Papers in Evolutionary Economic Geography

17.16

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Industry Evolution in Varieties of Capitalism: a Comparison of the Danish and US Wind Turbine Industries

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June 8, 2017

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Abstract: In this study, we combine Klepper's framework on the evolution of industries with the Varieties of Capitalism approach to argue that industry evolution is mediated by institutional differences. We expect that new industries will evolve with a stronger connection to established industries in coordinated marked economies than in liberal market economies. Our assumptions are supported by the survival analysis of US and Danish wind turbine manufacturers from 1974 to 2014.

Keywords: industry evolution, varieties of capitalism, heritage theory, wind turbine industry, institutions

JEL: L64, O15, P51,

Introduction

There are different explanations of the driving forces 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 on firms' routines (Klepper 1996, Klepper 2002a, Klepper 2002b). Firms perform according to their pre-entry experience, and those with the best routines in terms of their research and development (R&D) investments steadily increase the competition in an industry resulting in a shakeout of less competitive firms (Klepper and Simmons 2000).

This focus on purely firm-specific factors determining industry evolution is contrary to the expectations from an institutional perspective (Nelson 1993, Boyer 1997, 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, Saxenian 1994). From this point of view, institutional differences would lead to deviations in evolution not only between industries (Malerba 2002) but also between regions and countries (Piore and Sabel 1984, Martin 2000).

However, all studies that apply the heritage framework provide evidence for its main assumptions, examining a wide variety of industries, including automobiles (Klepper 2007, Boschma and Wenting 2007), tires (Bünstorf and Klepper 2009), book publishing (Heebels and Boschma 2011), fashion houses (Wenting 2008), and semi-conductors (Klepper 2010). Furthermore, studies on industries such as laser manufacturers in the US (Klepper and Sleeper 2005) and Germany (Buenstorf 2007) as well as on automobile manufacturers in the US (Klepper 2002a), Germany (Cantner et al. 2006), and the UK (Boschma and Wenting 2007), which allow for inter-country comparisons, also show comparable results. The few deviations are explained by the peculiarities of the specific cases. The longer time, for example, leading up to the shakeout in the German automobile industry compared to the US industry is explained by the slower market formation (Cantner et al. 2006); the larger number of spinoffs in the German laser industry compared to that of the US is interpreted as a sign of entrepreneurial opportunities (Buenstorf 2007).

Admittedly, these are small differences; nevertheless, the question is whether these differences in industry evolution are random or whether they reflect a structural bias accruing from institutional differences. Answering this question requires the integration of assumptions on how institutions affect the evolution of firms and industries into the heritage framework. For this task, we use the Varieties of Capitalism (VoC) approach developed by Hall and Soskice (2001). Like the heritage theory, the VoC approach focuses on the firm as a unit of analysis. Aggregate outcomes from the activities of firms diverge into two ideal types of capitalism: liberal market economies (LME) and coordinated market economies (CME). Each type encourages behavior by firms that is suited to its specific institutional configuration and penalizes deviant firms. Their common focus on firms allows the derivation of assumptions on firm performance from the VoC approach, which can be tested in the heritage framework. While Klepper (1996, 2002a) argues that firms' routines affect firm performance, the VoC approach argues that firms benefit when their activities are compatible with their institutional environment (Hall and Soskice 2001).

By combining these two approaches, we can derive assumptions on how institutional differences affect resource transfer from old to new industries and in doing so, affect the evolution of an industry. We assume that resource transfer into new industries takes place more slowly and with tighter connections to established industries in CMEs than in LMEs. We operationalize resource transfer from an old to the new industry via different forms of entry into a new industry, i.e., spinoffs, diversifiers, entries from related fields, as well as inexperienced entrepreneurs.

To analyze differences between LMEs and CMEs in industry evolution, we apply a survival analysis to 29 US and 32 Danish wind turbine manufacturers between 1974 and 2014. There are four reasons for this selection. First, the VoC approach already assigned the US and Denmark to two different institutional systems: the US as an example of an LME, and Denmark as an example of a CME (Hall and Soskice 2001, c.f. Campbell and Pedersen 2007). Second, as VoC studies aim to understand contemporary differences between countries, they usually cover the time until the 1970s (Hall and Gingerich 2009). This constraint requires the analysis of an industry that has evolved since then, and rules out older industries such as automobiles. Third, there are several qualitative studies on the wind turbine industries in Denmark and the US (e.g.. Karnøe 1999, Garud and Karnøe 2003, Van Est 1999, Gipe 1995), which provide an in-depth investigation of institutional differences that shaped the development of the two industries. Fourth, usually either spinoffs or diversifiers dominate industries, (Simons 2001). However, the biggest US producer of wind turbines, GE, and the biggest Danish wind turbine producer, Vestas, both the largest producers in 2012, differ in the following respect: Vestas diversified from agricultural machineries, while GE based upon Zond, which was a spinoff of US Windpower. The question arises whether this difference resulted from chance or, as proposed in this paper, by different institutional environments.

The next section of this paper presents the heritage theory. The third section describes the VoC approach and elaborates how institutional differences would affect industry evolution. The fourth section investigates to what extent the Danish and US wind turbine industries align with the assumptions made by the VoC approach. The fifth section describes our data set. The sixth section analyzes entry pattern, depicts genealogical developments of the two industries, and tests our assumptions on the different evolutionary dynamics of the US and Danish wind turbine industries. It also discusses the effects of an emerging dominant wind turbine design on industry evolution. The last section comprises our conclusion.

Klepper's Heritage Theory

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 such experience; and the performance of firms is related to the performance of their parent firms (Klepper 1996, Klepper 1997, Klepper 2002a).

Based on these observations, Klepper developed a theory explaining industry evolution through the inheritance of firms' routines. His theory is based on three different lines of argument (Klepper 2002a). The first concerns the quality of firms' routines. Entries benefit when they can rely on routines acquired before the entry; for example, entrepreneurs previously heading a firm, entrepreneurs and diversifiers that can apply experiences from technologically related fields to the new industry, and spinoffs benefiting from routines of well performing parent firms. The better a firm's routines, the better it performs. Furthermore, better-performing firms are quicker to reach the size at which they generate spinoffs. As spinoffs inherit the routines of their parent firms, they also grow more quickly and may, in turn, spin out new firms sooner than other firms. 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 an earlier generation of spinoffs. The third line connects the individual firm with industry dynamics. Firms reduce product prices by investing in R&D. When prices drop beneath a certain threshold, a shakeout occurs, and only the most competitive firms survive. Early entrants have more time to invest in R&D, and firms with better routines can invest larger amounts, i.e., early entries with pre-entry experience are especially likely to survive the shakeout.

In the following section, we describe the studies that analyzed the automobile industries in the US (Klepper 2002a), Germany (Cantner et al. 2006, Von Rhein 2008), and the UK (Boschma and Wenting 2007) in greater detail as they allow for a comparison between countries. Arguing that these past developments are reflected in institutional differences today would be a bold assumption even if national institutional systems remain remarkably stable over time (Nelson 2002). Yet, this comparison gives an impression of the differences in industry evolution between different institutional systems.

Table 1 presents information on the time of industry formation, defined by the number of years from the establishment of the first firm until the start of the shakeout, the percentage of intra-industry spinoffs (i.e., entries with previous experience in the respective industry[1]) and experienced entries (i.e., diversifiers, entrepreneur previously heading a firm in another industry, and entries from related fields; we indicated different measures of relatedness in a footnote), and how this pattern changes over time. The table also includes the hazard rates of experienced entries and spinoffs compared to inexperienced entries. As most studies compare different models, we give the results for the model with the least variables, which still includes different entry cohorts and pre-entry experiences as well as allowing differentiation between entry time and experience. As experienced entries are defined in different ways, which also affects the composition of inexperienced firms, this comparison can only be a rough indicator of inter-country differences at best.

Table 1 shows that the duration of the period of industry formation differs widely across countries, from 12 years in the US to 38 years in Germany. The proportion of spinoffs also differs. It ranges from 20%in the US to 11% in Germany. The temporal changes to the entry patterns can only be compared between the US and the UK. While the US industry shows a decreasing proportion of diversifiers and an increase in spinoffs over time, this ratio is stable in British industry. All studies show better survival rates for experienced firms, and the studies that consider spinoffs also find lower hazard rates for these. The US studies exhibit the lowest

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

advantage of pre-entry experience over inexperienced entries. However, this difference is surely affected by the different measures of pre-entry experience.

Study	*t* industry formation	% entry, exp/ spinoffs	% entry, exp vs. spinoffs over time	Hazard rates of exp/spinoffs in % compared to inexperienced firms[2]
Klepper (2002), US	12	31[3]/20	exp[4] – spin 1. 42 – 7 2. 28 – 17 3. 26 – 35	-37[5]/-49 (Model 4)
Cantner et al. (2006); Germany	38	56[6]/	exp – spin 1. 75 – 2. 67 – 3. 50 – 4. 49 –	-55/ (Model 3)
Von Rhein 2008); Germany		46/ 11[7]/	Not applicable	-58/-74 (Model A)
Boschma and Wenting 2007); UK	25	68[8]/ 17	exp – spin 1. 75 – 15 2. 63 – 19 3. 65 – 17	-57*/-73* (Model 3)

Table 1: Comparison of the evolution of the automobile industries in the US, the UK, and Germany.

[2] The relevant formula is 1-exp(beta) ×100 (c.f. Klepper 2002, Cleves et al. 2008).

[3] The total number of firms is 713, with 120 experienced firms, 108 experienced entrepreneurs and 145 spinoffs. Experienced firms have previously produced other products (i.e., were diversifiers) and experienced entrepreneurs previously were heading another company. The latter two entry types were distinguished according to pre-entry experiences in related industries such as bicycle, engines, carriages and wagons.

