	**-**
GDP per inhabitant	0	**6**	**-**
growth rate of GDP	0	**10**	**-**
population density	**2**	**3**	**-**
growth rate of population	**3**	0	**-**
unemployment rate	**4**	**6**	**-**
share of small firms	**4**	**3**	**-**
share of large firms	0	**14**	**-**

Table 3: Number of industries in which the factor is found to have a significant effect on the founding activity in the region.

In total 22 industries are studied. Compared to the maximally possible value of 22 the entries in Table 3 are rather small. There seems to be no local factor that has the same kind of influence on start-up activities for all industries. The population in a region and the share of large firms come nearest to having a general impact. The impact of the other variables seems to be very industry-specific.

Nevertheless, Table 3 shows for some factors a clear picture, meaning that if there is an impact it is always of the same kind. In the case of some other factors the evidence is mixed. There are factors that are found to have for some industries a positive impact on the founding probability and for some other industries a negative one. Since in total we test a huge number of potential relationships between factors and founding rates, some results might be statistical artefacts. Therefore, we should interpret results carefully if they occur only for one industry.

In the case of the total population [TOTPOP] we obtain a very clear and strong result. The total population is a factor that very often positively influences either the number of potential founders (DA15, DB17, DI26, DJ28, DK29, DL31, DL32, DL33 and DM34) or the founding probability (DE22) or even both (in DB18, DC19, DD20, DE21, DG24.4, DJ27 and DM35). In most cases (16 of 22) the total population contributes to the source of potential founders (exceptions are those industries with low numbers of start-ups and the chemicals and plastic & rubber industries). This can easily be explained by the argument that the more people live in a region, the more people might start a firm. However, in some cases the total population affects (also) the founding probability. A possible explanation is the fact that a larger population implies a larger market, especially if the industry produces for the consumer market, and thus better conditions for establishing a firm.

In the literature a number of factors is repeatedly found to have a positive impact on the start-up rates in regions (see the references given above). These are the GDP per inhabitant [GDP], the growth rate of the GDP [ΔGDP], the population density [POPDENS], the growth rate of the population [ΔPOP], universities [UNI and STUD], public research institutes [PUBRES], and the share of employment in small firms [SMALL]. In our study these results are not confirmed for most of the variables. Especially in the cases of GDP and ΔGDP we find often negative impacts on the probability of potential founders to start a firm (see Table 3). In the literature a positive or at least no negative impact of GDP and its changes are normally identified. In contrast to most findings in the literature which are based on studies that include all industries or focus on technologically oriented start-ups, we cannot find this expected effect if we consider manufacturing industries separately. On the contrary, the negative impact for manufacturing industries leads to the conclusion that in a prosperous environment in which agents have alternatives to earn their living, e.g. by working in an established firm, the start-up likelihood is strongly diminished.

Universities can be expected to be rather a source of potential founders than a determinant of the founding decisions. There is only one industry in which we obtain results that confirm that universities provide the region with potential founders (DJ27: basic metals). Hence, we are not able to confirm, at least not with strong empirical evidence, that universities improve the local entrepreneurial situation by providing people that have the competences to start a firm. For the impact on the founding decision we find mixed results for the university budget [UNI] and the number of students [STUD]. There are different potential explanations for these findings. First, the overall budget of universities or the total number of students might not be sufficiently specific to explain start-up rates in specific industries. Second, universities might be too uniformly distributed in Germany to explain the varying start-up rates. Third, the number of academic start-ups might be too small in most industries to obtain results statistically.

The results from the literature are confirmed, although not very frequently, in the case of population growth [ΔPOP]. We find for three industries (DE22: publishing & printing; DJ27: basic metals; and DL30: office machinery) a positive impact of the population growth on the founding decisions. Regions that grow in population seem to motivate start-up activities or vice versa.

The advantages of new firms being located in densely populated regions range from the access to diversified input and output markets (e.g. capital, labour, services, suppliers, customers and knowledge) to a high probability of many face-to-face-interactions (Armington and Acs 2002). Besides this, start-ups also have to face up negative externalities when they are located in highly agglomerated urban regions. For instance, it is much more expensive to start and to run a business due to higher rents, business taxes or wages within such areas. All in all, population density might have a positive or a negative effect on firm growth.

