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Industry Evolution in Varieties-of-Capitalism: a Survival Analysis on Wind Turbine Producers in Denmark and the USA

Max-Peter Menzel and Johannes Kammer

Utrecht University
Urban & Regional research centre Utrecht

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Max-Peter Menzel* and Johannes Kammer**

Abstract: Klepper developed a theory that explains the evolution of industries purely by the inheritance of firm-specific factors. Institutional approaches argue that the evolution of industries differ according to their institutional environment. We prose an extension of the heritage theory to analyse institutionally induced differences in evolutionary patterns. In doing so, assumptions from the Varieties of Capitalism approach on firm performance in different institutional contexts are integrated into the heritage theory. Such a perspective would expect that institutional differences affect the connection of a new industry to established resources. We apply a survival analysis of wind turbine manufacturers in Denmark and the USA, which represent different types of capitalism. We find that the industries differ both in entry pattern and performance. Compared to the US, the Danish industry forms slower and firms benefit when they adhere to already established resources like diversifiers, while others like startups of spin-offs perform worse.

*Corresponding author: menzel@geowiss.uni-hamburg.de, University of Hamburg, Institute of Geography. Bundesstraße 55, D-20146 Hamburg, Germany

** Vattenfall Europe Windkraft, Überseering 12, D-22297 Hamburg, Germany

Introduction

There are different explanations on the drivers behind the evolution of industries (Abernathy and Utterback 1978, Murmann and Frenken 2006). Klepper developed a heritage theory that explains the evolution of industries based upon firm routines (Klepper 1997, Klepper 2001). Firms perform according to their pre-entry experience. Early industries are marked by many entrants. Firms with the best routines by their R&D investments steadily increase competitive pressure in an industry, which results in a shake-out of less competitive firms (Klepper and Simmons 2000).

This focus on pure firm specific factors determining industry evolution is contrary to expectations form institutional perspectives (Nelson 1993, Boyer 1997, Hall and Soskice 2001, Coriat and Dosi 1998). Institutional approaches would argue that the evolution of firms and industries is affected by the institutional setting in which they are embedded (Lundvall 1988, Cooke 1992, Saxenian 1994). From this view, institutional differences would not only lead to deviations in evolution between industries (Malerba 2002), but also between regions and countries (Piore and Sabel 1984, Martin 2000).

However, all studies applying his heritage-framework, including diverse industries like automobiles (Klepper 2007; Boschma and Wenting 2007), tires (Bünstorf and Klepper 2009), book publishing (Heebels and Boschma 2011), fashion houses (Wenting 2008) or semi-conductors (Klepper 2010), provide evidence for the main lines of the theory.

Due to the many studies applying the heritage framework, studies on industries like laser producers in the US (Klepper and Sleeper 2005) and Germany (Buenstorf 2007) as well as automobile producers in the US (Klepper 2002), Germany (Cantner et al. 2006) and Great Britain (Boschma and Wenting 2007) allow also for country comparisons. All studies show comparable results. The few deviations are explained by the particularities of the specific case. For example, the longer times till the shakeout in the German automobile industry compared to the US industry is explained by slower market formation (Cantner et al. 2006). The larger number of spin-offs in the German compared to the US laser industry is interpreted as a sign for entrepreneurial opportunities (Buenstorf 2007). These are only small differences. Nevertheless, the question is justified, if these differences in industry evolution are random or do they reflect a structural bias.

Answering this question requires integrating assumptions into the heritage framework on how institutional affects would affect the evolution of firms and industries. For this task, we apply the Varieties of Capitalism (VoC) approach (Hall and Soskice 2001) on the heritage theory. Like the heritage theory, the VoC approach dedicatedly focuses on the firm as unit of analysis. While Klepper (1996; 2002) argues for firm routines affecting industry evolution, the VoC approach considers the behavior of firms in relation to its institutional environment as crucial. Aggregate outcomes from firm activities diverge to two ideal types of capitalism: liberal market economies (LME) and coordinated market economies (CME). Firms benefit when they adjust their activities in a way that they fit to their institutional environment (Hall and Soskice 2001). Thus, we would expect differences in the evolutionary pattern of an industry between an LME and a CME. The common focus on the firm level allows deriving assumptions on firm performance from the VoC approach that can be tested in the heritage framework.

To analyze differences in industry evolution between LMEs and CMEs, we apply a survival analysis on US and Danish wind turbine producers from 1973 to 2009. Various reasons apply for this selection. First, the VoC approach already assigned the US and Denmark to two different institutional systems: the USA as an example of a LME, and Denmark as an example of a CME (Hall and Soskice 2001, c.f. Campbell and Pedersen 2007). Second, VoC studies intend to understand contemporary differences between countries, they usually cover the time till the 70s (Hall and Gingerich 2009). This constraint requires the analysis of an industry that evolved since then and rules out older industries like automobiles. Third, the industry in both countries grew to a considerable size at the same time and. Fourth, there are already several qualitative studies on the WEC industries in Denmark and the US (Karnøe 1999, Garud and Karnøe 2003, Van Est 1999) that provide an in-depth investigation of institutional differences between the US and Denmark with respect to wind turbine industry.

The paper proceeds as follows. The next section presents the heritage theory and a review on empirical results. The third section describes the VoC approach and elaborates how institutional differences would affect industry evolution. The fourth section combines heritage theory and VoC and derives hypotheses, which can be tested within the heritage theory framework. The fifth section reviews qualitative accounts on the Danish and US wind turbine industries and how they match to the assumptions made by the VoC approach. The sixth section describes our data base and analyses difference between the US and Denmark regarding entry pattern and industry formation. The seventh section moves to the firm level and compares performances of US and Danish producers. The eights section concludes.

The Heritage-Theory of Klepper

The heritage-theory of Klepper is mainly based on three observations: most industries experience a shakeout, marked by a number of exits; firms and entrepreneurs with experience in the same or a related industry outperform entries without that experience; the performance of firms is related to the performance of their parent firms (Klepper 1996, Klepper 2001, Klepper 1997).

Based on these observations, Klepper developed a theory to explain industry evolution by inheritance of firm routines. His theory is based on three different lines of argument (Klepper 2002). The first concerns the quality of firm routines. Entries benefit from previous experience in other or related fields (Frenken et al. 2007) or as spin-offs from the quality of their parent's routines. The better a firm's routines, the better it performs. Furthermore, better performing firms sooner gets the size to generate spin-offs. As spin-offs inherit the routines of their parent firms, they also grow faster and sooner might spun-out new firms themselves. The second line of argument says that firms with better routines also attract better employees. This in turn leads to further improvements in routines, faster growth and sooner generation of spin-offs. The third line connects firm with industry dynamics. Firms reduce product prices by investment in R&D. When prices undergo a certain threshold, a shakeout occurs and only the most competitive firms survive (Klepper 1996; Klepper 2002). Early entrants have more time to invest in R&D and firms with better routines can invest larger amounts, i.e. especially early entries with pre-entry experience survive the shakeout

In the following, we describe the studies on the automobile industries in the US (Klepper 2002), Germany (Cantner et al. 2006, Von Rhein 2008) and Great Britain (Boschma and Wenting 2007) in more detail, as they allow for a country comparison. Arguing that these past developments reflect nowadays institutional differences would be a bold assumption, even if national institutional systems remain remarkably stable over time (Nelson 2002). But this comparison gives an impression on country differences in industry evolution.

