Path dependence in emerging industries?

Dominant logic development within the German photovoltaic industry

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Abstract

At first glance, path dependence and emerging industries and organizations are scientific concepts that seem difficult to reconcile. On the one hand, between the formation of an industry and its comprehensive consolidation usually lie decades of growth and subsequent decline. Furthermore, young companies are considered rather flexible. On the other hand, path dependence is a concept which can help explain processes of rigidification based on the “history matters” argument. Path formation is a process that bit by bit leads to a “lock-in” situation that raises difficulties for the actors to change again substantially. In the German photovoltaic industry between its formation and its decline lie about ten years in which new companies were founded, grew rapidly, reached global leadership, and failed to adapt in the face of changing market conditions which eventually led to numerous insolvencies. This paper discusses the possibility to find path dependencies in young and emerging contexts. Based on the development of three organizations which belonged to the top-performing group and which ended up in insolvency, it is argued that a dominant logic evoked by adaptive expectation effects among actors within the industry might have prevented the companies from adapting timely to changing market conditions. Further, an industry cycle is proposed that may have determined the pace of industry development and an accelerated formation of adaptive expectations in favor of a dominant growth and leadership logic among firms in the German photovoltaic industry that eventually made them underestimating upcoming changes and prevented them from making strategic precautions.

Content

Introduction

One of the first things people usually say when talking about path dependence is “history matters” as this notion is often used as a synonym for path dependence (Schreyögg & Sydow, 2010). Taking path dependence more serious means looking at a process which – triggered by positive feedback loops – eventually results in rigidification that cannot be dissolved readily by respective actors anymore leading to a high degree of inflexibility. Recent studies that based their analyses on this notion of path dependence traced these processes over a period of more than half a century (e.g. Schreyögg et al., 2011; Schüßler, 2009) and even the lock-in state sometimes lasted up to 30 years (Schreyögg et al., 2011). This raises the fundamental question if path dependence might occur in emerging contexts as well? The question is inspired by the development of the German photovoltaic industry which experienced birth, a short but breathtaking rise, and its decline in not much more than ten years. The industry was fairly young the time it - and the organizations within it - experienced this sharp decline but, nonetheless, hardly any of them was able to adapt itself substantially in order to stay competitive. Several insolvencies, lots of redundancies and plant closures have been the result. In retrospect, it appears unintelligible how it came to happen that hardly any of the German firms was able to build up viable strategies and business models as at least some of the environmental changes should have been foreseeable. This is why many critics reproach the companies for “slumbering away” technological developments (Krümpel et al., 2009), for “losing sight of” production costs (Höppner & Weishaupt, 2012), for “failing to build up” their foreign business operations early enough (ibid.), for “failing to adjust” the company structures to the fast growing sales volume (Murphy, 2012b), and for “underestimating” the Asian competition (Murphy, 2012a). According to the CEO of the Swiss mechanical engineering company Meyer Burger „some industry giants ultimately failed because they reacted too late or not at all anymore to the sudden market changes“ (anon., 2012).

There are several papers which broach the issue of lacking industry adjustment to changing market conditions such as the US steel industry (Hoerr, 1988; Reutter, 1988), the British dye makers (Chandler, 1990), the US automobile industry (Yates, 1983), the Scottish knitwear industry (Porac et al., 2011), or the German textile and clothing industry (Schüßler, 2009). But the development of the German photovoltaic industry still is remarkable as flexibility (Morris et al., 1999) and greater capacities for organizational learning (Lichtenstein et al., 2003) are typically attributed to younger companies like the German photovoltaic producers. Moreover, since young companies are less burdened with traditions (Sommer et al., 2009), and less constrained by their existing structures and policies (Schindehutte & Morris, 2001), change is generally expected to be easier than in more mature companies (Ambos & Birkinshaw, 2010).

Building on prior literature on lacking industry adjustment like the research cited above and literature on joint interpretation patterns within industries and among groups of firms such as on Abrahamson and Fombrun (1994: 750) who suggest that “spirals of macrocultural homogenization […] would leave

organizations within its grip increasingly vulnerable to exogenous changes in the structure of value added networks and, thus, limit collective adaptation" it is assumed here that the occurrence of a dominant logic among firms in the German photovoltaic industry might be the result of path dependence. Based on these premises this paper seeks to explain what might have accelerated path formation to such a degree that path dependence can even occur in emerging industries.