We obtain mixed evidence for the variables POPDENS and SMALL. We are not able to confirm the results in the literature for these two variables. We rather find that their impact depends strongly on the industry that is studied. In some industries we find high start-up rates in regions with a high population density (DB17 and DL32) or a dominance of small firms (DC19, DJ27, DL32 and DM34), in some industries we find the opposite (DH25, DJ27 and DL31, and DE21, DL31 and DL33, respectively).

In the cases of the unemployment rate, the share of the population with age between 25 and 50, and the share of large firms mixed results are recorded in the literature. For the unemployment rate and the share of the population with age between 25 and 50 our study confirms these results. Different results are obtained for these factors for different industries (see Table 3). As Keeble and Walker (1994) we find more often a negative impact of the unemployment rate on the start-up rate in manufacturing industries (DA15, DC19, DE21, DE22, DJ28 and DL32). However, we also find some positive impact especially for high- and medium-tech industries (DF23, DJ27, DL30, DL31 and DL33). Hence, this impact of the unemployment rate seems to depend on the studied industry.

In the case of large firms [LARGE] we find a very clear negative impact on the founding decision.

In 14 industries the dominance of large firms in a region makes potential founders less likely to start a firm. This might be caused by the good opportunities that are offered in the region by these large firms in terms of salaries and career options.

Only in one industry (DG24 without DG24.4: chemicals without pharmaceuticals) a significant impact is found for public research institutes [PUBRES]. In this industry public research institutes contribute to the number of potential founders, as claimed in the literature (Cohen, Nelson & Walsh 2002). The rare empirical evidence might results from the following problem. There are many regions that do not have a research institute, so that the data contains many zeros and significances are low. Furthermore, some research institutes are deliberately set up in regions with little economic activities. We also do not distinguish between research institutes that research topics related to the studied industry and other research institutes in the empirical analysis. These facts are likely to interfere with the otherwise expected positive impact on start-up activities. However, we are not able to make a founded statement here.

The spatial correlation [SPATCOR] is included in this study for two reasons. First, the inclusion implies that our results are not disturbed by spatial autocorrelation. Second, we intended to study the relationship between the start-up activities in neighbouring regions. We find two kinds of impact that hold, at least, for a few industries. First, for three industries spatial correlation represents a source of founders. This means that the start-up activities in neighbouring regions show some correlation. We may interpret that some potential founders decide to start their firm in a neighbouring region or that, at least, founding a firm in the neighbouring region is much more likely than founding it elsewhere. Second, for six industries the spatial correlation term has a negative impact on the founding decision. This means, that if there is a high start-up activity in the neighbouring regions, founders are distracted from founding a firm in the region; maybe they decide to start the firm in the neighbouring region instead or they fear strong competition.

4.2 Path-dependence within the industry

In the theoretical section we discussed the interaction between industries. However, it can be expected that the number of employees in firms of the same industry have a strong impact on the start-up rate. This has been repeatedly shown in the literature (see, e.g., Fritsch & Audretsch 1994, van Praag 1996; for the general labour market approach see Evans and Jovanovic 1989). Furthermore, the discussion of local clusters is strongly based on the argument that an industry develops much stronger in a location in which it is already very present due to local externalities (see, e.g., Porter 1990, Fujita & Thisse 2002, and Brenner 2004). Besides this, according to input-output tables in most industries most of the inputs come from the same industry and most of the outputs go to the same industry. The technological relationship is also given within an industry, so that the arguments in Section 2 can be applied within an industry, probably even stronger than between industries.

Industry code	**Industry name**	***Impact on founding decision:*** a_k / α_k	***Source of potential founders*** s_k
DA15	Food products and beverages	not sign.	**2.424**
DA16	Tobacco products	not sign.	not sign.
DB17	Textiles	not sign.	not sign.
DB18	Wearing apparel; dressing and dyeing of fur	not sign.	**11.35**
DC19	Leather and leather products	not sign.	not sign.
DD20	Wood and wood products	**0.0002292 / 0.9756**	not sign.
DE21	Pulp, paper and paper products	not sign.	not sign.
DE22	Publishing, printing and reproduction of recorded media	not sign.	**16.15**