Table 1 presents information on the time of industry formation, defined by number of years from the first firm till the start of the shake-out; the percentage of intra-industry spin-offs (i.e. entries with experiences in the respective industry[1]) and experienced entries (both firms and entrepreneurs from related fields; we indicated different measurements of relatedness in a footnote) as well as how this pattern changes over time. The table also includes hazard rates of experienced entries and spin-offs compared to inexperienced entries. As most studies

[1] Buenstorf (2007) indicates that also this measure can imply different definitions that might result in different numbers.

compare different models, we give the results for the model with the least variables, which yet includes different entry cohorts, pre-entry experiences and allows differentiating between entry time and experience. As experienced entries are defined in different ways, which also affects the composition of inexperienced firms, this comparison can be a rough indicator of country differences at best.

The table shows that the time of industry formation differs strongly, from 12 years in the US to 38 years in Germany. Also the proportion of spin-offs differs. It ranges from 20 per cent in the US to 11 per cent in Germany. The temporal change of entry pattern can only be compared between the US and Great Britain. While the US industry show decreasing proportion of diversifiers and an increase of spin-offs over time this ratio is stable in the British industry. All studies show better survival rates for experienced firms and the studies that also consider spin-offs also found lower hazard rates. The US studies indicates the least advantage of pre-entry experiences over inexperienced entries. Yet, this difference surely is affected by the different measures of pre-entry experience.

Together, the overview shows that the industries in the three countries especially differ in the duration of industry formation and entry pattern. These differences are argued to emanate from the particularities of the industry or the single case (Simons 2001). Cantner et al. 2006, 56) for example explain the slower industry formation in Germany by smaller sized firms and specific market development in Germany. Yet, the question arises if such idiosyncratic explanations can be retraced to more general institutional differences between countries.

<table>
<tr><th>Study</th><th>t industry formation</th><th>% entry exp vs. Spin-offs</th><th>% entry exp vs. spin-offs over time</th><th>Hazard rates of Exp/Spin in % compared to inexperienced firms[2]</th></tr>
<tr><td>Klepper 2002), US</td><td>12</td><td>31[3]/20</td><td><table><tr><td></td><td>exp[4]</td><td>Spin</td></tr><tr><td>1.</td><td>42</td><td>7</td></tr><tr><td>2.</td><td>28</td><td>17</td></tr><tr><td>3.</td><td>26</td><td>35</td></tr></table></td><td>-37[5]/-49

(Model 4)</td></tr>
<tr><td>Cantner et al. 2006); Germany</td><td>38</td><td>56[6]/</td><td><table><tr><td></td><td>Exp</td><td>Spin</td></tr><tr><td>1.</td><td>75</td><td></td></tr><tr><td>2.</td><td>67</td><td></td></tr><tr><td>3.</td><td>50</td><td></td></tr><tr><td>4.</td><td>49</td><td></td></tr></table></td><td>-55/

(Model 3)</td></tr>
<tr><td>Von Rhein 2008); Germany</td><td></td><td>46/ 11[7]/</td><td>Not apply</td><td>-58/-74

(Model A)</td></tr>
<tr><td>Boschma and Wenting 2007); Great Britain</td><td>25</td><td>68[8]/ 17</td><td><table><tr><td></td><td>exp</td><td>Spin</td></tr><tr><td>1.</td><td>75</td><td>15</td></tr><tr><td>2.</td><td>63</td><td>19</td></tr><tr><td>3.</td><td>65</td><td>17</td></tr></table></td><td>-57*/-73*

(Model 3)</td></tr>
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Table 1: Comparison of the Evolution of Automobile Industries in the US, Great Britain and Germany

Varieties of Capitalism and Industry Evolution

The VoC provides a framework to elaborate expectations on how institutions affect firm behavior. The basic assumption of the VoC is that firms chose forms of coordination that are

[2] The respective formula is 1-exp(beta)*100 (c.f. Klepper 2002, Cleves et al. 2008).
[3] Total number of firms is 713, with 120 experienced firms + 108 experienced entrepreneurs and 145 spin-offs.
[4] Based on Table 1 in Klepper (2002, 653).
[5] Reduction of weighted average of hazard rates for experienced firms and entrepreneurs. The respective reduction of firms and entrepreneurs with experience in bicycles, engine, carriages and wagons is 54%.
[6] Firms and entrepreneurs with a background in another (most of them carriages and wagons) or the same industry, spin-offs are subsumed under this category.
[7] Von Rhein (2008) uses the same data set like Cantner et al. (2006), which allows to differ between number of spin-offs and experienced firms. Their data base comprises 349 firms, among them 196 experiences firms. Experienced firms comprise 56% of all entrants. From the 37 spin-offs indicated by Von Rhein (2008), we can calculate 159 experienced, resulting in 46% diversifiers and 11% spin-offs.
[8] I.e. experience in related industries like bicycle or coach making or semi-related industries like engineering.

institutionally supported. Institutional differences between countries lead to different behaviors of the firms, while institutions adapt to economic practices and actions vice versa (Hall and Gingerich 2009; Hall and Soskice 2001). Institutions are complementary, i.e. institutions are interdependent and “presence (or efficiency) of one increases the returns from (or efficiency of) the other“ (Hall and Soskice 2001, 17). These complementarities aggravate the altering single institutions and consolidate or reinforce institutional differences between countries.

Upon this framework, the VoC approach distinguishes between to two archetypes of capitalism: liberal and coordinated market economies. In LMEs, coordination takes place mainly via markets, competitive relations, contracting and internal corporate hierarchies; in CMEs, non-market institutions support strategic interactions and collaborations, which serve to address and align the needs of different stakeholders (Hall and Soskice 2001). These coordination differences find their expression in different spheres. For example, labor markets in LMEs are shaped by flexibility and investment in general skills that can be applied in different jobs, while labor markets in CMEs are shaped by long-term relations and investment in specific assets.

How institutional differences between LMEs and CMEs affect economic practice is exemplarily described the difficulties manufactures in Canada (a LME) had with implementing machines designed in Germany (a CME). The same machines that worked well in Germany caused difficulties in Canada. Gertler (1995) described institutional differences as responsible for it. The machines were designed for the workplace practices in Germany. Long-term relations and a tradition of workforce training enables machine operators to get used to the new machines. In contrast, workplace practices in Canadian factories are shaped by arms-lengths relations, a highly mobile workforce, and a steady change in machine operators, which usually had neither the time nor the support to manage the comparatively complex machines. These institutional differences led to malfunctions of the machines in Canada that worked well in Germany.