This paper is divided into five sections. First, the theoretical underpinnings will be clarified. Second, the choice of firms and time frame will be established as well as the data sources in use. Third, it will be argued that the firms shared a dominant growth and leadership logic which will be the starting point for the fourth section in which an explanation for the pace issue will be proposed. And finally, the results and the implications will be discussed.

Theoretical foundations

At first glance, the development of the German photovoltaic industry actually is captured pretty well by stylized models of industry evolution in general. These models assume that industries follow patterns similar to life cycles. When an industry is emerging there are usually few small firms, market volume is low, there is considerable uncertainty, tentative production machines are used, and products tend to be expensive. Over time more and more firms push into the industry, each firm raises its output, product standards evolve, specialized production machines are used, and prices decrease. Firms continue to raise their output, not every firms it able to stay competitive anymore and industry consolidates by major firm shakeouts[1] (e.g. Jovanovic & MacDonald, 1994; Klepper, 1997). These shakeouts sometimes occur because foreign competitors force incumbents out of the market, e.g. within the British dye industry (Chandler, 1990) or the US automobile industry (Halberstam, 1986; Keller, 1989). By 1900, the British dye makers even showed the same reaction as the German photovoltaic producers did quite recently. They "had petitioned Parliament for tariff or other protective legislation" against the German competitors back then (Chandler, 1990: 135). Often these crowding outs are attributed to "a homogeneous and insular interorganizational macroculture that encouraged manufacturers to overlook new types of competitors, cling to traditional technologies, and remain mired in similar, yet outdated, strategic postures" (Abrahamson & Fombrun, 1994: 728f.).

The establishment of common understandings among firms has been observed by several researchers before. Abrahamson and Fombrun (1994: 729), for example, suggest that "homogeneity of believes within an interorganizational macroculture encourages member firms' managers to interpret environments in similar ways, [and] to identify similar issues as strategic." Not only may a homogenous macroculture may lead to strategic similarity but also to a collective cognitive inertia (ibd.). This is in line with Hodgkinson (1997) who expounds the problems of cognitive inertia for UK residential estate agents. Porac and

[1] Of course there are industries that do not experience this shakeout phenomenon (e.g. Klepper, 1997).

colleagues (1989) describe the reinforcement of shared mental models in the Scottish knitwear industry, or Huff (1982) and Spender (1989) assume that there are certain industry recipes which guide firms' understandings of the competitive space and subsequently their strategic decision making. As Huff (1982: 125; italics in original) puts it: "[T]he industry provides a repertoire of possible strategic frameworks. The strategies of other organizations within a competitive group help each organization make sense of the environment and their opportunities to operate within it." All the studies share the assumption that these cognitive representations once established incorporate the danger of a deficient adaptation to changing environmental conditions. Beyond that, all these studies have in common that they investigate the dominant logic in mature contexts, in which these logics might have evolved over decades. This is where the present paper ties in with its study of the occurrence of path dependence in emerging contexts assuming that the emergence of a dominant logic among firms in an industry might be the result of path dependent development.

Path dependence is a recently well acknowledged process theory for the investigation and explanation of organizational and strategic persistencies (e.g. Sydow et al., 2009). Becoming path dependent, or rather locked-in means that an organization's range of possible strategic action alternatives is narrowed down dramatically and enduringly due to self-reinforcing mechanisms (e.g. Koch, 2011). As a result, the organization loses its flexibility (e.g. Schreyögg & Sydow, 2011). This can cause serious problems for firms which become visible as changes in the firms' environment call for changes in the firms' strategies. Path dependence has been researched on many levels of analysis[2], even already on an industry level (Schüßler, 2009), but mostly the empirical cases which were investigated have a long history. This is why it seems promising to investigate how path dependence might occur in contexts that are fairly young. According to Sydow and colleagues (2009), a lock-in may be either primarily resource-based, cognitively, or normatively constituted. As structures in emerging industries are far less stable (Santos & Eisenhardt, 2009) and young organizations are less burdened with existing policies and structures (Schindehutte & Morris, 2001) this hyperstability can be expected to be found predominantly on the cognitive level. Bogner and Barr (2000: 213) suppose that "the development of […] [cognitive] frameworks is path dependent; as individuals interact with their environments and build cognitive frameworks, they use those frameworks to make sense of future interaction. Thus, the past shapes the template for understanding the future." While interacting with the environment one can assume that adaptive expectation effects evolve that eventually lead to cognitive rigidifications, i.e. a dominant logic (Prahald & Bettis, 1986), among several companies[3]. Adaptive expectation effects "relate to interactive building of preferences, which are not considered to be fixed dispositions but to develop in response to the expectations of others" (Schreyögg & Sydow, 2011:

[2] E.g. on the market level (e.g. Arthur, 1989; David, 1985), on the level of institutions (e.g. David, 1996; North, 1990; Pierson, 2000) on the organizational level (e.g. Schreyögg et al., 2011) and even on the individual level (e.g. Nooteboom, 1997).

[3] For an extensive literature review on self-reinforcing mechanisms others than adaptive expectations see Beyer (2010).

325). Feedback from the environment thus has an impact on the aspiration level of future expectations (Lant, 1992). When there is uncertainty about the right choice actors "feel rewarded by the fact that others are likely to prefer the same" (Schreyögg et al., 2009: 700). This is how adaptive expectation effects might lead to the diffusion of best practices because when actors expect that others adopt these practices they are likely to adopt them as well to end up on the winning side (ibd.). Adaptive expectation effects therefore intuitively go together with network externalities. The more actors adopt a logic the more attractive it is to adopt it for other actors due to the aforementioned reasons.

Hence, adaptive expectation formation during organization-environment interaction might produce a dominant logic among firms in general, that is independently of the age or maturity of the context. Still, what might differentiate the pace of path formation in emerging industries from path formation in more mature contexts remains an open question. The present paper seeks to answer this very question: *How can path dependence occur in emerging contexts? Are there differences between emerging and mature contexts?* As this paper presents work in progress only a tentative model to answer the first question will be proposed as a start.

Method

Research design

The German photovoltaic industry has been chosen as research context because it shows many parallels with the old-established German textile and clothing industry for which Schüßler (2009) demonstrated path dependence on an industry level. Among other things both industries have experienced a major structural change which several firms did not survive. Studying the entire German photovoltaic industry is beyond the scope of this paper. In alignment with the explorative purpose of this study a small subgroup of firms has been chosen whose development will be analyzed in depth employing a longitudinal qualitative case study. This method has often proven to be advantageous to research processes involving complex mechanisms such as path dependence (Holtmann, 2008). Identifying a coherent group of firms turned out to be quite difficult as the application of the strategic group concept which is often used as an intermediary level of analysis between industry and single organizations (e.g. Hunt, 1972; Newman, 1973; Reger & Huff, 1993) in a narrow sense did not work here. Many organizations within the industry integrated and de-integrated several parts of the value added chain over time. Caves' and Porter's (1977) suggestion that strategic groups occur because of the isolation by intergroup mobility barriers which prevent firms from changing industry segments does not necessarily take effect in emerging industries which are rather characterized by instable structures (Santos & Eisenhardt, 2009). To identify a strategic group on the basis of the degree of vertical integration (Newman, 1972) did not work for the same reason. These difficulties are in line with Reger and Huff (1993) who found that strategic groups are often fuzzy and that there tend to be some repositioning and changes in firms' strategies due to reactions to