Industry code	Industry name	*Impact on founding decision: a_k / α_k*	*Source of potential founders s_k*
DF23	Coke, refined petroleum products and nuclear fuel	not sign.	not sign.
DG24 without DG24.4	Chemicals and chemical products	**0.03041 / 0.3302**	not sign.
DG24.4	Pharmaceuticals, medical chemicals and botanical products	not sign.	not sign.
DH25	Rubber and plastic products	not sign.	not sign.
DI26	Other non-metallic mineral products	not sign.	**4.905**
DJ27	Basic metals	**0.03430 / 0.2182**	not sign.
DJ28	Fabricated metal products, except machinery and equipment	not sign.	**27.21**
DK29	Machinery and equipment n.e.c.	not sign.	not sign.
DL30	Office machinery and computers	not sign.	**5.1490**
DL31	Electrical machinery and apparatus n.e.c.	**0.0004347 / 0.7652**	not sign.
DL32	Radio, television and communication equipment and apparatus	**0.06215 / 0.1450**	not sign.
DL33	Medical, precision and optical instruments, watches and clocks	**0.0000672 / 0.9659**	**10.18**
DM34	Motor vehicles, trailers and semi-trailers	not sign.	**0.8970**
DM35	Other transport equipment	not sign.	not sign.

Table 4: Results for each industry for the impact of the employment in this industry on the start-up rate.

The empirical results in Table 4 confirm this expectation partly. There are quite a number of industries in which the employment in the industry influences the start-up rate in the same industry positively. However, there are 9 (out of 22) industries for which no significant impact is found. The literature on clusters and local spin-offs suggests much stronger findings.

This might be caused by the fact that local clusters form not only within one industry, but also through the interaction between a number of industries. We take a closer look on the interactions between industries in the next two subsections. It might also be the case that the impact of an industry on the development of this industry in a region is strongest during an early phase of this industry's existence. We are not able to make a statement here because most industries in the used classification contain young and old sub-industries at the same time.

We do also not find a clear answer to the question of whether the employment in an industry affects that number of potential founders in the same industry and region or their probability to start a firm. In six industries the founding probabilities are influenced, while in eight industries employment in the industry seems to be a relevant source of potential founders. In the cases in which we find a significant contribution to the number of potential founders the value of s_k ranges between 0.897 and 27.21. This implies that it is around 1 to 27 times more likely that a randomly chosen employee in the industry and region starts a firm there than that a person who has decided to start a firm in the industry decides to move to the region and starts the firm there.

To sum up, we find quite some evidence for the claim that the economic activity (here in the form of employment) that is already present in an industry and region has a positive impact on the start-up activity in this industry and region. However, this impact is only in around half of the studied industries significant. Other factors are of similar importance. Especially, other industries play a role as discussed in the next subsection.

4.3 Relationships and path-dependence between industries

The main aim of this paper is to identify relationships and path-dependencies between industries.

Therefore, we tested for each industry the impact of a large number of other industries on the start-up rates. The number of industries that are considered in the study of each industry ranges between 7 and 19 (see Table 2). These industries have one or more out of three kinds of relationships to the studied industry: they supply the industry strongly, they are important customers, or they are technologically related. In Section 2 we have formulated a number of propositions about what kind of relationship should imply a strong influence on the start-up rates.

In order to check these propositions empirically we examine here the relationships between the studied industries and those industries that have a significant impact on their start-up rates. The frequencies of the occurrence of significant impacts for the three kinds of relationships are listed in Table 5.

Relationship	Positive impact on founding decision	Negative impact on founding decision	Contribution to potential founders	Number of included industries
Supplier industry	10 (10%)	8 (8%)	12 (12%)	97
Customer industry	9 (12%)	9 (12%)	18 (25%)	73
Technologically related	22 (15%)	8 (5%)	11 (7%)	148
Total number	33	23	35	267
Chi-square test (p-value)	0.651	0.254	**0.009**	
Own industry	6 (27%)	0	8 (36%)	22

Table 5: Frequencies of significant findings for industries with specific kinds of relationships to the studied industry.[6]

Let us first discuss each column in Table 5 separately. Starting with the second column, we find a quite high number of occasions in which the founding decision in an industry and region is significantly positively influenced by the employment number in another related industry. In total 33 such occasions are observed, which is 12.4% of the number of industries that are included in all studies. The same percentage for all local factors that are included in this study and usually examined in the literature is 10.1%. Hence, the employment in related industries shows a slightly higher importance as a positive influence on founding decisions as the factors usually studied in the literature. We conclude that the presence of other related industries is a relevant factor for potential founder in their decision to start a firm.