Unfortunately, the VoC approach does not decisively deal with the evolution of industries. But it makes assumptions on how different forms of co-ordination affect the way of how firms allocate their resources, innovate and transfer their resources in new fields of activity. LMEs allow to quickly adjusting and switching processes and resources. This capacity enables firms in LMEs a comparatively easy exploitation of technology developments outside of existing paths or paradigms. In CMEs, long-term relationships favor incremental developments. Firms in CMEs benefit from investing into assets "whose returns depend heavily on the active cooperation of others" (Hall and Soskice 2001, 17).

These differences in resource allocation lead to different prevailing innovation modes. Hall and Soskice (2001, 38f, emphasis in original) distinguish between

> "*radical* innovation, which entails substantial shifts in product lines, the development of entirely new goods, or major changes to the production process, and *incremental* innovation, marked by continuous but small-scale improvements to existing product lines and production processes."

The assumption on the structural differences in innovation between LMEs and CMEs is contested by empirical studies. Taylor (2004) show with patent data that actually the US is the only country that specializes in radical innovation. Akkermans et al. (2009) indicates also upon patent data that both LMEs and CMEs can specialize in radical innovations, but in different fields: LMEs in chemical products and electronics and CMEs in machinery and transport equipment. Yet, the distinction made by Hall and Soskice (2001) regarding innovative activities refers not to the radicalness of an innovation, but to the way resource allocation is rewarded. LMEs award resource allocation when it is independent from established ones and takes place in new filed, while CMEs award resource allocation when it is exploiting synergies with existing ones and takes place in established fields (c.f. Akkermans et al. 2009).

Established industries are marked by distinct resources and institutions (Malerba 2002). Emerging and growing industries first have to develop these specific assets and supporting institutions over time (Boschma 1997). They thus depend on resource transfers from established industries (Storper and Walker 1989). We assume that differences between LMEs and CMEs in the way they switch resources from established industries to new industries affect industry evolution: new industries in LMEs evolve loser, while new industries in CMEs evolve tighter connected to established industries.

The Heritage theory from a VoC perspective

The VoC approach argues that switching of resources into new fields is easier in LMEs. Firms in LMEs benefit from independence of old and established fields, while firms in CMEs benefit from their connection to it. The heritage framework distinguishes entries according to their relation to the new industry. This distinction enables the analysis of differences in resource transfer into a new industry.

The heritage-framework depends on two sets of key variables: one set measures different qualities of pre-entry experience. The granularity ranges from a simple separation between firms with production experience in the same or related fields and inexperienced startups (Cantner et al. 2006) to differentiation between entrepreneurs and firms, different degrees of relatedness (Klepper 2002, Boschma and Wenting 2007) and forms of spin-offs (Buenstorf 2007). The second set of variables consists of time data on firm entry and exit. These data allow denominating entry according to the phase of the industry life cycle, time of industry evolution and constructing survival time as dependent variable.

We operationalize the processes assumed by the VoC approach within the Klepper-framework in the following way. New industries depend on entries (Klepper 1996). We use firm entries as indicator for resource transfer and generation of the new industry. The heritage theory framework describes four forms of connections to established industries (Klepper 2002, Boschma and Wenting 2007). The first is entry by diversification. The connection to established fields is obvious for diversifiers, which still remain active in other industries, at least for a while. They also might apply established production competencies into the new industry. The second form is entry from related fields. Entries with this background transfer more specific routines to the new industry that might be applied for product development (Frenken et al. 2007, Boschma and Wenting 2007). Both diversifiers and entrepreneurs can enter from related fields. The third form is the intra-industry spin-off. In contrast to the previous entries that benefit from connections to established industries, intra-industry spin-offs formed on resources already built up in the new industry. The last category comprises startups without experience from related industries, which exhibit the least connection to established resources.

In addition to connections to related fields, the VoC-framework would also expect different rates of resource transfer to new industries in LMEs and CMEs. Dates on entry and exit dates of firms serve to analyze the timing of resource transfer and to analyze differences in temporal patterns. The time span from the first entry till the start of the shakeout serves as measure for the speed of industry formation. Finally, length of survival as measure of performance enables us to differentiate between different firm performances

We expect that the differences in resource transfer in CMEs and LMEs affect entry pattern, duration of industry formation and performance of different entry types, thereby altering industry evolution. Entries in CMEs are more constrained by established resources, while firms in LMEs can act more independently from them. We therefore expect in CMEs a larger proportion of entries that adhere to established industries, either with respect to production experience or regarding technological relatedness (Breschi et al. 2003). Accordingly, we expect more startups and spin-offs in LMEs.

We expect that the disadvantages of CMEs in freely switching resources into new field results in a slower intensity of firm formation. We additionally expect that these firms also have a lower capability to transfer resources in R&D and thus a slower increase in productivity (Klepper 1996). As this increase in productivity causes the shake-out, we expect a longer time span between first entry and start of shakeout in CMEs compared to LMEs as indicator for time of industry formation.

Furthermore, we also expect that these differences in industry formation also affect temporal patterns of entry. The heritage theory expects diversifying firms at the beginning and spin-offs in later phases. An example for this pattern is the number of entries in automobiles in the US (see Table 1). We yet expect a slower industry formation in CMEs and entries to longer benefit from resource transfer from established industries. As a result, we expect diversifying firms and entries from related fields in CMEs to enter at considerable extent also at industry maturity, i.e. the assumed overall difference in entry pattern would mostly accrue from differences in at later stages.

Finally, the heritage framework allows to measure performance of different entry types. The heritage-theory expects those firms with better routines performing better, while the VoC would expect that firm performance depends on how firms' actions relate to their institutional environment. We expect that those firms in CMEs perform better that can exploit synergies to established fields, i.e. diversifiers and entries benefiting from knowledge of technologically related fields. In contrast, we expect those firms in LMEs to perform better that allocate their resources independent from the requirements of other fields, i.e. startups from unrelated fields, as well as spin-offs that benefit from resources already established in the new industry.

We expect this general assumption also mediated by temporal developments. The heritage-theory assumes changes in firm performance during the industry life cycle (Klepper 1997). Investments in R&D by early entrants hardly can be caught up by later entrants, whereby early entrants often outperform later entrants. Industry formation and the establishment of a respective production system is assumed to take longer in CMEs and firms in CMEs benefit when they relate their activities to established resources. We therefore expect late entering diversifiers and general entries benefiting from knowledge in related fields a smaller disadvantage in CMEs compared to LMEs.

	No. of		Performance of	
	early	late	early	late
inexp startups	0	-	-	-
diversifiers	0	+	0	+
relatedness	0	+	0	+
spin-offs	0	-		-

Table 2: Expectations on entry and performance of firms in CMEs compared to firms in LMEs

Klepper developed his theory on US industries (Klepper 2002, Klepper 2001, Bünstorf and Klepper 2009). The US is considered as a paradigm example of a LME (Kenworthy 2006, Akkermans et al. 2009). We therefore take his theory as a baseline model for LMEs. In addition to the expected longer time span between first entry and start of shakeout, Table 2 summarizes our assumptions on entry pattern and firm performance of CMEs compared to LMEs.