environmental events. This is why the sampling ultimately had been driven by the phenomenon of interest. The first sampling criterion was that firms did have to operate at least for some time on the midstream segment of the value added chain (production of ingots, wafer, cells, modules) as this segment was first and most intensely affected by the market change. Furthermore, it is required that firms had to be listed in the Prime Standard of the stock market because these companies are subject to the highest transparency and disclosure standards, a fact which makes it possible to gain the most richest information from their company reports. And finally, only companies that ended up in insolvency until today have been chosen. Thus, unsuccessful adaptation is what all of them have in common. Such a design is recommended by Yin (2009: 59) when "the multiple-case inquiry focus[ses] on how and why the exemplary outcomes might have occurred and hoping for literal (or direct) replications of these conditions from cast to case." After applying these requirements, three companies that belong to the group of organizations that have experienced the most outstanding success and ended up with becoming insolvent constitute the group whose development was examined in depth. The first organization, Q-Cells once had been the largest cell manufacturer worldwide for crystalline silicon-based solar cells. Solon, the second company, made it to count as the largest European solar panel producer in the crystalline silicon technology and Conergy, the third one, once had the largest photovoltaic sales volume in Europe and therefore had been the largest photovoltaic company in Europe. What is different here is that Conergy did not produce itself products that belong to the main value added chain before 2006. All three ended up in insolvency but they still do exist as investors bought parts of the companies. In appendix A, table 2a to table 2c give an overview of selected operating figures from the companies' reports.

The time frame chosen covers the years between 1998 and today because, first, Solon and Conergy have been founded in 1998 (Q-Cells in 1999) and, second, the development of the industry and the companies is still ongoing. Conergy has filed for insolvency only three months ago.

Data collection and analysis

Twelve interviews have been conducted with members of the executive board, with members of the board of directors, and with leading managers from the three companies. Table 1 gives an overview of the interview partners. Because strict anonymity has been guaranteed to informants and I often have been told that everyone knows everyone else in this industry the table only depicts the number of interview partners and the covered time span for each company. The interview partners' positions are not named for each company separately to guarantee anonymity as best as possible. Also, when cited later in this paper all interviewees will be referred to as "manager" and a number will be assigned in connection with the respective company. It is important to acknowledge that there was some movement within and across companies. This is why the total number of interview partners is smaller than the sum of the second column of table 1 and the sum of the positions within companies. Additionally, company records have

been used to reconcile the informants' statements with the companies' actual development and decisions as retrospect accounts bear the risk of exhibiting several biases (Golden, 1992).

Table 1: Data sources

Company	Number of interview partners	Time span covered by interviews	Time span covered by company reports[4]
Conergy	5	1998 (formation) - today	2004 - 2012
Hanwha Q-Cells	4	1999 (formation) - today	2004 - 2011
Solon	5	1998 (formation) - today	1999 - 2010
Positions within companies:	CEO (4), CFO (2), COO (5), other function in the executive board (1), board of directors (1), management sales (2), management products (2)		

Research context: the German photovoltaic industry

To sketch the context within which the three companies acted a short summary of some important developments will be given. Of course it is not possible to give an account of the complexity and all major factors that affected the development of this industry and subsequently the firms' strategic orientations and expectation formation due to the confined space.

It has been not too long ago that the German photovoltaic industry reached a considerable size. Most of the producing companies operating today have not been founded before the mid-1990s. When the German federal government enacted several laws to support demand for photovoltaic in Germany the market successively grew to a substantial size. At the latest in 2004 when the feed-in tariffs granted by the EEG had risen again substantially the market took off. One should imagine this situation as a real boom and hype. The firms had been confronted with a seller's market and had not been able to meet the demand at all. They grew rapidly and some of them soon reached a billion in revenues. Because of the generous supporting program, Germany soon became the globally leading solar market. Other markets followed step by step. Soon major shortages in raw material determined company and therefore market growth. If these had not arisen the growth could have even been much faster. As demand was larger than supply more and more firms saw an opportunity and pushed heavily into the market. In particular, firms from China rapidly built up major production capacities, much larger than those of the German producers and they sold at lower prices. Within a couple of weeks the situation changed at the end of 2008. Spain which had become the largest solar market regarding the newly installed capacity by then cut the tariffs and restricted the annual construction of additional photovoltaic systems. Other countries also reduced the tariffs substantially. Companies became problems selling their stock. Major excess capacities evolved. These excess capacities caused decreases in prices for solar panels up to 40% per annum; several years in

[4] The time span covered by company reports differs with the date of the companies IPOs and accordingly with the date of the companies' insolvencies.

a row. Additionally, the major financial crises lead to restricted credit policies. Until today numerous companies became insolvent.