However, no specific kind of relationship between industries makes this influence especially relevant. The distribution of the occasions among the different kinds of relationship does not differ significantly from the same distribution of all studied industries (see the result for the chi-square test in Table 5). Industries with all the three different kinds of relationship seem to have the potential to positively influence founding decisions.

Considering the third column, there are also many – although slightly less – occasions in which the founding decision in an industry and region is negatively influenced by the employment number in another related industry. The fact that positive effects are found much more frequently confirms Hypotheses 1 and 2. A negative impact was argued in Section 2 to occur if the dominance of other industries in a region influences the founding conditions in an industry negatively, for example by causing high wages or by decreasing the availability of qualified labour. Again, Table 5 does not provide us with a significant result about what kind of industries might be more or less relevant in this context. All kinds of other industries might have such a negative impact or it is highly industry-depend what other industry influences start-up decisions negatively.

A more significant structure of relationships between industries is obtained for the question in which industries founders have worked before. Here, customer industries play an important role.

[6] The last row represents the total number of examined industries with these kinds of relationships. The fourth row contains the results of a chi-square test comparing the distribution in the respective row with the distribution in the last row.

The presence of customer industries generates significantly more often additional potential founders in an industry than the presence of other industries. This supports the theoretical argument in Section 2.3 that often employees leave a company to start a firm that supplies this company. Nevertheless, the provision of founders by other industries is not restricted to this mechanism (see Section 4.4).

Table 5 also confirms that the main impact of other industries on the start-up rate in an industry is caused by these other industries providing potential founders (Hypothesis 3). There are more significant results obtained for a positive impact on the number of potential founders than for a positive or a negative impact on the founding decision, although the frequency of significant findings for positive impacts on the founding decision is not much smaller. However, we should take into account that an impact on the founding decision results from two mechanisms: attracting founders to the region (Section 2.1) and making potential founders in the region more likely to start a firm (Section 2.2). We find that the third mechanism, providing potential founders in the region (Section 2.3), is statistically more visible than the other two mechanisms together.

To sum up, we find that other related industries have an impact on the start-up rate in an industry and region that is comparable to those of other local factors usually analysed in the literature. Most frequently other industries provide potential founders and customer industries are most relevant in this context. Furthermore, other related industries also influence the founding decision, often positively but also sometimes negatively. All this impacts cause the start-up activities in a region to depend on the industrial structure present in this region. Hence, the development of regions is path-dependent.

4.4 Industrial interrelationship structure

Above it has been found that industries often provide potential founders for start-up activities in other industries. Besides the total population in a region, which is across all industries the most important source of potential founders, the employment in other industries explains the largest part of the source of founders. It is much more important than the deliberate move of founders into the region and other local factors, such as universities and public research facilities.

A measure for the importance of this source of potential founders is the parameter s_k. This parameter is defined in relation to the probability of a founder of a start-up to move into the studied region. A value of s_k=1 for another industry denotes a case in which an employee in this other industry has the same likelihood to start a firm in the considered industry and region as the likelihood that a founder moves to the region to start the firm there. For the population [POP] in the region the values of the parameter s_k range between 0.014 and 0.447. For the employment in the studied industry we obtain values between 0.897 and 27.21. Employees who work for a firm in the same industry are found to start an own firm in this industry with a 20 to 700 times higher likelihood than any person in the region.

The values of s_k for other industries range between 0.75 and 38.99 and employees in these other industries start a firm with a 10 to 300 times higher likelihood than any person in the region. Hence, employees in these industries are similar likely or slightly less likely to start a firm in the studied industry than employees who work in this industry. However, the industry itself appears more often to be significantly contributing potential founders than related industries (see Table 5), which confirms Hypothesis 3. Employees in the same industry are the most likely founders of start-ups, but employees in other related industries, especially customer industries, follow not much behind.

This fact is a strong indication for an inter-industrial path-dependence in regional development. One industry breads another industry. Thus, if a region is strong in one industry, it is also more likely than other regions to become strong in another industry. This connection seems to occur most frequent from a customer industry to its supplier industry. However, other connections are also found (see Table 5). We depict all breading connections between industries in Figure 1.