Varieties of Capitalism, Policies, Resource Transfer and Innovation in the US and Danish Wind Turbine Industries

All accounts agree that the US is a liberal market economy (Hall and Soskice 2001; Campbell and Pedersen 2007). Some even argue that the US is too a typical LME to compare it with other forms of LMEs like the UK or Canada (Taylor 2004, Kenworthy 2006). The assignment of Denmark as a CME by Hall and Soskice 2001), however, is contested. While Hall and Gingerich (2009) confirm Denmark as a CME, Kenworthy (2006) defines Denmark as an intermediate form and Campbell and Pedersen (2007) argue that Denmark is a hybrid form of capitalism[9]. This tentativeness requires elaborating to what extent the developments in the US and Danish wind turbine industries fit into the categorizations made by the VoC approach.

Fortunately, the institutional underpinnings of these two industries are well analyzed. Especially the studies by Karnøe (1999) and Garud and Karnøe (2003) are useful in this respect, as they analyze how institutional differences caused actors in the two industries to follow different innovative approaches: a technology driven "breakthrough" approach in the US, and an interactive driven "bricolage" approach in Denmark (Garud and Karnøe 2003).

Karnøe (1999) retrace the reasons for the different approaches to the stronger implementation of Fordist and Taylorist modes of organization in the US compared to Denmark. This implementation results in a high degree of division of labor in the US, both within firms by a strong division between blue and white collar worker and between firms in the form of high degree of market based exchange. This development is reflected in the US wind turbine industry, where different tasks like design and production were strongly separated. US firms had a strong emphasis on in-house research and knowledge related collaborations between firms were muted. Interactions mostly took place on a marked based level. Even maintenance and ownership of windmills were separated, as windmills were treated as financial investments.

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[9] Campbell and Pedersen (2007) describe the recent economic success of Denmark by liberalization of labor market, vocational training and industry policy. Yet, these sea changes took place in the 90s. It is unclear to what extent they affected the industry evolution in Denmark, which already started in the 70s. In contrast, Kenworthy (2006) analysis over the years 1970-2000 overlaps with our period of investigation.

Yet, this separation enabled a fast transfer of resources into the emerging industry. In addition to 900 Mio$ in tax exemption, the industry benefited from a research program involving amongst others NASA, the Department of Energy and technology driven producers from aircraft construction, accounted for 486 Mio.$ between 1974 and 1992 (Gipe 1995, Table 3.2). It also included universities that offered coursed in wind turbine design from the mid 70s (Karnøe 1999). The research program was mostly devoted to basic research with the intention to create breakthroughs in wind turbine design.

The “breakthrough thinking” (Karnøe 1999) that was formed in this institutional setting led to a light-weight model, characterized by the combination of rapid rotation and light material and large developmental steps between each new product generation (Garud and Karnøe 2003). A number of technology oriented spin-offs from aircraft producers and universities resulted from these developments.

Danish firms organized their relations and innovation processes in a different way. Denmark shifted to a lesser extent towards a Fordist mode of production. Traditional forms of crafts based production and worker education remained important. The separation between tasks of the production process was thus less sharp, design and production were strongly interlinked and hierarchical differences were less pronounced and relations to users important. This form of organization requires a high degree of interaction, not only between different departments of a single firm, but also between firms and to windmill owner. Garud and Karnøe 2003) describe the Danish wind turbine engineers as “communities of practice” (Brown and Duguid 2001).

Compared to the US, the resources invested into the new industry were small: 53 Mio $ in basic research and about 150 Mio $ in subsidies and tax exemption between 1974 and 1992 (Gipe 1995, Table 3.2). Yet, in 1979 the state demanded that wind turbines are to be approved by the Danish Wind Turbine Test Station (DWTS). As a result, turbine producers collaborated with the DWTS to get their systems approved (Karnøe 1999).

Due to the few resources devoted to the new industry, entries were mostly small firms and entrepreneurs that adhered to local competencies in construction of agricultural machineries, shipbuilding or even handcrafts like blacksmith. Firms started with a design invented already by Juul in the 50s and proved to be reliable (Garud and Karnøe 2003). Each firm incrementally improved the design. Improvements were imitated by other firms, even if the underlying principles were not understood. New designs were marked by only incremental improvements, yet short periods of development (Garud and Karnøe 2003). The "Danish Design" (Heymann 1995b; Oelker 2005) that resulted from this “bricolage” approach (Garud and Karnøe 2003) was a rather simple and heavy construction.

The above descriptions of innovative practice and industry evolution would be expected from a VoC perspective. The institutional setting in the US favors a high degree of market based co-ordination, which enabled a fast transfer of resources into the WEC industry. The institutional setting in Denmark favors a more relational and interactive mode of co-ordination. Fewer resources were devoted into the industry and the industry developed incrementally. Yet, both industries experienced considerable input from related industries: the US industry adopted a science based approach with strong relations to universities and aircraft industry, while the Danish industry benefited from agricultural machinery construction, which is marked by relations to farmers as first users of wind turbines (Lundvall 1992).

Also respective policies follow the assumed pattern. LME policies are expected to comprise “tax incentives, vocational programs focused on formal instruction in marketable skills, and government subsidies for basic research” (Hall and Soskice 2001, 49), while the coordination between firms takes place via the market. These were exactly the policies applied in the US. Policies in CMEs are expected to focus on coordination between firm activities, whereby the state might deliver the coordination task to particular stakeholders (Hall and Soskice 2001). In the Danish case, the stakeholder to coordinate firm activities was the DWTS.

Data and Variables

Our quantitative comparison of the US and Danish wind turbine industry bases upon an original data base. We gathered data on time of entry and exit of on-shore wind turbine producers, pre-entry experience and applied technological design. A company was integrated in the database, when it has installed one wind turbine at least. We define as entry the beginning of production. Exit marks the end of production. The last investigated year in our data base is 2009.

We distinguish between several forms of pre-entry experiences. Spin-offs are firms which spawned from existent producers of wind turbines (Boschma and Wenting 2007, Klepper 2007). Diversifiers are entries that were still active in other industries, at least for a particular time. The remaining group consists of entrepreneurs.

Additionally, we consider if entering from a related industry additionally affects survival rates of entrepreneurs and diversifiers. Like other studies (Klepper 2002, Bünstorf and Klepper 2009), we defined relatedness in an inductive way by number of entrants as well as by qualitative accounts (e.g. Garud and Karnøe 2003). Qualitative accounts consider aircraft industries and universities as well as R&D facilities important source of firms in the US, and engineering, especially of agricultural machinery as well as shipbuilding in Denmark. Yet, we found only two entries from this field in our data. The marine industry seems be more important on the supplier side (Karnøe and Garud 2012) and we omit shipbuilding from the related industries.