[4] Based on Table 1 in Klepper (2002: 653).

[5] Reduction of the weighted average of hazard rates for experienced firms and entrepreneurs. The reduction for firms and entrepreneurs with experience in bicycles, engines, carriages and wagons is 54%.

[6] "Experience" in this study refers to diversifiers and entrepreneurs with a background in a related industry (most frequently carriages and wagons) or the same industry. Spinoffs are subsumed under this category.

[7] Von Rhein (2008) uses the same data set as Cantner et al. (2006), which allows a differentiation between the figures for spinoffs and experienced firms. Their data set comprises 349 firms, among them 196 experienced firms. Experienced firms comprise 56% of all entrants. From the 37 spinoffs indicated by von Rhein (2008), we can calculate 159 experienced firms, resulting in 46% diversifiers and 11% spinoffs.

[8] "Experience" in this study refers to related industries such as bicycle or coach building, or semi-related industries such as engineering.

Overall, the overview shows that the industries in the three countries differ, in particular in the duration of industry formation and entry pattern over time. These differences are argued to emanate from the particularities of the industry or the individual case. According to Cantner et al. (2006: 56), for example, the slower industry formation in Germany is the result of smaller-sized firms and the specific market development in Germany. Nonetheless, the question arises of whether such idiosyncratic explanations can be traced to more general institutional differences between countries.

Varieties of Capitalism and Industry Evolution

The VoC provides a framework that allows an elaboration of the expectations of how institutions affect firms' behavior. The basic assumption of the VoC is that firms choose forms of coordination that are institutionally supported. Institutional differences between countries lead to different behaviors of the respective firms, while institutions, conversely, adapt to economic practices and actions (Hall and Gingerich 2009). Institutions are complementary, i.e., they are interdependent, and the "presence (or efficiency) of one increases the returns from (or efficiency of) the other" (Hall and Soskice 2001: 17). These complementarities make alterations to individual institutions more difficult and consolidate or reinforce institutional differences between countries. Based on this framework, the VoC approach distinguishes between two archetypes of capitalism: LMEsand CMEs. In LMEs, coordination mainly takes place via markets, competitive relationships, contracting, and internal corporate hierarchies. In CMEs, non-market institutions support strategic interactions and collaborations that serve to address and align the needs of different stakeholders (Hall and Soskice 2001). Labor markets in LMEs, for example, are shaped by flexibility and investment in general skills that can be applied to different jobs, while labor markets in CMEs are shaped by long-term relations and investment in specific assets.

Unfortunately, the VoC approach does not deal conclusively with the evolution of industries. However, it makes assumptions on how different forms of coordination affect the way firms allocate their resources and shift their resources to new fields of activity. LMEs allow for quickly adjusting and switching processes and resources. This capacity allows a comparatively easy exploitation of technological developments outside of existing paths or paradigms by firms in LMEs. In CMEs, long-term relationships favor incremental development. Firms in CMEs benefit from investing in 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 modes of innovation. The VoC approach assumes that LMEs are better suited to radical innovation, while CMEs are better suited to incremental innovation (Hall and Soskice 2001). This assumption regarding the structural differences in innovation between LMEs and CMEs is challenged by empirical studies. Using patent data, Taylor (2004) shows that the US is actually the only country specialized in radical innovation. Also based on patent data, Akkermans et al. (2009) indicate that both LMEs and CMEs can specialize in radical innovation but in different fields: LMEs in chemical products and electronics and CMEs in machinery and transport equipment.

However, the distinction made by Hall and Soskice (2001) regarding innovative activities refers not to how radical an innovation is but to the way firms are able to switch resources. Accordingly, 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.

They then describe how resource allocation is rewarded. LMEs reward resource allocation when it is independent from established structures and takes place in new fields, e.g., in new industries. In contrast, CMEs reward resource allocation when it exploits synergies with existing structures and takes place in established fields (c.f. Akkermans et al. 2009).

The effect these institutional differences can have on the evolution of industries is already described by Dosi (1990). He distinguishes between marked-based and credit-based financial systems that roughly resemble the LME and CME categorization of Hall and Soskice (2001) and define different selection environments. He argues that market-based financial systems allow for more exploration, resulting in new firms. In contrast, credit-based systems favor diversification of incumbent firms. More recently, Boschma and Capone (2015) show on the country level that CMEs and LMEs differ in industrial renewal, as industrial diversification of CMEs is more affected by related sectors than diversification of LMEs.

Established industries are marked by distinct resources and institutions (Malerba 2002). Emerging and growing industries have to develop these specific assets and supporting institutions over time (Storper and Walker 1989). Thus, they are dependent on resource transfers from established industries. From a VoC perspective, shifting resources into new fields is easier in LMEs compared to CMEs, and firms in LMEs benefit from the independence from established fields. In contrast, shifting resources in CMEs is more constrained by established resources, and firms benefit when they switch resources in connection to established fields. Accordingly, the differences between the ways LMEs and CMEs transfer resources from established industries to new industries affects industry evolution: new industries in LMEs evolve more loosely, while new industries in CMEs evolve with tighter connections to established industries.

New industries depend on entries (Klepper 1996), and as entries base upon established resources, an entry's origin indicates where a new industry's resources come from. In this respect, the heritage framework depends on two sets of key variables that make it possible to analyze differences in how resources are transferred into a new industry. One set measures different qualities of pre-entry experiences of entries. Pre-entry experiences describe the relationship an entry has to the industry it enters. Pre-entry experiences are distinguished in several ways. The level of detail ranges from a simple separation between firms with production experience in the same or related fields and inexperienced start-ups (Cantner et al. 2006) to differentiation between entrepreneurs and firms, different degrees of relatedness (Klepper 2002a, Boschma and Wenting 2007), and forms of spinoffs (Buenstorf 2007). Yet, the heritage theory framework describes four main entry forms that connect new and established industries to different extents (Klepper 2002a, Boschma and Wenting 2007). The first is entry by diversification. The connection between the new and an established industry is obvious for this entry form as it still remains active in other industries, at least for a while. In addition to capital, diversifiers transfer established production competencies into the new industry (Klepper 2002a). The second form is entry from related fields. Entries with pre-entry knowledge in related industries transfer more specific and technologically related routines to the new industry giving them an advantage (Boschma and Wenting 2007). Breschi et al. (2003), for example, show that firms do not diversify randomly but into fields that are technologically related to their established knowledge base. The third form is the intra-industry spinoff. In contrast to the previous entries, which benefit from connections to established industries, intra-industry spinoffs base upon firms already existing in the respective industry and therefore are formed using resources already built up in the new industry. The last form comprises inexperienced entrepreneurs whose connection to new industry remains unclear. Therefore, these four entry types describe different degrees of connection between new and established industries. While inexperienced entrepreneurs exhibit the largest distance to a new industry, diversifiers and entries from related industries are close enough to connect resources from established to the new industry, and spinoffs result from resources already formed in the new industry. The second set of variables consists of time data on firm entry and exit. This data allows measuring survival time as indicator for the success of different kinds of resource transfer as well as investigating differences in speed and timing of resource transfer.

We expect that the differences in resource transfer in CMEs and LMEs will affect entry patterns, the performance of different entry types, and the duration of industry formation. First, we expect a slower industry evolution in CMEs marked not only by lesser early entrants but also by a delayed shakeout. We expect that the institutional differences also affect the internal organization of the firm. Accordingly, firms in CMEs will have a lower capability to transfer resources into R&D and thus show a slower increase in productivity than firms in LMEs (Klepper 1996). As this increase in productivity causes the shakeout, we expect a longer time span between the first entry and the start of the shakeout in CMEs than in LMEs.

Second, we expect the disadvantages of CMEs when it comes to freely transferring resources into new fields to result in a larger proportion of entries that benefit from connection to established industries, either in terms of production experience or regarding technological relatedness (Breschi et al. 2003). Therefore, we expect more diversifiers and entries from related industries in CMEs. Accordingly, we expect more inexperienced entrepreneurs in LMEs. Additionally, as spinoffs base upon resources already established in a new industry and as we expect a faster growth on industries in LMEs, we expect more spinoffs in LMEs compared to CMEs.

Furthermore, we also expect differences in the temporal pattern of entries. The heritage theory expects diversifying firms at the beginning and spinoffs in later phases. We assume a slower industry formation in CMEs and thus entries to benefit from resources from established industries for a longer period of time than in LMEs. As a result, we expect diversifying firms in CMEs to enter to a considerable extent at industry maturity as well. We expect a similar pattern for entries from related industries. To conclude, we assume that the assumed overall difference in entry pattern would mostly arise from differences in the later stages.

Industry Evolution		
Time until shakeout	+	
Entry Pattern	Number of entries	
	Early	Late
Inexperienced entrepreneur	0	-
Diversifiers	0	+
Related	0	+
Spinoffs		-
Performance	Survival time	
Inexperienced entrepreneur	-	
Diversifiers	+	
Related	+	
Spinoffs	-	
Late entries	+	

Table 2: Expectations on Industry Evolution, Entry Pattern, and Firm performance in CMEs compared with LMEs

Finally, the heritage framework makes it possible to measure the performance of different entry types, i.e., different forms of resource transfer. The heritage theory expects that firms with better routines will perform better, while the VoC approach would expect that firms' performance depends on how their actions relate to their institutional environment. We expect firms that can exploit synergies with established fields, i.e., diversifiers and entries benefiting from knowledge in technologically related fields, to perform better in CMEs. In contrast, we expect inexperienced entrepreneurs to perform better in LMEs, where they benefit from comparatively freer resource transfer despite disconnection to established industries. For the same reasons, we expect spinoffs to also perform better in LMEs.