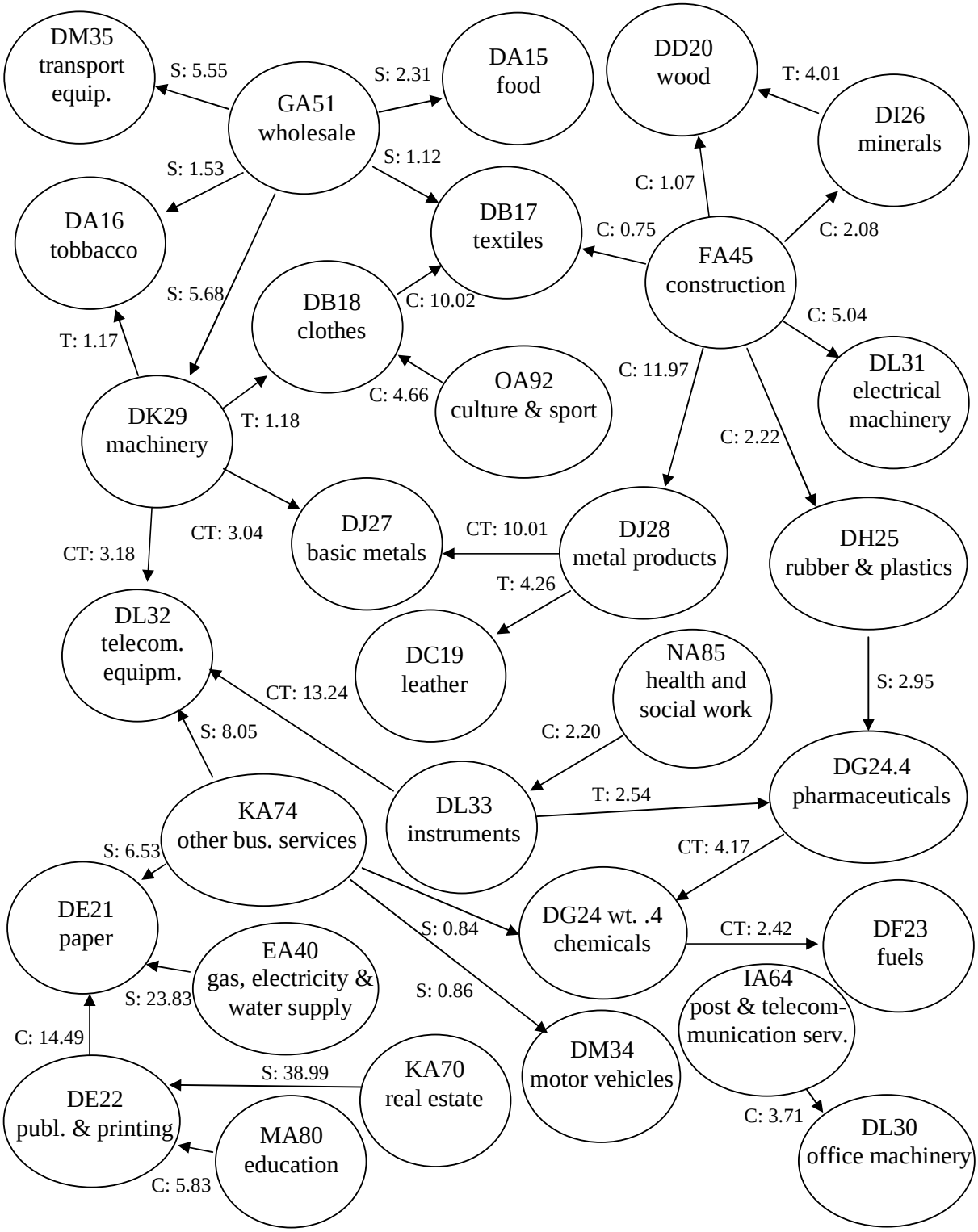

Figure 1: Connections between industries based on all significant finding in which one industry provides potential founders for another industry.[7]

[7] Letters denote the kind of connection between the industries (S: supplier industry; C: customer industry and T:

Most of the connections in Figure 1 depict a customer industry influencing the start-up rate in one of its supplier industries. Some industries are of specific importance because they provide potential founders for many other industries. These are especially the industries KA74 (other business services), GA51 (wholesale), FA45 (construction) and DK29 (machinery). Regions that have high employment in these industries have high start-up rates in a number of manufacturing industries. These four industries are very different in their characteristics (see Figure 1).