We also have to account for the fact the demise of the US industry is connected with its technological approach and the survival of firms strongly depend on the adopted technological design (Garud and Karnøe 2003). We therefore classified the technological design in two main categories: the light-weight design, which was the US approach and the Danish-design, which became the dominant design (Heymann 1995a). The remaining category comprises other technological approaches like the Darreius design with a rotation on the vertical axis. Classification of technological designs was done upon product specifications or pictures of the wind turbine. The designs can be disentangled by rotating axis, blade design or shape of nacelle.[10]

Data have been collected from several sources. Older data were mainly gathered from literature (for example Gipe 1995; Heymann 1995a; Oelker 2005; Righter 1996; Van Est 1999; Gilles 2008; Karnøe and Jørgensen 1995), while more recent data were collected from trade journals (Windpower Monthly; New Energy; North American Wind Power) or company journals (Enercon Windblatt; Nordex Windpower Update, VestasInside) as well as the internet (www.windsofchange.dk). If possible, missing data was supplemented by telephone interviews and visits to trade fairs. In total, we collected data on 34 Danish and 31 US firms.

Data are missing for 15 of the 65 firms. Due to the small firm population and as missing data is biased towards small US based firms that produced during the Californian wind bubble from 1981-1985[11], we applied heuristics to fill in the missing data. Assumptions on year of entry and exit, and technology were based on the available firm information (e.g. technology, home country, entry date or exit reason etc.) in connection with the then dominating market trends. For example, when we could not find any sign of activity for a firm after the Californian wind rush, we assumed its exit at the end of the bubble. In doing so, we assessed

[10] The research design allows for changes in the applied technological designs. No firm changed its mainly applied technological design during its lifetime. Yet, there are examples of US spin-offs like Zond that spawned from US Windpower and applied another technological design than their parent firm.

[11] Tax reduction in California starting from 1978 led to a bubble in the wind turbine industry in these years. Till the mid 80s, 97% of all wind turbines worldwide were installed in California (Karnøe 1999, 184). The bubble ended with the cease of tax reduction in 1986.

for 6 firms years of entry or exit and for 1 firm the technological design. We assigned 8 firms with unknown pre-entry experience as technologically unrelated.[12]

Evolution of the Wind Turbine Industry in the US and Denmark

The following section compares pattern of entries in Denmark and the US as well as the industry development. Table 3 describes the distribution of light-weight, and the Danish designs in the U.S. and Denmark. The different technological approaches that were pursued in the two countries are obvious. Furthermore, the larger number firms following other technological designs in the USA might indicate that the capabilities of LMEs to switch resources to new fields allow for a higher degree of experimentation.

	US	Denmark	total
light-weight	24	0	24
DK-design	1	31	32
other	6	3	9
total	31	34	65

Table 3: Comparison of Applied Technological Designs ($p < 0.01$)

Figure 1 shows the Kaplan-Meier graph for the applied technological design. Kaplan-Meier graphs describe the percentage of a population that after a period still exist. The survival of firms strongly depends on the adopted technological approach. Firms applying the light-weight design show considerably higher hazard rates than firms applying the Danish design.

[12] These firms showed lower survival rates than the other entries from unrelated field, yet not to a significant degree ($p = 0.22$).

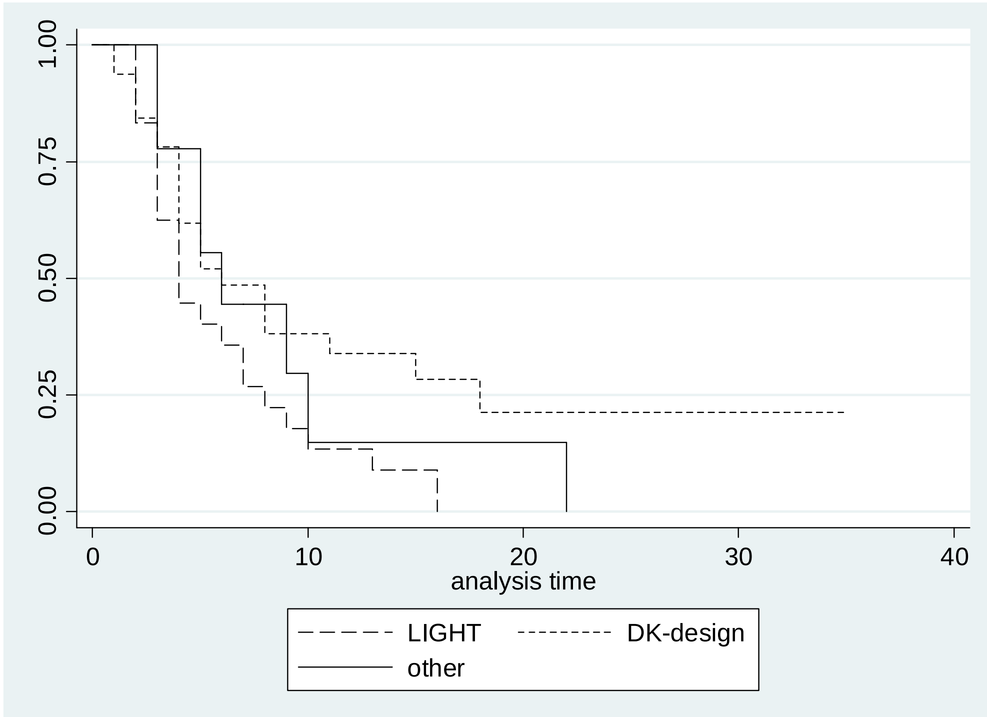

Figure 1: Comparison of Survival Rates by Applied Technological Design (p < 0.1)

We analyze the evolution on the aggregate level of the industry in the following. Figure 2 compares the quantitative development of the industries in the US and Denmark. We assumed a longer time period from first entry till shakeout in the Danish industry. The Figure shows that both industries experienced a shakeout. The industry thus followed the pattern of most industries (Klepper 1997, Simons 2001). Yet, growth phase and shake-out took place at the national level at different points in times. First firms formed in the US in 1973[13]. The industry peaked in 1982 and 1983 with 18 producers. After 1983, a shakeout followed. Thus, the time period till shakeout is 10 years. Danish firms started to produce in 1975. The industry peaked in 1986 and the shakeout resulted after 1987.[14] The respective period from first firm till

13 First Danish firms followed in 1975. This contradicts account on the earlier wind energy activities in Denmark (e.g. Karnøe 1999). As our data contains producers in the market, it does not capture this era of experimentation, mostly by craftsmen, which took place before 1975.