We expect these performances to be mediated by the different temporal developments of industries in CMEs and LMEs. The heritage theory assumes changes in firms' performance during the industry life-cycle (Klepper 1997). Investments in R&D by early entrants can hardly be compensated by later entrants resulting in early entrants often outperforming later entrants. Yet, we assume industry formation to be slower in CMEs. We therefore expect later entries to have a smaller disadvantage in CMEs than in LMEs.

Klepper developed his theory on US industries (Klepper 2002a, Klepper 2001, Buenstorf 2007), and the US is considered a paradigmatic example of an LME (Kenworthy 2006, Akkermans et al. 2009). We therefore adopt his theory as a baseline model for LMEs. Table 2 summarizes our assumptions on entry pattern and firms' performance in CMEs compared with LMEs.

Firms, Policies and Innovation Patterns in the US and Danish Wind Turbine Industries

In their seminal contribution, Hall and Soskice (2001) classified Denmark as a CME and the USA as an LME. However, recent contributions show that national models exhibit diverse institutional solutions, which also diverge from the dominant institutional form. Schröder and Voelzkow (2016) show that firms often surprisingly easy deviate from the national model. They therefore consider these divergences as "productive incoherencies," which align national models with sectoral needs and firm-specific ones.

This literature also investigates to what extent the USA and Denmark diverge from their classification as LME or CME. 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 typical an LME to compare it with other forms of LME such as the UK or Canada (Taylor 2004, Kenworthy 2006). However, Crouch (2005) points out that the military sector diverges from this national model. Aircraft companies are particularly tied via close and long-term relationships to federal departments. This form of coordination strongly diverges from the arms-length and marked-based interaction predominant in LMEs. Yet, this sectoral divergence does not affect the general national model.

In contrast, the classification of Denmark as a CME by Hall and Soskice (2001) is more controversial. While Hall and Gingerich (2009) confirm that Denmark is a CME, Kenworthy (2006) defines Denmark as an intermediate form and Campbell and Pedersen (2007) argue that Denmark is a hybrid form of capitalism. However, these different classifications might result from the timing of the analyzes. The study of Hall and Gingerich (2009) ended in the 1990s, while Campbell and Pedersen (2007) base their argument for Denmark as a hybrid form on liberalization of labor market and industry policy in Denmark in the 1990s. Although most entries in Denmark took place in the 1970s and 1980; these institutional changes might affect the evolution of the industry.

This tentativeness requires elaborating the extent to which the developments in the US and Danish wind turbine industries correspond to the categorizations of the VoC approach. Fortunately, the institutional underpinnings of these two industries are well-analyzed. The studies by Karnøe (1999) and Garud and Karnøe (2003) are particularly useful in this regard, as they analyze how institutional differences caused actors in the two industries to take different approaches to innovation: a technology-driven “breakthrough” approach in the US, and an interaction-driven “bricolage” approach in Denmark (Garud and Karnøe 2003). Yet, they do not assign the differences to different forms of capitalism but trace the reasons for the different approaches to the stronger implementation of Fordist and Taylorist modes of organization in the US compared to Denmark (Karnøe 1999). But the richness of their accounts on institutional differences between the US and Danish wind energy industries enables the assessment of their differences from a VoC perspective, especially how these institutional differences affected transfer of resources into the emerging industries.

In the US, organization of production was marked by a large degree of separation between tasks (Karnøe 1999). Garud and Karnøe (2003) describe a high degree of division of labor within US wind turbine producers, marked by a strong division between blue- and white-collar workers. Different tasks such as design and production were strongly separated. Even maintenance and ownership of windmills were separated, as windmills were treated as financial investments. US firms had a strong emphasis on in-house research and knowledge-related collaborations between firms were limited. Inter-firm exchanges were highly formalized and took place on a market-based level.

Danish firms organized their relationships and innovation processes in a different way. In contrast to the US, pre-Fordist forms of craft-based production and worker education remained important in Denmark (Karnøe 1999). The separation between the tasks of the production process was thus less sharp, design and production were strongly interlinked, hierarchical differences were less pronounced. This form of organization requires a high degree of interaction, not only between different departments within a single firm, but also between firms and with windmill owners, which were mostly single users in Denmark, most of them organized within the Wind Mill Owners Association (Garud and Karnøe 2003).

Another dimension is state policies. 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). The US offered 900 million USD in tax exemptions (Garud and Karnøe 2003). Additionally, there were programs to advance basic research with the intention of achieving breakthroughs in wind turbine design accounting for 486 million USD between 1974 and 1992 (Gipe 1995, Table 3.2). This research program also involved universities that offered courses in wind turbine design from the mid-1970s onwards (Karnøe 1999). Furthermore, the Solar Energy Research Institute (later National Renewable Energy Laboratory) started research in wind turbine design in 1977.

Policies in CMEs are expected to focus on coordination between firms' activities. This coordination is often done by public stakeholders (Hall and Soskice 2001). Compared to the US, resources invested into the new industry were small in Denmark and accounted for 53 million USD in basic research and about 150 million USD in subsidies and tax exemptions between 1974 and 1992 (Gipe 1995, Table 3.2). As in the US, a research institute was formed in 1979 with a focus on wind energy, the Danish Wind Turbine Test Station (DWTS). As the state demanded that wind turbines be approved by the DWTS, but standards were unclear, turbine manufacturers collaborated with the DWTS to get their systems approved and collective learning processes evolved around this institute (Karnøe 1999). In contrast to its US pendant, which financed basic research, the DWTS severed as governmental stakeholder to coordinate firms' activities.

The different institutional settings in the US and Denmark affected technological approaches. In the US, engineers adopted a "breakthrough thinking" (Karnøe 1999), which led to large developmental steps between each product generation (Garud and Karnøe 2003). This approach was driven by entries from the aircraft industry that tried to adapt their aerodynamic expertise on wind turbines as well as from universities that implemented scientific approaches to wind turbine design into the industry. The result was a light-weight model, characterized by the combination of rapid rotation, use of light materials, and two or three blade downwind rotor (Gipe 1995). Yet, this design was prone to failures and damages (Garud and Karnøe 2003).

In Denmark, firms started from a design that had been invented by Juul in the 1950s, which had proved to be reliable. Each firm improved the design incrementally. Improvements were imitated by other firms, even if the underlying principles were not understood. New designs were marked by only incremental improvements, but short periods of development (Garud and Karnøe 2003). Due to the few resources devoted to the new industry, entries were mostly small firms and entrepreneurs that adhered to local competencies in the construction of agricultural machinery (as farmers were the first buyers), shipbuilding or even skilled crafts like blacksmithing. The "Danish Design" (Gipe 1995) that resulted from this "bricolage" approach (Garud and Karnøe 2003) was a rather simple and heavy construction, described by a three blade upwind rotor. This design became the blueprint for today's dominant wind turbine design.

These descriptions of innovative practice and industry evolution are largely what would be expected from a VoC perspective. The institutional setting in the US favors a high degree of market-based coordination accompanied by a strong division of tasks and function. Resource transfer is accelerated by massive public investments in research and educational programs as well as subsidies. The institutional setting in Denmark instead favors a more relational mode of coordination. Fewer resources were devoted to the industry and the industry evolved more incrementally and connection to established resources.

However, the US industry diverged from this picture in one important aspect. An important part of industry research in the US was coordinated by the NASA. NASA coordinated a large-scale wind turbine program financed by the Department of Energy (DOE) and provided a test site at Rocky Flats, Colorado. In particular, this research involved aircraft companies such as Boeing, but also other firms from the electricity sector in close relationships with the government. Therefore, the sector of the US economy that more resembles CMEs than LMEs (Crouch 2005) was involved in the emergence of the US wind turbine industry.

Additionally, the qualitative analysis showed two differences that were not covered in the VoC framework but have important implications for the evolution of the respective industries. First, the two industries differed in their related industries: the US industry adopted a science-based approach and was shaped by entries from universities and the aircraft industry, while the Danish industry tended to have entries from agricultural machinery or shipbuilding firms. Second, the two industries differed in adopted designs, which affected firm survival. Most US firms used a light-weight design, which was prone to damages, thereby negatively affecting firm performance. In contrast, most Danish firms adopted a comparatively heavy design, which became the dominant design of the industry later.

These two industries competed on the same market. Tax reduction in California from 1978 to 1986 led to the "Californian Wind Rush." Due to this bubble, 97% of all wind turbines worldwide were installed in California (Karnøe 1999: 184) and nearly all were produced by US and Danish manufacturers. After the bubble burst, Danish firms dominated the market (Garud and Karnøe 2003).

Data and Variables

Our quantitative comparison of the US and Danish wind turbine industries is based on an original database. Data has been collected from several sources. Older data was mainly gathered from literature (for example Gipe 1995; Righter 1996; Van Est 1999; Maegaard et al. 2013), while more recent data was collected from trade journals (*Windpower Monthly*) or internet-based databases (www.windsofchange.dk, www.wind-works.org). If possible, missing data was supplemented by telephone interviews and visits to trade fairs. In total, we collected data on 32 Danish and 33 US firms from between 1974 and 2014.

We gathered data on the time of entry and exit, pre-entry experience and applied technological design of on-shore wind turbine manufacturers. A company was integrated into the database if it installed at least one wind turbine. Additionally, this wind turbine should have grid connection. This condition rules out producers of small-scale wind turbines, which are for example used to power water pumps on farms.

We defined entry as the beginning of production and distinguished between several forms of pre-entry experience. Spinoffs are firms whose founders have a background in the same industry. Diversifiers are entries that were also still active in other industries, at least for a certain amount of time. The remaining group consists of entrepreneurs. We also consider if firms or entrepreneurs entered from a related industry. Qualitative accounts consider both the aircraft industry and universities an important source of firms in the US; and agricultural machinery and shipbuilding a source of firms in Denmark (Gipe 1995, Karnøe 1999). Yet, not all these forms of relatedness benefit firm survival. Garud and Karnøe (2003) show that US aircraft producers failed in applying their aerodynamic on wind turbines.