The industry KA74 (other business services) contains firms that do technological consulting and conduct research and development for other firms. Employees in this industry collect during their work a lot of experience with technology and products of their customer firms. They might use this experience to start their own firm supplying the same market as their former customers. This means that industry KA74 provides potential founders to industries for which it is a supplier, which goes against the finding that founders originate mainly from customer industries.

The same holds for industry GA51 (wholesale). Employees in this industry collect experience with the products they sell. They seem to use this knowledge to start an own firm that produces the good which they have supplied before. It can be expected that not all kind of wholesale is relevant for the manufacturing industries, but especially those wholesale companies that trade the products of manufacturing industries provide potential founders for these industries.

Industry FA45 (construction) requires a wide variety of different materials from a number of supplier industries. Our results suggest that employees in industry FA45 are a significant source of founders in these supplier industries. These employees collect knowledge about the needs of the construction industry and use this to start a firm that supplies the needed products. This is in line with the general finding that often employees in customer firms start a firm that supplies these firms or, at least, the industry in which they worked before.

The situation is different for industry DK29 (machinery). This industry provides potential founders mainly to industries that are technologically related (see Figure 1). This implies that employees in the machinery industry acquire technological knowledge during their work that can be successfully used in other technologically related industries.

If we exclude the two specific industries GA51 and KA74, most connections are based on a customer relation or a technological relationship. The phenomenon that supplier industries might provide potential founder seems to be restricted to these two industries. However, often the classification into GA51 and KA74 or a manufacturing industry is not that obvious nowadays. Hence, the importance of supplier industries seems to be caused by a problem with classifying firms.

Two other things become obvious in Figure 1. First, there is quite some connection between manufacturing industries and service industries. We only analysed manufacturing industries in this study. Nevertheless, many service industries have shown up to have a significant impact on the development of these manufacturing industries. The results suggest that employees in the service sector collect experience that is relevant for founding a firm in the manufacturing sector. This shows that manufacturing activities and service activities are not that distinct nowadays. Something similar is identified for Cambridge (U.K.) where spin-offs from technical consultancies, often becoming involved in product design and the commercialization of new technologies, can be observed (Lawson, 2003).

Second, nearly all studied industries are connected, at least indirectly, with each other in Figure 1. Thus, the dependence between industries does not only apply to a few industries. It is a general feature that connects (almost) the whole economy. Hence, economic activity in regions is very path-dependent. More activity in a number of industries leads to more activity in a number of

technologically related industry. Numbers are the parameters s_j, which denote the relative (to a founder moving to the region) probability of an employee in the industry to start a firm in the other industry.

additional industries. Strong regions have an advantage not only in the industries in which they are strong but also in many related industries.

5. Conclusions

This paper analyses the start-up rates in industries and regions. It finds that the number of potential founders and their probability to start a firm is both significantly influenced by the activities of other industries in the region. Different kinds of other industries, technologically related, supplier and customer industries, play a role. The most dominant impact is identified for customer industries on the number of potential founders in a region. However, for all kinds of related industries a number of significant results are obtained.

Besides this, we find very mixed results for the factors that are usually studied in empirical analyses of start-up activities. Robust results, which hold in the same way for a number of industries, are only found for the population as a source of potential founders and the share of large firms, which negatively affects the decision to start a firm. Quite frequently the number of employees in the industry itself provides potential founders and has a positive impact on their founding decision. The GDP per inhabitant and the growth of the GDP are found to have often a negative impact on the founding decision. For all other factors we find weak or very mixed evidence.

Hence, we can conclude that the actual industrial structure in a region determines strongly the start-up activities in this region. Start-ups are much more likely to occur in industries that are already present and industries that are related in some way – technologically or by buyer-supplier relations – to the existing industries. As a consequence, the evolution of the industrial structure in a region is path-dependent.

This also means that a new industry will not occur and develop in every region with the same probability. Local factors matter to some extent. The industrial structure plays an important role. This has also important consequences for regional policy. If policy makers try to get a region forward by establishing a new industry there, they should strongly consider the already existing industrial structure.

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