14 A robustness check only including firms with complete data resulted in a shakeout in the US starting already in 1980 and indicates an even faster industry formation in the US.

shakeout for Danish firms is 12 years. This reflects the assumptions we made in hypothesis 1 that the slower switch of resources of CME in new industries results in a slower formation of the industry.[15]

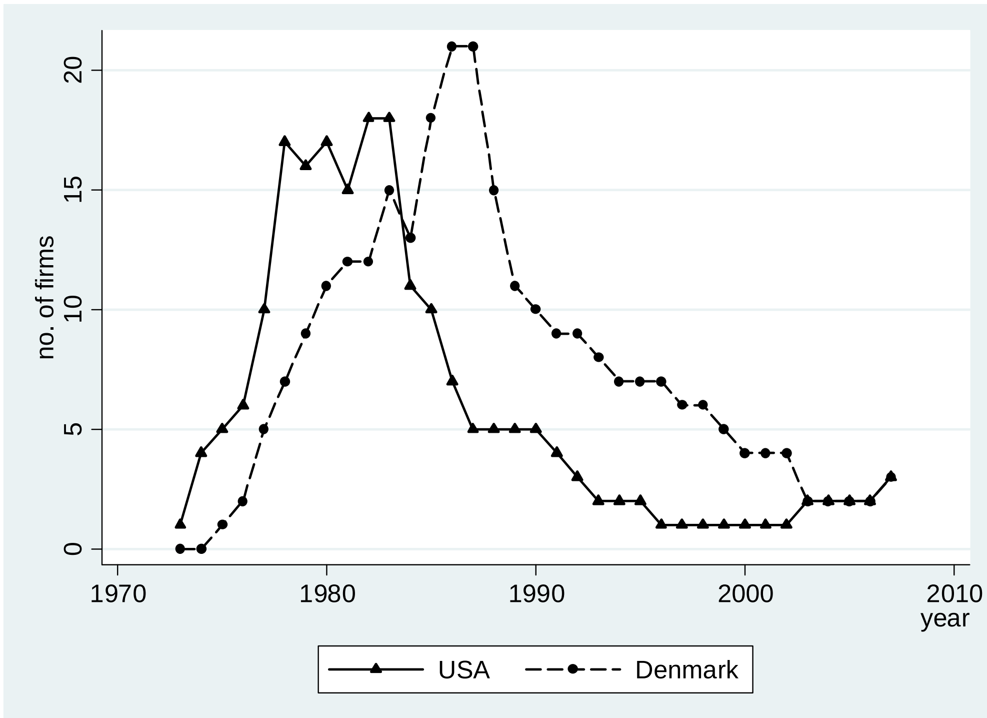

Figure 2: Comparison of Industry Development in the US and Denmark

Additionally, both industries are shaped by entrants form related fields. Table 4 gives the respective numbers. The total numbers of entries form related fields are similar. Yet, which fields are related strongly differs: aircraft production in the US and rural industries like agricultural machinery and blacksmiths in Denmark.

[15] The stop of tax reduction in California that ended the Californian wind rush and might have caused the shake out of US firms occurred three years after the shakeout of US firms, i.e. in 1986. It rather seems that the cease of tax reduction affected Danish firms.

		US	Denmark	total
unrelated		17	17	34
Related	total	9	10	19
	aircraft	7	0	
	universities and R&D facilities	2	2	
	Agricultural machinery and handcraft	0	8	
Spinoff		5	7	12
Total		31	34	65

Table 4: Comparison of Technological Relatedness ($p > 0.1$; $p < 0.01$ when considering differences in relatedness)

Table 5 gives the temporal development of entries from related fields. To compare US and Danish entry cohorts regarding their stage during industry evolution and to gain comparable numbers, Danish and US cohorts use different time ranges. Compiling US entries from 1973-1978 and 1979-2009 and Danish entries ranging from 1975-1981 and 1982-2009 results in cohorts comprising 14 to 17 entries. The length of the second cohort reflects the fact that only few firms, three in the US and one in Denmark, were formed after the shakeouts in their countries.

US

	73-78	79-09	total
unrelated	10	7	17
related	7	2	9
Spinoffs	0	5	5
Total	17	14	31

Denmark

	75-81	82-09	total
Startups	9	8	17
Diversifier	7	3	10
Spinoffs	1	6	7
Total	17	17	34

Table 5: Comparison of Relatedness over Time ($p < 0.05$ for the US, $p < 0.10$ for Denmark)

The entry pattern in the US and Denmark is quite similar, while we would have expected a larger share of respective late entries in Denmark. This result is hard to assess, as both industries are shaped by different forms of relatedness. A reason for the many previous producers of agricultural machinery in Denmark is their contact to farmers as first customers (Karnøe 1999). These became less important at industry maturity and the benefits from relatedness vanished faster compared to a stronger technological relatedness.

We expected also different forms of entries in both countries, i.e. a larger number of diversifiers and a smaller number of spin-offs and startups in CMEs. Table 6 shows only small differences in the total number of diversifiers, spinoffs and startups. The appearance of many startups in Denmark might reflect the start of the industry upon craftsmen and individual entrepreneurs (Karnøe 1999). But especially the larger number of spin-offs in Denmark is contrary to our expectations. However, in a study comparing the Germany (which would be an example for a CME) and US laser industries, Buenstorf (2007) found also more spin-offs in Germany in the US (c.f. Klepper and Sleeper 2005). And also in this case, the larger number of spin-offs in Germany is accompanied by a slower industry formation. It might be the case that the longer time of industry formation gives existing firms more time to spawn firms and results in larger numbers of spin-offs in CMEs.

While, the differences in total numbers are small, Table 6 also shows the changing entry pattern over two entry cohorts. The US industry was marked by early diversifiers and later spin-offs. This difference is significant and follows the assumption made by Klepper 1996). In Denmark, spin-offs entered lately like in the US, but the number of diversifiers did not considerably cease during industry evolution. In contrast to the US example, the change in temporal pattern in Denmark is not significant, which reflects our assumptions.

US

	73-78	79-09	total
Startups	6	5	11
Diversifier	11	4	15
Spinoffs	0	5	5
Total	17	14	31

Denmark

	75-81	82-09	total
Startups	8	5	13
Diversifier	8	6	14
Spinoffs	1	6	7
Total	17	17	34

Table 6: Comparison of Pre-entry Experience ($p > 0.05$ for US, $p > 0.10$ for Denmark)

Firm Survival in the US and Danish Wind Turbine Industry

The previous section investigated differences on the industry level. This section moves the perspective to the firm to analyze how different types of entries perform in the different institutional environment of the USA and Denmark. We expect diversifiers and entries with additional knowledge form related fields to perform better in Denmark as CME, while spin-offs and startups to perform better in the US as LME. We expect these differences to be stronger for late entries.

We apply a hazard model with Gompertz estimation. This allows for different hazard rates with changing age of the firm, which is known as a regular pattern for industries that experienced a shakeout (Cantner et al. 2006). The Model is

$$h(t|x_j) = \exp(\gamma t)\exp(\beta_0 + x_j\beta_j)$$

Firm performance as dependent variable is measured by survival time, i.e. years of production. Firms that still existed in 2010 or were acquired by other wind turbine manufacturers were right-censored, as their performance after 2010 as well as if their acquisition resulted from failure or success is unclear. Right-censoring drops the respective firm from the population at risk at these dates, but allows using information previous to these dates. In contrast, acquisitions from firms of other industries, whereby production continued, even under a different name, led not to censoring or exit (see also Boschma and Wenting 2007).