Exit is defined by the end of production, either by leaving the market or being acquired by another wind turbine manufacturer. Instead, when the firm was acquired by one from another industry, but still produces turbine, we eventually changed the name and kept the firm as an active producer (see also Boschma and Wenting 2007).

We also have to account for the fact the demise of the US industry is connected to its technological approach, and the survival of firms might be dependent on the adopted wind turbine design (Garud and Karnøe 2003). Therefore, we divided the technological designs into three categories: light-weight design (two or three bladed downwind turbines), which was the US approach; Danish design (three bladed upwind turbines), which became the later dominant design; and a category for remaining designs, like four bladed designs or the Darreius design with rotation on the vertical axis. The classification of technological designs was made upon product specifications or pictures of wind turbines.

Additionally, we have to consider two shortcomings of our sample. First, many firms were involved in the DOE program coordinated via NASA at Rocky Flats, Colorado. These firms with tight relations to the government might affect the results. Aircraft producers such as Boeing, Bendix, Grumman, Kaman, Lockheed, United Technologies, and McDonnell Douglas were part of it, but also large power plant manufacturers like GE and Westinghouse as well as aluminum producer Alcoa. A second group, which largely overlaps with the first one, are firms that only produced prototypes and did not manage to commercialize their turbines. All the large firms of the DOE/NASA program at Rocky Flats did not manage to sell their turbines except Boing, which managed to sell one turbine. Enertech as only newly formed firm involved in this program was the second exception that successfully sold wind turbines (Gipe 1995). US company Tumac as well as Danish firms Dana Vindkraft and Dansk Vindkraft were added to this group of firms that remained at the prototype level.[9] As studies using the heritage framework usually exclude these firms, these firms might well bias the results.

Data were not complete for 13 the 65 firms. Due to the small firm population we applied heuristics to fill in the missing data if only data regarding one category (year of entry, year of exit, background, design) is missing. For US firm WTG Energy, we defined 1976 as entry year, as we knew the firm entered in the 1970s and 1976 is the mean between the first US entry in 1974 and 1979 as last year of the 1970s. For US firm Dynergy we defined exit in 1985, as we knew this firm was formed in 1981, it did not survive the burst of the Californian Wind Rush, and 4 years was the average life span for this group of firms. For three other firms (Bendix, McDonnel Douglas, Dansk Vindkraft Industri) that only installed a prototype, we defined exit as two years after entry. Dynergy, Danish firms Scandinavian Wind Systems and DWP with unknown relatedness were defined as unrelated. We defined DWP, US firms Flo Wind and

[9] United Technologies and Alcoa were sources for spinoffs. For analyses without these firms, we recoded these spinoffs as entrepreneurs from the industry of their parent firm.

WECT-Tech entrepreneurs. We omitted four US wind turbine producers with too many missing variables were missing from further analysis, which leaves us 32 Danish and 29 US firms.

Evolution of the Wind Turbine Industries in the US and Denmark

The following section compares the patterns of entries in Denmark and the US as well as the industries developments. Regarding industry development, we expect a slower formation in Denmark. Regarding pattern of entries, we expect more diversifiers and entries from related industries as well as less spinoffs and inexperienced entrepreneurs in Denmark. Additionally, we expect a larger temporal difference in the pattern of early and late entries in the US than in Denmark.

Entry Patterns

Figure 1 compares the quantitative development of the industries in the US and Denmark. We assumed a longer time period from first entry until shakeout in the Danish industry. Figure 1 shows that both industries experienced a shakeout and thus followed the pattern of most industries (Klepper 1997, Simons 2001). However, the growth phases and shakeouts at the national level took place at different points in time. The first firms formed in the US in 1974 and the industry peaked in 1981, with 18 manufacturers. In 1983, a shakeout started, which resulted in a time period of 9 years from first entry until shakeout. Danish firms began manufacturing in 1976[10]. The industry peaked in 1987 with 19 firms, followed by a shakeout in the next year[11]. The respective period from first firm until shakeout for Danish firms is 11

[10] This later start contradicts accounts on the earlier wind-energy activities in Denmark (e.g., Karnøe 1999). As our data consists of manufacturers on the market, it does not capture this era of experimentation, mostly by craftsmen, which took place before 1976.

[11] Robustness checks excluding firms involved in the DOE/NASA program, firms that did only prototypes, or firms with incomplete data sheets confirmed these years.

years. This reflects our assumption that the slower transfer of resources to new industries in CMEs results in a slower formation of the industry.[12]

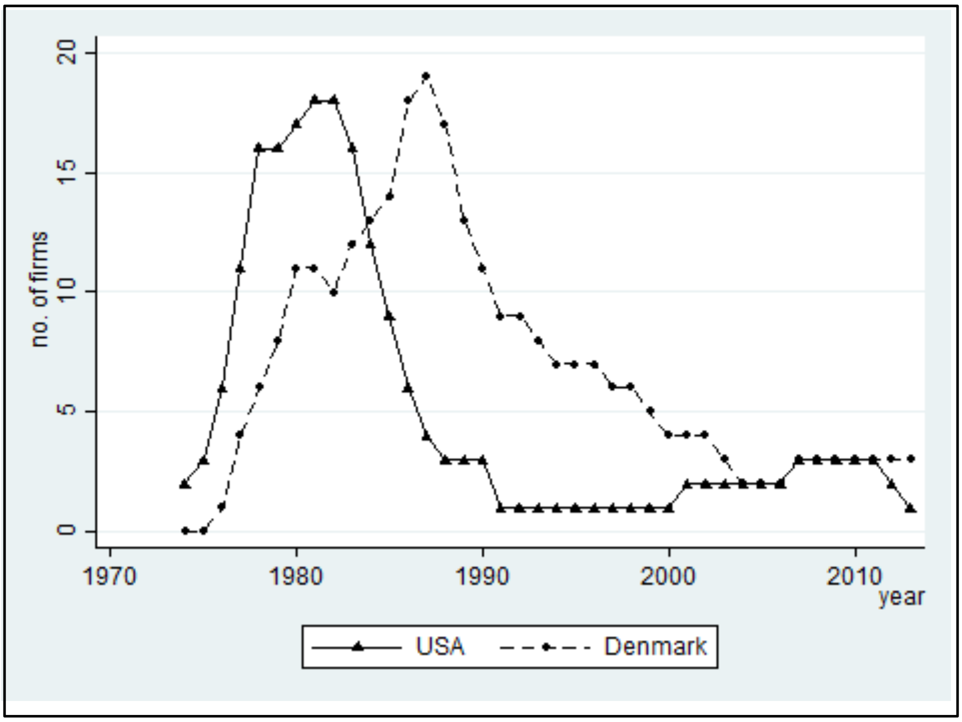

Figure 1: Development of Wind Turbine Industries in the USA and Denmark

The heritage framework expects a sequence of entries, whereas diversifiers are followed by spinoffs. We expect this sequence to be less pronounced in Denmark as a CME. To account for these differences, we distinguish between two entry cohorts. Entry cohorts differ between the US and Denmark to account for different temporality of industry evolution. The first cohort of US firms covers firms entering before 1978, while the first cohort of Danish firms covers firms entering before 1982. Separation between these years results in roughly even numbers of firms

[12] The expiration of the tax reduction in California that ended the California wind rush and may have caused the shakeout of Danish firms, which occurred five years after the shakeout of US firms, i.e., in 1987. It seems that the expiration of the tax reduction especially affected Danish firms, and not US firms.

in each cohort and considers that the Danish industry both started two years later and experienced its shakeout additional two years later.

	Entrepreneurs	Diversifiers	Spinoffs	Total
USA				
1974–1977	7	9	0	16
1978–2014	4	4	5	13
Total	11	13	5	29
Denmark				
1976–1981	7	7	1	15
1982–2014	8	5	4	17
Total	15	12	5	32

Table 3: Comparison of pre-entry experience ($p<0.05$ for the US; $p>0.1$ for Denmark).

Table 3 shows only shows small differences between the US and Denmark in the total number of diversifiers, spinoffs, and entrepreneurs. We did neither find more spinoffs in the US nor more diversifiers in Denmark. The only difference is the large number of entrepreneurs in Denmark, which is contrary to our assumption. The smaller than expected number of US spinoffs might results from the bigger success of Danish wind turbine producers, as especially successful firms are a source for spinoffs (Klepper 2002a). Their number might also be connected to the speed of industry formation. When comparing the German (Buenstorf 2007) with the US laser industry (Klepper and Sleeper 2005), the German industry evolved slower than the US industry and had a higher share of spinoffs, like in our example. Another explanation would also explain the larger number of entrepreneurs in Denmark. Lazear (2004) found that successful entrepreneurs are not those that specialized in certain fields, but those that have skills in a range of fields. This explanation might be supported by studies that describe the permeability between functions and tasks in Danish firms (Garud and Karnøe 2003), which might have provided potential entrepreneurs with the broad skill base necessary to form a firm.

The industry exhibits, however, a temporal difference of entry pattern. While both industries are marked by early entering diversifiers and later entering spinoffs, this pattern is only statistically significant in the US case. To conclude, we did not evidence for different types of entries in the two industries. However, we found differences as expected when considering timing of entries: the US industry as LME follows stronger a pattern predicted by the heritage theory than Denmark.