Figure 3 depicts the regression results. Negative values indicate a decrease in the probability of exit, and thus an increase the probability of survival. The analysis includes variables on firm qualities and entry time. DESLIGHT indicates that a firm applies the lightweight design and DESDK indicates the Danish-design. DESOTHER contains other technological approaches. We omit this variable for the main effects. COHORT1-2 refer to the entry period of firms. The entry cohorts for US and Danish firms refer to different years, as depicted in Table 4. We omit COHORT1 in the first models, but integrate it in the interaction terms. The variable DIVERSI accounts for firms that already had experience in other industries and diversified in wind turbine production. With SPINOFF, denominates intra-industry spin-offs. The variable REL indicates startups and diversifies that exhibit an additional relatedness in aircraft industry, R&D facilities or agricultural industries. We interacted DIVERSI and REL to account for diversifiers from related fields, while REL alone measures entrepreneurs from related fields (Klepper 2007, Boschma and Wenting 2007). We measure these variables against startups from unrelated fields (INEXP). Finally, we use dummy DK for Danish firms.

The analysis suffers from the few observations, which will result in few significant results and aggravates an interpretation based solely on the data. Yet, the qualitative accounts on both industries help to assed the reliability of our results. Therefore, we include results with a p-value of < 0.2 in our discussion, if not stated otherwise.

The first model analyzes firm performance regardless of country differences. Only few variables seem to have an effect. Firms using the Danish design have a significant lower rate of hazard. Additionally, spin-offs outperform other firms. Co-efficients for later entries and diversifiers from related fields also are as expected, but not significant.

The second model includes a dummy for Denmark. This variable would account for general performance differences of Danish firms. However, the integration of this variable does neither increase the explanatory power of the model, nor does it change the effect of single variables. This unimportance of the dummy for Denmark points out that the performance differences between Danish and US firms are already measured by the applied technological approaches DESLIGHT and DESDK.

The third model analyses deviations in firm performance between US and Danish entries according to different entry strategies. In doing so, we additionally interact all variables with DK to describe how the hazard rate is affected if the firm is Danish. Accordingly, the variables not interacting with DK approximate the performance of US firms.

Compared to the previous models, the explanatory power strongly increases. The main effects show expected results for spin-offs. Astonishingly, even if not significant, is the disadvantage US diversifiers from related industries seem to have. This result contradicts the heritage theory. The reason surely lies in the particularities of the US wind turbine industry. The group of diversifiers from related fields entails entries from aircraft industries like Lockheed or Boeing. The positive coefficient confirms qualitative accounts that the relatedness between aircrafts and wind turbines was only perceived. Instead, using technological heuristics from aircraft to wind turbine engineering even negatively affected the reliability of wind turbines which affected firm performance (Gipe 1995, Garud and Karnøe 2003).

	Model 1		Model 2		Model 3		Model 4	
	coef	Std. Err	coef	Std. Err	coef	Std. Err	coef	Std. Err
DESLIGHT	-0.14	0.43	-0.04	0.54	0.52	0.61	0.30	0.58
DESDK	**-0.77***	0.45	**-0.94**	0.64	-13.32	1466.31	**-1.60****	0.71
COHORT2	0.33	0.33	0.35	0.34	0.45	0.47	0.28	0.42
DIVERSI	0.16	0.37	0.16	0.37	0.19	0.53	0.33	0.46
DIVERSI*REL	-0.95	0.77	-0.87	0.80	1.07	1.29		
REL	0.06	0.58	-0.03	0.62	-0.63	1.14	0.22	0.48
SPINOFF	**-0.69**	0.49	**-0.71**	0.50	**-1.17**	0.85	**-1.07***	0.82
DK			0.28	0.76				
DK*DESLIGHT					(omitted)			
DK*DESDK					14.02	1466.31		
DK*DESOTHER					**1.85**	1.12		
DK*COHORT1					-0.12	0.75		
DK*COHORT2					(omitted)			
DK*DIVERSI					0.29	0.84		
DK*DIVERSI*REL					**-6.65*****	2.22		
DK*REL					-0.24	1.48		
DK*UNREL					-0.54	1.18		
DK*SPIN					(omitted)			
DK*DIVERSI*COHORT1							0.66	1.00
DK*DIVERSI*COHORT2							**-1.19**	0.82
DK*REL*COHORT1							**-3.85****	1.58
DK*REL*COHORT2							1.00	1.28
DK*INEXP*COHORT2							**1.30**	0.98
DK*INEXP*COHORT2							**2.52****	1.11
DK*SPIN							**2.07****	1.05
ageLN	-2.37***	0.29	-2.35***	0.30	-3.09***	0.39	-2.99***	0.40
Cons	1.28**	0.52	1.15*	0.64	0.71	0.74	0.92	0.75
LogLK	-42.91		-42.84		-28.21		-32.05	

Figure 3: Survival Analysis (bold p < 0.2; * p < 0.1; ** p < 0.05; *** p < 0.01)

The interaction variables illustrate the performance of the Danish firms in relation to the US firms. We could detect a significantly better performance of Danish diversifiers from related fields compared to their US counterparts. This group of firms entails diversifiers from agricultural machinery construction like Vestas. The different performance of diversifiers from related fields in the US and Denmark are a surely result of the different forms of relatedness in both countries. The indicator for diversifying firms, which allows for a better comparison of US and Danish firms than relatedness does not show a significant difference in this model.

Additionally, firms experimenting with alternative designs perform worse than respective US firms. The elaboration of the Danish design co-evolved with knowledge flows between firms and engineers. Thus, firms following alternative approaches would be less connected to these knowledge flows. In turn, the higher hazard rate of Danish firms following alternative approaches also indicates that LMEs might reward higher degrees of experimentation than CMEs.

In model 4, we test for different performances according to entry time. As it takes longer to establish these resources in new industries in CMEs, we expect Danish diversifiers and entries form related fields to benefit longer from resources in other industries compared to their US counterparts. The model accounts for this effect by interacting all main variables both with DK and with COHORT1 and COHORT2. The exception is SPIN, as only one spin-off in the whole sample formed in the first cohort.

The coefficients for the main effects did not change significantly compared to previous models. Both firms applying the Danish design and spin-offs survived longer. Yet, the model showed differences of Danish firms compared to US firms according to entry time. As predicted, late Danish diversifiers perform better, while late Danish startups perform worse than in the US. Also the higher hazard rates for Danish spin-offs meet our expectations.

However, entries from related industries outperform US firms in the first cohort, while we would have expected this result in the second cohort. Again, the different forms of relatedness in both countries aggravate an assessment of this result. [16]

Conclusion

Klepper's heritage theory explains the evolution of industries by firm specific factors (Klepper 1996, Klepper 2002). We contribute to the strand of literature that emerged upon his theory by arguing that also institutions affect the pattern of industry evolution (Lundvall 1992). To assess institutional effects, we applied a VoC perspective on the heritage theory (Hall and Soskice 2001). In contrast to other institutional approaches, the VoC perspective focuses on the firm and thus shares its analytical level with the heritage theory.

We argued that the most important difference between LMEs and CMEs regarding the emergence of new industries is how they successfully switch resources to a new industry. LMEs are expected to switch resources relatively independent from established fields to the new industry and firms benefit when they do not need to consider the requirements of other established fields. CMEs are expected to switch resources in relation to established fields and firms benefit when they benefit from synergies to established fields.

[16] We included several robustness checks. We included additional forms of relatedness like shipbuilding and engineering. This resulted in five additional entries form related fields. Significance levels were weaker, but the overall pattern did not change. Additionally, as both the design and country variables are highly correlated, we checked for interaction with DESDK as design variable instead of DK. Applying the Danish design mostly significantly increases survival time for all entry types, except for early diversifiers in model 4 ($p = 0.17$). Thus, the applied design affects the general survival of firms, but does not result in a distinct pattern observed for Danish firms.

Within the heritage-theory framework, entries are indicators for the quantity and quality of resource transfer. Pre-entry experiences indicate connections to established resources, whereby diversifiers and entries from related industries exhibit the strongest connection to established industries, spin-offs stem from resources already established in the new industry and unrelated startups exhibit the loosest connection to established resources. The entry pattern indicates which strategies of resource transfer into the new industries entrepreneurs and firms apply. The performance of different types of entries shows which forms of resource transfer are supported by the different form so of capitalism. The duration of industry formation indicate the speed of resource transfer.

As the heritage theory was established examples US industries, we used the heritage theory as a model for LMEs and elaborated expectations for CMEs. In CMEs, we expected a larger amount of entries that benefit from established industries, i.e. diversifiers and related entries. On the aggregate level, we expected a delayed industry formation compared to LMEs. With respect to firm performance, we expected that those firms benefit in CMEs that adhere to established resources, while entries without such relations perform worse. Additionally, we expected late entering diversifiers to perform better in CMEs than in LMEs, reflecting the longer time of industry formation and a thus stronger dependence on inputs from already established industries.

We tested these assumptions on wind turbine manufacturers in Denmark and the US. Both countries are assigned to different types of capitalism, the US as LME and Denmark as CME (Kenworthy 2006). A review on existing studies on the differences in institutions, firm strategies and innovative practice confirmed this assignment (Garud and Karnøe 2003, Karnøe 1999).

Our analysis shows that the industries in the US and Denmark exhibited different evolutionary patterns that needed to be disentangled. The US industry evolved mostly as expected from the heritage theory. The industry was started by diversifiers, whereby later spin-offs entered the industry (Klepper 2009). Spin-offs performed better than firms without pre-entry experience and early entrants better than later entrants. Additionally, the many US firms that applied other than the Danish or light-weight design indicates higher degrees of experimentation. Unexpected is the negative performance of diversifiers from related fields.

The WEC industry in Denmark offers a different picture. The industry emerged slower. Diversifiers were more important and also entered in large amounts in later stages of industry evolution. Spin-offs and inexperienced entrepreneurs perform worse, while entries that adhere to other fields outside the wind turbine industry like diversifiers from related fields perform better. Furthermore, late entering diversifiers performed better than US firms, showing that the Danish industry remained connected to neighboring industries longer than in the US.

With the exception of relatedness, whose effect is difficult to assess due to the particularities in the US and Danish industries, the US and Danish industries show differences that would be expected from a VoC perspective, especially when considering different times of entry. While these results generally support our assumptions on the institutional effects on industry evolution, some points require deeper considerations. The first unexpected result is the larger number of spin-offs in Denmark. Actually, we expected these numbers for the US. This result could be a random deviation. But the larger amount of spin-offs in CMEs in connection with a longer duration of industry evolution is also found in other studies (c.f. Buenstorf 2007). It seems that the duration of industry formation affects entry pattern. We can only speculate on this connection. It might be that the slower industry formation provides firms with more time to establish the resources upon which spin-offs can spawn (Klepper 2007). Examples like the evolution of the automobile industries in the US compared to Great Britain and Germany, however, show that the US industry has both the fastest industry formation and the largest percentage of spin-offs (Klepper 2002, Boschma and Wenting 2007, Cantner and Graf 2006).

The second unexpected result refers to the different forms of relatedness in the US and Denmark. US firms entered mostly from aircraft industries and R&D facilities, while a large amount of Danish entries had experiences in agricultural machinery construction. One reason is surely the missing of a remarkable aircraft industry in Denmark, which points to path dependent processes in the US and Danish industries. Each industry evolved on existent industries. However, it seems that what is perceived as related strongly depends on institutional factors. In Denmark, the large marine industry could be related to wind turbines for the same reasons as the aircraft industry (Cooke 2008). However, we only found two shipyards that diversified into wind turbines, compared to eight producers of agricultural machinery and firms from the marine industry mostly served as suppliers (Karnoe and Garud 2012**).** The marine industry in Denmark was not perceived as related to wind turbine production, while the aircraft industry in the US was. Furthermore, Garud and Karnøe 2003) describe how the perceived relatedness led aircraft producers to ignore the particularities of wind turbines. This ignorance aggravated learning processes for aircraft producers, while entries without this background did not have this cognitive lock-in (Grabher 1993). This difference would support qualitative accounts that institutional differences might affect what is perceived as related and what is not (Garud and Karnøe 2003, Frenken et al. 2007).

The wind turbine industries of the US and Denmark served as example for industry evolutions in different types of capitalism. There are several limitations to derive generalizations from our approach. First of all, the heritage theory usually analyzes historical processes like the emergence of the automobile or tire industry (Bünstorf and Klepper 2009) while the VoC covers institutional differences since the 70s. Our proposed framework is only applicable on younger industries. Furthermore, our studies suffer from few observations, which aggravate the derivation of general dynamics. However, many of the deviations between the US and Danish industry took place as predicted by theory and they fit to the qualitative accounts.

Considering these limitations, the support the main point we intend to put forward, i.e. that the institutional environment affects the pattern of industry evolution. Our study shows that the approach presented by Klepper (1996, 2001) is not only applicable to a variety of industries. Furthermore, it shows that applicability to analyze institutional differences enables a contribution to studies on comparative institutional analysis (Martin 2000, Hall and Soskice 2001).

We only observed this pattern on the country level. The heritage theory also serves to explain the emergence of spatial concentrations on basis of firm routines (Boschma and Wenting 2007, Klepper 2007, Bünstorf and Klepper 2009). Usually, indicators to detect agglomeration economies are insignificant. We found the same insignificant effect for Denmark. Even if Danish firms dominated the industry, after testing for firm specific factors, being a Danish firm did not increase performance. Yet, we found a significantly different emergence pattern in Denmark. It might be that agglomeration effects work the same way, i.e. they do not increase performance of all firms in a particular agglomeration, but affect the pattern of entry and performance of different entry types. There are some indications for this. Certain agglomerations exhibit an increased spawning rate (Klepper 2010), better performance of spin-offs compared to other places (Klepper 2007, Boschma and Ledder 2010), and positive effects of related variety (Boschma and Wenting 2007). Thus, the connection between forms of agglomeration effects, entry pattern and performance of particular entry types would require further investigation.

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