Both industries were also shaped by entrepreneurs and diversifiers from related fields. However, which fields these were differs greatly: in the US, the aircraft industry was the source of nine entries, while four entries came from universities. Studies show that entering from the aircraft industry provided firms with a disadvantage, as heuristics from this industry guided technological search processes in wrong directions (Garud and Karnøe 2003). As in our sample, these firms exhibit comparatively short survival times, and we classify only firms with a university background as "related." This classification is not perfect, as universities are not industries and entrepreneurs with this background have no experience in industrial production. Yet, neither literature nor our own data show other possibly related industries. Therefore, we use a university background as indicator to investigate how entries benefit from knowledge generated in other fields and to allow a comparison with Danish entries.[13]

In Denmark, manufacturers of agricultural machinery were the source of five entries, and the only entry with a background in shipbuilding was in Denmark. A larger number would be expected from literature. As studies define related industries by the number of entrants from

[13] There were also four entries from universities in Denmark. However, these entries usually deviated from the Danish design and were also responsible for the only two Danish firms that remained at the prototype level. As neither literature suggests academia as a crucial source of entries, nor did these entries fit into a "typical" Danish firm, we did not define these entries as "related".

these industries and the marine industry seems to be more important on the supplier side (Karnøe and Garud 2012), we delete shipbuilding as a related industry. Therefore, we have a US industry with four entries from universities and a Danish industry with five entrants from an agricultural machinery industry defined as "related." These different backgrounds illustrate the different dynamics in the two industries.

All US entries with a university background were entrepreneurs. All Danish entries with a background in agricultural machinery were diversifiers. Despite these differences, the entry pattern of these firms is comparable. In the US, three of these four entries started in the first cohort. This pattern is comparable to Denmark, were four of these five entries started in the first cohort. While we did find a difference in entry pattern regarding diversifiers, this difference disappears when investigating entries from related fields.

Genealogical Developments

Figure 2 shows the genealogical development of wind turbine manufacturers in the US and Denmark. It includes entry, exit, design, the background of the entry (e.g. diversifier or entry from a related field) and if the turbines the firm produced were only prototypes. This illustration also shows relationships between firms via spinoff processes and acquisitions. In doing so, Figure 2 gives further impressions on the similarities and differences between the industry evolution in the US and in Denmark.

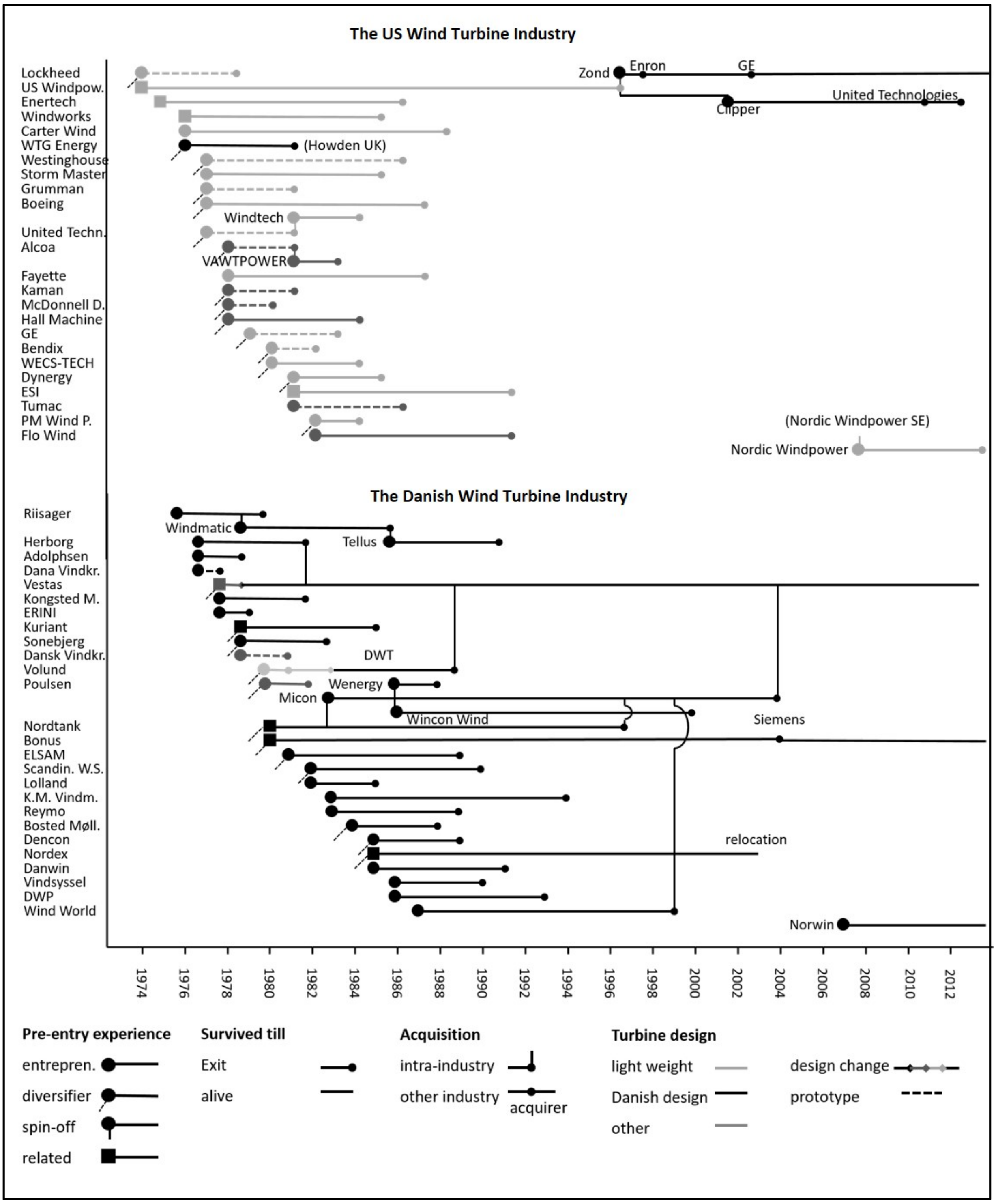

Figure 2: Genealogical Development of Wind Turbine Manufacturers in the USA and Denmark

Both industries resemble each other in their spinoff dynamics. Spinoff processes in both industries are based on few sources. In the US, US Windpower was the parents of two of the five spinoffs. Two further spinoffs, VAWTPOWER and Windtech, formed as their parent firms decided not to commercialize their wind turbines and to withdraw from the industry. These spinoffs, which resulted rather from the failure than the success of their parent firms, survived only two or three years, respectively. Finally, Nordic Power was a relocation of a Swedish company. As the firm already had production experience, but newly formed in the US, we classified it as spinoff. Thus, the spinoffs of US Windpower were the only ones that formed out of a successful company, which also showed considerably longer survival rates than the other three spinoffs. In Denmark, all five spinoffs were based on Riisager and Nordtank, i.e., firms with considerable production experience. The figure shows that, as in the US sample, the survival time of spinoffs correlates with the survival time of their parent firms.

Beside the similar spinoff processes, the figure reveals four differences. The first difference revealed by the figure is the kind of firm that survived the shakeout, or was even formed afterwards. Both industries had three firms that were alive at least till 2011. We use the year for a comparison, as two US firms exited in 2012 and 2013, respectively. In both industries, two of the three firms have roots in the early development of the industry: in the US, GE and Clipper can trace their roots back to the formation of US Windpower in 1974. In Denmark, Vestas entered the industry in 1978 and Siemens is based on the firm Bonus, which diversified in 1980. Both industries had a recent entry in 2007. Yet, while all the US firms still alive in 2011 were spinoffs, two of the three Danish survivors were diversifiers. Norwin, the third Danish firm, was a design office that started to produce wind turbines on its own. As the company has no previous production experience, we did not assign it as a diversifier.

The second difference refers to intra-industry acquisitions. We could only detect one US manufacturer that was acquired by another wind turbine firm (WTG acquired by Scottish manufacturer Howden), while five manufacturers were acquired from another wind turbine manufacturer in Denmark. Furthermore, similar to spinoff processes, acquisitions also took place selectively. Only two firms were responsible for the five acquisitions. Micon acquired two firms, among them its parent Nordtank. Vestas acquired three firms, among them Micon. As a result, all firms acquired by wind turbine manufacturers firms ended up in Vestas.

These acquisitions affect industry evolution. With the exit of a firm, its routines also vanish from an industry, unless the firm was the source of a spinoff. This selection of routines is part of the heritage theory and allows only better routines to reproduce, while others vanish. The US industry is a good example for this selection: the three surviving firms of 2011 base upon two different genealogical threads (US Windpower and Nordic Windpower). In contrast, many firms in the Danish industry exited by acquisition. Hence their routines did not vanish, but were included into the routines of the acquiring firm. As a result, the three Danish firms of 2011 based upon routines from nine firms, i.e., nearly one-third of all firms that entered the industry. While the Danish industry allocated resources more slowly than the US industry, the intra-industry acquisitions served to preserve these resources. It is however possible that these acquisitions were an indicator for the success of these firms (de Vaan et al. 2013), which benefited acquisitions of the more successful Danish firms. Yet, this difference shows that not only different entries, but also different form of exits require consideration regarding industry evolution (Boschma and Heebels 2011).

	US	Denmark	Total
Light-weight	19	1	20
DK-design	3	28	31
Other	7	3	10
Total	29	32	61

Table 4: Comparison of applied wind turbine designs ($p<0.01$).

The third difference refers to the wind turbine design. The figure shows the distribution of light-weight design, Danish designs and other designs. Table 4 gives the numbers for the designs applied by firms in the two countries when they entered the industry. The table indicates the different dominant designs applied in the two countries, from which only few firms deviated. Yet, US industry shows more diversity of approaches than the Danish industry. This diversity might indicate that the ability of LMEs to transfer resources to new fields might allow for higher rates of experimentation (Dosi 1990).

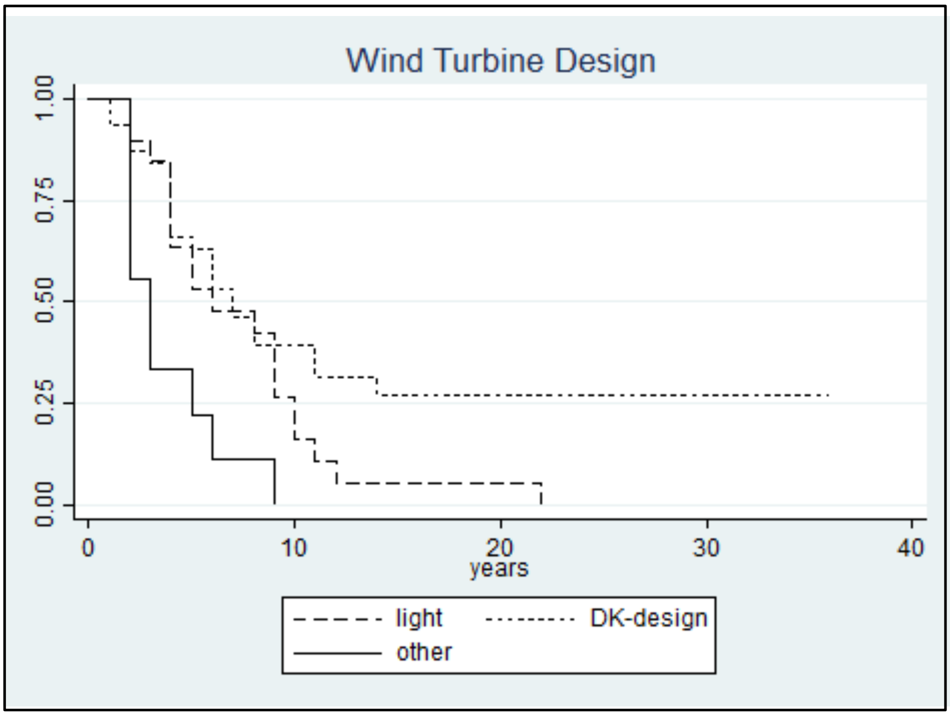

Figure 3: Comparison of Applied wind Turbine Designs[14]

The research design allows also for changes of designs. These design changes took place in both industries and all firms that changed their design changed it toward the Danish design. Figure 3 shows that these design changes were crucial for firm survival. Firms applying the light-weight or other designs show significantly higher hazard rates than firms applying the Danish design. Yet, these design changes took place in different ways. Two Danish firms

[14] We used the log-rank test to estimate the p-value, as this still gives meaningful results when many cases are censored.

changed their applied wind turbine design. Vestas started with a Darrieus Design and Volund with a version of the light-weight design. While the Danish firms like Vestas and Volund changed designs within the established structure of the firm, firms like Zond and Clipper performed a design change via spinning-off from their parent US Windpower. Due to the few examples, we do not want to overrate these differences. Yet, these changes within established firms in Denmark and resulting in new firms in the US fit our basic assumption that industries in CMEs evolve in stronger connection to established resources than in LMEs.

To conclude, we actually assumed only differences in industry evolution on the basis of resource transfer between industries. However, changes in technological designs and acquisitions shown in Figure 2 indicate the industries also differ in the way they allocate and transfer resources within the boundaries of the industry.

Survival Rates of US and Danish Wind Turbine Manufacturers

The previous section investigated differences at the industry level. This section moves the perspective to the firm-level analyzing how different entries perform in the different institutional environments of the US and Denmark. We expect diversifiers and entries from related industries to perform better in Denmark and spinoffs and inexperienced entrepreneurs to perform better in the US. We expect Danish late entry firms to have a lesser disadvantage than their US counterparts.

We use the following variables for the analysis: *DK* is a dummy-variable for Danish firms, and *cohort2* is an indicator for firms entering in the second cohort. In contrast to other studies (Bünstorf and Klepper 2009, Klepper 2007, Boschma and Wenting 2007), we use an indicator for the late instead of the early entries as we are especially interested in the performance of late entries. The entry cohorts for US and Danish firms refer to different years as already depicted in Table 3. The analysis includes further dummy variables for diversifiers (*diversi*), spinoffs (*spinoffs*), and entries from related fields (*related*). The variable *design* designates firms applying the Danish design. We focus on the Danish design to simplify the model and because this design became the dominant one.

	cohort2	diversi	related	spinoff	design	DK
cohort2	1					
diversi	-0.38*	1				
related	-0.46*	0.28	1			
spinoff	0.69***	-1.00***	-1.00	1		
design	0.32	-0.31	-0.04	0.29	1	
DK	0.08	-0.06	0.1	-0.07	0.94***	1

Table 5 : Correlation matrix (tetrachoric, *p< 0.1; **p<0.05; ***p<0.01).

Table 5 describes the correlation between the different independent variables. As we have only binary variables, we use tetrachoric correlation estimates. *Diversi, related,* and *spinoff* are negatively correlated with -1, as one category excludes the other, e.g. no diversifier is a spinoff. The strong and significant correlation between the technological design a firm applies and the country in which it is located is clear from the data. Yet, country and design affect firms in different ways as already described in the genealogical development of the industry. Therefore, we include both variables in the subsequent analysis.

We use Cox regression to analyze the hazard rate at age t, denoted as $h(t)$. The baseline hazard rate is described by h_0, while x elucidates a vector of independent covariates describing pre-entry backgrounds, entry cohort, and wind turbine design. We use a stratified model (g) to account for different baseline hazards of Danish and US firms:

$$h_g(t) = \mathrm{h}_{g0}(t)\exp(x\beta)$$

Firm performance as a dependent variable is measured by survival time, i.e., years of production. Firms that still existed in 2014 or were acquired by other wind turbine manufacturers were right-censored. The performance of these firms after 2014 as well as whether 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 the use of information prior to the censored events.

We compare different models. The first pair of models (Models 1 and 2) tests to what extent the industry evolves according to the heritage theory. It includes the variables known from the heritage theory (Klepper 2002a): coefficients for time of entry as well as pre-entry experience. In addition to Model 1, which tests for the "pure" heritage theory, Model 2 accounts for the adopted wind turbine design as particularity of the wind turbine industry. The second pair of models (Models 3 and 4) interacts all variables of the previous two models with *DK*. This interaction opposes firm survival of Danish to US firms. The non-interacting variables describe the performance of US firms and the interacting variables describe the performance of Danish firms in relation to their US counterparts. These comparisons allow to test if firms performed differently in Denmark and the US. Models 5 and 6 test our assumptions regarding inexperienced entrepreneurs. They base upon Models 3 and 4, with the only difference that variables for firm experience (*diversi, related, spinoff*) are interchanged with a variable for inexperienced entrepreneurs (*inexp*). [15]

The models are nested; i.e. Model 1 is nested in Model 2 and Model 3, Model 2 is nested in Model 4, Model 3 is nested in Model 4, and Model 5 is nested in Model 6. We measure both

[15] We applied several robustness checks. We use a Gompertz estimation that allows for different hazard rates as the age of the firm increases, which is a regular, known pattern for industries that experienced a shakeout (Klepper 2002b). Using a Gompertz estimation slightly increases the validity, yet did not affect the overall results. We also used a complementary log-log model along the line described by Jenkins (1995) to account for the fact that Cox regressions require continuous time and we have discrete time data. The discrete time model supports the result of the Cox regression. We also checked for unobserved heterogeneity. We did not find meaningful results for unobserved heterogeneity, which reflects the assumption of Klepper (2002b) that measuring unobserved heterogeneity is sensitive to the functional form of the hazard in a way that is not guided by theory. Additionally, we excluded six US and three Danish firms for which we found a missing variable. This omission also did not affect the results.

the fit of the overall model as well as the fit in relation to the model that is nested within the tested model. As we use robust standard error estimates, we apply the Wald test. The Wald test indicates that all models and the extensions from one model to another create a significant improvement in the fit of the model. The better fit of Models 3 and 4 compared to Models 1 and 2 shows the value of accounting for different performances of US and Danish firms; while the better fit of Models 3 and 4 compared to Models 5 and 6 shows the value of accounting for different forms of pre-entry experience.

Table 6 shows the regression results. Negative values indicate a decrease in the probability of exit and thus an increase in the probability of survival in a certain year. The regression is based on the data presented in Figure 2. Yet, in accordance with Klepper (2002a), we excluded firms that only made prototypes. This exclusion additionally reduces the bias towards bad performing diversifiers in the US industry, as the DOE/NASA program drew many established firms into the industry, which left the industry soon.[16] Also like Klepper (2002b), we use one-tailed tests for significance at for all variables, except for *design*. While we assume that applying the Danish design positively affects firms, we do not have any assumption if Danish firms adopting to the Danish design perform better or worse than respective US firms do.

[16] Using a sample of all firms would lead to a significantly larger hazard rate of US diversifiers.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
cohort2	0.164	0.441	1.581***	1.708***	0.752**	1.410***
	(0.386)	(0.415)	(0.482)	(0.541)	(0.444)	(0.488)
diversi	0.006	0.011	0.732	0.810		
	(0.344)	(0.363)	(0.518)	(0.573)		
related	-1.518***	-1.475***	-1.045**	-1.123**		
	(0.500)	(0.483)	(0.618)	(0.659)		
spinoff	-.849	-0.318	-2.276***	-0.089		
	(0.505)	(0.484)	(0.913)	(0.572)		
inexp					0.780**	0.365
					(0.460)	(0.504)
design		-1.771***		-3.052***		-2.380***
		(0.611)		(0.786)		(0.845)
DK*cohort2			-2.234***	-2.311***	-0.902*	-1.487**
			(0.653)	(0.703)	(0.641)	(0.693)
DK*diversi			-0.857	-1.028*		
			(0.701)	(0.736)		
DK*related			-1.588	-1.401		
			(1.402)	(1.406)		
DK*spinoff			1.760*	-0.434		
			(1.086)	(0.826)		
DK*inexp					-0.121	0.369
					(0.636)	(0.682)
DK*design				2.231**		0.802
				(1.110)		(1.278)
n	49	49	49	49	49	49
Obs.	51	51	51	51	51	51
failures	38	38	38	38	38	38
Wald (df)	11.52(4)**	18.89(5)***	24.35(8) ***	40.25(10)***	7.57(4)	21.92(6)***
ΔWald(df)		M1: 8.39(1)***	M1: 19.10(4)***	M2: 17.51(5)*** M3: 16.19 (2)***		M5: 10.94(2)***

Table 6: Survival of Wind Turbine Manufacturers 1974–2014 (standard errors in parentheses; *p <0.1; **p <0.05; ***p <0.01)

The test of the heritage model for the wind turbine industry in Model 1 is mostly positive. Coefficients can be transformed in percentage of increased or decreased hazard rate (see footnote 2). Late entries have an 18% higher hazard rate. Entries from related industries as well as spin-offs have a lower hazard rate of 78%, respective 57% compared to the reference group of inexperienced early entries. However, only relatedness has a significant effect on firm survival, and being a diversifier decreased hazard by less than 1%. The second model includes *design* to account for performance differences by the adopted design.[17] *Design* has a significant positive effect on firm survival and decreases hazard rate by 83%. Additionally, being a spin-offs decreases hazard only by 27%, while hazard of late entries increased by 55%. As especially late entries and spinoffs applied the Danish design, introducing *design* had a negative effect on their performance. To conclude, the first pair of models show that the turbine industries in the US and Denmark follow the heritage theory of Klepper (2002b) with the exception of diversifiers and the particular role of the wind turbine design.

The second pair of models compares the performances of Danish and US firms. In Model 3, coefficients for US entries had the same sign as in the previous models. Coefficients describing the performance of Danish firms differ as expected from those of US firms: late entries, diversifiers, and entries from related fields perform better, while spinoffs perform worse than their US counterparts. In addition to the first pair of models, estimates for both US and Danish late entries and being a spinoff became significant.

[17] We also tested a non-stratified model including DK and design. In this model, being a Danish firm negatively affects firm survival, while applying the Danish design significantly increases survival time. Although DK and design are highly correlated (see Table 5), being a Danish firm and using the Danish design seems to have different effects.

		US	Danish v. US	Danish
Model 3	cohort2	386	-89	-48
	diversi	108	-58	-12
	related	-65	-80	-93
	spinoff	-90	481	-40
Model4	cohort2	452	-90	-45
	diversi	125	-64	-20
	related	-67	-75	-92
	spinoff	-9	-35	-41
	design	-95	831	-56

Table 7: Comparison of Percentage Change in Survival rate for Danish and US Firms.

Table 7 compares the percentage reduction in hazard rates for Models 3 and 4. To align Table 7 with Table 6, minus marks a reduction in probability to exit the industry and plus marks a respective increase. Percentages are given for US firms, for Danish firms in relation to US firms, as well as for Danish firms (the latter computed upon the sum of coefficients of US and Danish firms). For Model 3, the table shows entries from related fields as well as spinoffs performing both according to the heritage theory and according to our assumption. Entries from related fields have a hazard reduction of 65% if they are US firms. Danish entries from related fields have an additional reduction of 80%, which leads to an overall reduction of Danish entries from related fields of 93%. Spinoffs in the US have a strong reduction of their hazard of 90%. Danish spinoffs perform worse. Compared to US spinoffs, their hazard rate is 481% larger. Yet, compared to the reference group, Danish spinoffs still have a 40% reduction of hazard rate.

Yet, the table reveals deviations from the heritage theory regarding diversifiers and late entries. Being a late US late entry increases hazard rate by 386%. Upon this increase, Danish late entries experience a reduction of 89%. This reduction is larger than the increase for US firms. As a result, Danish late entries have a hazard rate reduction of 48% compared to the reference group. This results deviates from the prediction of the heritage theory and might reflect the early phase of experimentation in the Danish industry (see also footnote 9). Yet, also the nowadays existing large Danish producers Vestas and Siemens (former Bonus) entered in the first cohort. Additionally, diversifiers have an increased hazard rate of 108% when they are US firms. Upon this increase, Danish diversifiers have a reduction of hazard of 58%. This reduction results in a reduction of 12% compared to the remaining reference group. Therefore, only Danish diversifiers perform according to the heritage theory and even their hazard reduction is much smaller than that of diversifiers in other industries (see for example table 1). Robustness checks indicate that *diversi* does not significantly increase the fit of the models and entry by diversification does not have the positive effects on survival than expected from the heritage theory.

Model 4 adds a variable for Danish design. Applying the Danish design reduces hazard rates for US firm by 95%, i.e. to 5% of the baseline hazard. This 5% increases by 831% if a Danish firm applies the Danish Design. Despite this strong increase, Danish firms adopting the Danish design still have a reduction of hazard by 56% compared to the reference group. Thus, applying the Danish design affected all firms positively, yet especially the few US firms.

Including *design* also changes coefficients of *spinoff*. In contrast to Model 3, being a US spinoff only has a negligible effect on firm survival with a hazard reduction of 9% while Danish spinoffs perform better (35%) and not worse than their US counterparts. This effect of the design variable points to an effect already observed in the genealogy of the US industry (Figure 2): only one of the three US firms producing Danish design wind turbines was not a spinoff and design changes in the US industry took place via spinoff processes.

In the first four models, we measured the performance of diversifiers, spinoffs, and entries from related fields against inexperienced entrepreneurs. Models 5 and 6 mirror Model 3 and 4 and test the performance of inexperienced entrepreneurs against experienced entries. Inexperienced entrepreneurs built upon the least resources applicable in the new industry in both Denmark and the US. However, we assumed that the institutional system of the US facilities the allocation of resources for these firms also, giving them an advantage over their Danish counterparts.

In both models, the hazard rates of late entries reflect the results of the previous models: Danish late entries performed better than US late entries and even better than early entries. Also *design* affects survival comparable to previous models. Comparing Models 5 and 6, the hazard of inexperienced entries exhibits ambiguous results. In both models, US inexperienced firms exhibited an increase in hazard rate. Yet, the significance of this increase disappears when including *design* in Model 6. Danish inexperienced entries had a lower hazard rate compared to US inexperienced entries in Model 5. Even if this reduction accounted only for 11%, we expected an increase. When including *design* in Model 6, inexperienced Danish entries perform worse than inexperienced US entries, as expected. As all inexperienced Danish entries applied the Danish design, the better than expected performance of Danish inexperienced entries might be affected by the choice of the right design. Indeed, firms formed by engineers like Riisager or Adolphsen that were important in the development of the Danish design (Gipe 1995) were classified as "inexperienced".

To conclude, we found that Danish firms performed as expected in relation to US firms: late entries, diversifiers as well as entries from related fields performed better than their US counterparts, while spinoffs and inexperienced entries (when accounting for wind turbine design) performed worse. Thus, we found that those firms that act comparatively freely from resources in established industries perform better in the US, while those firms that utilize resources form other fields perform better in Denmark.

The Heritage Theory and Dominant Designs

While we found that Danish firms performed as expected in relation to US firms, we also found some deviations from the heritage theory, especially the negligible importance of production experience by diversifiers and importance of design. These deviations might emanate from dynamics connected to the formation of a dominant design (Utterback and Abernathy 1975, Suarez and Utterback 1995, Garud and Karnøe 2003, Gipe 1995). Utterback and Abernathy (1975) argue that a dominant design, i.e. a design with a market share of at least 50% (Anderson and Tushman 1990), emerges as firms converge to a common design. The adoption of a common technological design allows firms to benefit from economies of scales and to shift from product to process innovation. As a result, firms following alternative designs and thus do not benefit from these network effects exit the market. A shakeout can also occur if an established dominant design is substituted by a new design, which has competence destroying effects on incumbent firms (Anderson and Tushman 1990). Thus, the dominant design explains a shakeout by the relation between the firm and the (later) dominant design. This reasoning stands in contrast to Klepper ((1996), who argues that a dominant design emerges, when firms with inferior routines are outcompeted, whereby variety of designs automatically decreases. These different causalities between dominant design and shakeout also lead to a different temporality. According to Klepper (1996), a design would become dominant during a shakeout, while it would become dominant before according to Utterback and Abernathy 1975).

Figure 4 describes the relation between industry evolution and the Danish design as later dominant design. The figure combines the two industries during time and shakeout of the industry. Firms from both industries directly competed against each other in the then global market of California (Karnøe 1999). The figure includes numbers of firms to define time of shakeout; share of firms that adopted the Danish design, as well as exits of firms according to design. The latter allows investigating which firms dropped out of the market.

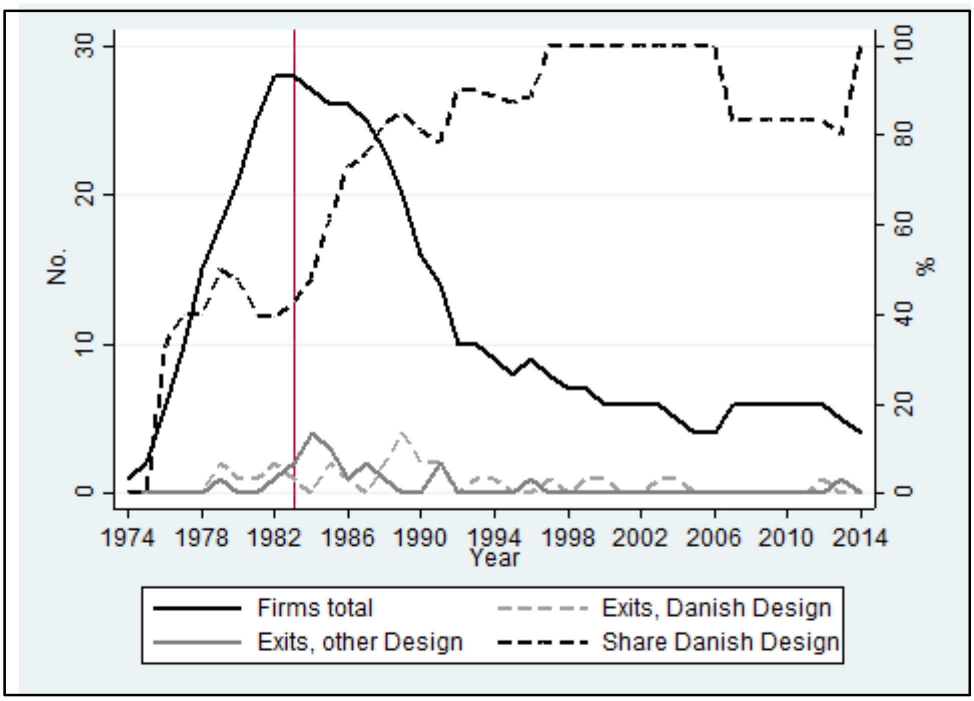

Figure 4 : Dominant Design and Shakeouts

The Figure shows a peak of the industry in 1983 with 28 firms[18], of which twelve firms adopted the Danish design[19]. The share of firms adopting to the Danish design strongly increased with the emergence of the Danish industry. Three Danish firms produced another than the Danish design. However, these firms dropped out or changed to the Danish design before the industry shakeout. Also the only early US firm that produced Danish Design wind turbines was acquired before the shakeout. Thus, the design sharply divides the two industries in 1983. The following shakeout took place in two waves. In a first wave, firms that did not apply the Danish design exited the industry; these were the US firms. In a second wave, also firms using the Danish design dropped out. Thus, there already was a considerable number of firms producing

[18] Without firms that produced only prototypes. With these firms, the shakeout would start one year earlier.

[19] As the dominant design is usually defined by market share, and we only have firm numbers as proxy, including firms that did not sell turbines would lead to a further bias.

according to the Danish design before the shakeout and this design became dominant during the shakeout.

A dominant design perspective might explain the negligible influence of being a diversifier on firm survival, as not production experience was important, but the relation to a particular design. The related fields that are beneficial for form performance also point in this direction. We denominated US entries from universities and Danish entries form agricultural machinery production as related. While the good performance of US entries from universities could be explained by the importance of academic knowledge and procedures in an emerging industry, the relation of agricultural machinery production to wind turbine production is less obvious. Yet, the Danish design was developed by a network of windmill owners, producers and suppliers (Karnøe 1999) that were mostly located in rural Denmark. Access to this network seemed to be more important than technological relatedness. In doing so, “agricultural machinery” might indicate that network access in combination with production experience was a beneficial combination for survival of Danish firms. In turn, the seemingly obvious technological relation between wind turbine production and the aviation industry resulted in many US entries from the aviation industry, which exhibited high hazard rates. These firms applied knowledge from the aviation industry to develop the US based light-weight design of a two-bladed fast rotating downwind rotor. The new dominant design of a three-bladed slow rotating upwind rotor devalued this design knowledge from the aviation industry (Garud and Karnøe 2003). The exits of aviation firms indicate the competence destroying effects of the dominance of the Danish design.

A further indicator for a dominant design dynamic are survival rates of spinoffs. Spinoffs performed as expected by the heritage theory, but only significantly, if they adopted the dominant design. Their pre-entry experience might have enabled them to mindfully deviate (Garud and Karnøe 2001) from the approaches of their parent firms. This effect is already indicated by Klepper (2007), who shows that disagreements between employees and managers are a driver of spinoff dynamics. In the case of the US spinoffs, these disagreements seem to refer to choices of the appropriate wind turbine design; which indeed was a debate within US firms, as Gipe (1995) pointed out.

To conclude, the effect of pre-entry experience on survival might be biased, as pre-entry experience included also the capability to adjust to a particular design. Yet, even under these conditions, the assumption of the heritage theory about the importance of firm routines for the performance of firms and the evolution of an industry hold.

Conclusion

Klepper's (1996, 2002a, 2002b) heritage theory explains the evolution of industries by firm-specific factors. We contribute to the strand of literature that expanded on his theory by arguing that institutions also affect the pattern of industry evolution (Lundvall 1992, Hodgson 1998). To assess institutional effects, we applied a VoC perspective to the heritage theory (Hall and Soskice 2001). In contrast to other institutional approaches, the VoC perspective focuses on the individual 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 resources are transferred successfully from old industries and accumulated in the new industry. We expected firms in LMEs to transfer resources to the new industry in relative independence from established fields and to benefit when they do not need to consider the constraints of established industries. We expected firms in CMEs to transfer resources into the new industry in relation to established fields and to benefit from synergies to established industries. Additionally, we expected that the more constrained resource transfer in CMEs result in a slower industry formation.

We operationalized the different entry forms of the heritage theory as different forms of connections between old and new industry. We used three types of indicator. First, we used the time between first formation and shakeout as indicators for the speed of resource transfer. Second, we used entry types as indicators for different forms or resource transfer. While diversifiers and entries from related industries exhibit the strongest connection to established industries, entrepreneurs from unrelated fields are more loosely connected to them and spinoffs build upon resources already established in a new industry. Differences in entry pattern would indicate different forms or resource transfer between established and the new industry. Third, we used survival analyzes to indicate which forms of resource transfer are supported by the different institutional environments, and which forms are penalized.

As the heritage theory was established using examples of US industries, we used it as a model for LMEs and derived expectations for CMEs. Regarding the speed of resource transfer, we expected a delayed industry formation in CMEs compared to LMEs, indicated by a longer time span from first entry till shakeout. Regarding entry pattern, we expected a larger amount of diversifiers and entries from related industries and a smaller number of inexperienced entrepreneurs and spinoffs in CMEs. Additionally, we expected the temporal pattern of diversifiers in early cohorts and spinoffs in later cohorts to be less pronounced in CMEs. Regarding firm performance, we expected diversifiers and entries from related industries to perform better in CMEs than in LMEs and other entries to perform worse. Additionally, we expected that—due to the longer connection of the new to established industries in CMEs—late entries would have a smaller disadvantage and therefore perform less poorly than in LMEs.

We tested these assumptions on wind turbine manufacturers in Denmark and the US. The two countries are assigned to different variants of capitalism, the US as an LME and Denmark as a CME (Kenworthy 2006). Our analysis found a slower industry formation, smaller differences in entry pattern between entry cohorts, a better performance of entries from related fields and a worse performance of inexperienced entrepreneurs for the Danish industry compared to the US industry. These results fit to our assumptions on how institutional differences affect evolutionary dynamics in these industries. In addition, our study also depicted intra-industry dynamics in the form of design changes and intra-industry acquisitions that met our assumptions. Resources were easily switched and abandoned also within the US industry. In Denmark, the slower formation of industry specific resource coincided with a higher preservation of already established resources via acquisitions.

Yet, our results seem to be biased by dominant design dynamics (Utterback and Abernathy 1975, Anderson and Tushman 1990). Production experiences of diversifiers became only important when there was a connection to the dominant design and spinoffs benefited from inherited routines only if they adjusted to the dominant design. Thus, pre-entry experience positively affected firm survival it if enabled the firm to adjust to the (later) dominant design.

In addition to the influence of a dominant design, there are further limitations when it comes to deriving generalizations from our approach. First of all, our study only deals with a low number of observations. We nevertheless chose this industry, as debate on the appropriateness of the VoC framework to distinguish between countries (Campbell and Pedersen 2007, Schröder and Voelzkow 2016) indicates a certain probability of a mismatch. Indeed, studies like Gipe (1995) and Garud and Karnøe (2003) helped to interpret particular dynamics, as different related fields, the effect of the NASA/DOE program as well as the importance of the wind turbine design. As our research was rather exploratory, the existence of such studies to meaningfully interpret the results was in our view more important than a higher significance of statistical analysis.

The second limitation lies in the differences of the industry evolution in the US and Denmark. Differences such as forms of relatedness and technological approaches affect firm survival and aggravate interpretations. Additionally, we did not only compare an industry in one institutional setting with an industry in another institutional setting, but also compared a successful one with a nearly extinct industry. In turn, it was our actual intention to analyze differences and it is only differences that make comparative research fruitful. Our way of handling these differences was to triangulate quantitative analysis with a case study approach, but there are surely others.

The third and most important limitation lies in the temporality of the VoC framework. The heritage theory usually analyzes historical processes, such as the emergence of the automobile or tire industry (Bünstorf and Klepper 2009), while the VoC covers institutional differences from the 1970s onwards. Our proposed framework is therefore only applicable to younger industries like wind turbine production. However, comparative studies on biotechnology in Germany and the UK from Lange (2009) and Herrmann (2008) show that in particular young and technology oriented industries are able to evade their institutional context. For example, firms in new technologies in CMEs use global labor markets and financial systems as well as institutional differences between countries to evade constraints of the dominant institutional forms in the country they are based. These particularities in the evolution of different institutional systems further aggravate a comparison.

Due to these limitations, we consider our contribution especially as a conceptual one. We presented an argument based on the VoC framework of how institutions affect industry evolution. We integrated our assumptions into the well-established framework of heritage theory of Klepper (1996, 2002a, 2002b). In doing so, we connect two broad but disconnected fields of research. The cases of the Danish and US wind turbine producers show that such a connection is feasible, but also the complexities and difficulties involved in this connection. Yet, by making this connection, our framework presents a step further toward comparative analyzes of industry evolution in different institutional environments.

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