Indicators for the existence of a dominant growth and leadership logic among firms leading to collective difficulties in adaptation

During the interviews it became more and more evident that there was a common misjudgement in the companies' anticipations about future industry development and their related strategic positioning. There are indicators that the companies jointly had seen themselves in globally leading positions in the long run. This is true for Q-Cells: "We saw ourselves as the market leader. In 2007, 2008 we had been the largest cell manufacturer worldwide. […] Yes, and actually it had been the ambition to form the world's largest company" (Q-Cells_2), and for Solon: "Well, there had always been the vision to become the largest module producer worldwide" (Solon_4). A Conergy manager even attributed this logic to the whole industry: "But this had been a kind of a chauvinist-thing. You know, everyone wanted to be larger, better, and more popular than the others" (Conergy_3). Hence, the tentative conjecture is that the reinforcement of a growth and leadership logic impeded at timely adaptation to the changing market because they jointly underestimated the speed and magnitude of immanent market changes such as the threat by Asian and especially Chinese producers or radical reductions in feed-in tariffs and other supporting programs. A Q-Cells manager described his impression as follows: "The development was so fast and so unforeseeable. And that the markets would grow so fast and that the competition and the excess capacities and so forth would come so forcefully - I think everyone in this industry was overtaken by this development" (Q-Cells_1). The same holds for Solon. A manager said that they did not ignore the impending threat, instead the Chinese pushed into the market more heavily and much faster than expected by German firms (Solon_2). Similarly, a Conergy manager summed up: "Everything that happened was more or less foreseeable because back then [2007] we already knew that the Chinese build their factories like blazes, that eventually a big wave of new capacities and thereby new products was going to roll towards us. We also knew that subsidies would not be forever and that countries like Spain – which already had budget problems back then – would ultimately cut the subsidies. Everything was known but the question was: When is that going to happen? And am I positioned appropriately to cope with these developments?" (Conergy_4). As the photovoltaic technology is not too far from technologies like chips or semiconductors the development of the photovoltaic industry might have been foreseeable to some degree. When asked about the predictability a Q-Cells manager answered: "It could have been expected. We didn't expect it because we always thought we were better. What we sometimes were not. Or we had been better regarding quality. The question is: Did the customers accept this extra quality? And this was exactly the issue that the customers especially in Germany oriented themselves on the price" (Q-Cells_2). Also, first and cumulative warning signals have been ignored. In 2004/2005, a Solon manger visited Yingli – today

one of the largest Chinese photovoltaic producers – and when he came back he went to warn Q-Cells. He told them that it would be essential to radically decrease production costs because it would not be long before the Chinese would have cells as well. But this advice was dismissed. Their response was described as follows: “We have such a high technological level. Our technological lead amounts to some five years. When they are where we stand now we will already be much farther. […] They won’t manage that within such a short time” (Solon_4). Closely associated with this are the early and very successful IPO’s of Chinese firms. In 2005, for instance, Suntech Power gathered about 400 million US dollar when it launched its IPO in the US. Also, first warning signals coming from the immediate domestic sphere had been put aside. When Conergy was close to insolvency in 2007 the industry was still booming and “back then the predominant opinion was: ‘Revenues are exploding everywhere. This industry is great. Only […] Conergy performed poorly. If you intervene a little bit it is going to be fine again.’ And only for this reason we got fresh money from new investors in a cloak-and-dagger-operation in November and December. […] People are somewhat – let me say – blind or they don’t take the time to examine things properly when there is an overall hype. […] The entire press is writing the same, analysts are writing the same and investors are throwing in their money” (Conergy_3).

These joint underestimations are reflected by several symptoms within the companies: the neglect of cost reduction issues, the neglect to build up essential business structures, the neglect to serve customers well, and the withdrawal of critics form their companies (for further interview excerpts see table 3, appendix B).

First, firms tended to neglect cost reduction issues or even wasted capital to some degree. The main factor was the unnecessary hiring of employees. Additionally, in retrospective interviewees admit that the large investments in the firms’ headquarters, e.g. Solon and Conergy, might have been exaggerations. The most capital intensive expenditures probably had been numerous acquisitions and strategic investments in other firms. Q-Cells for example, invested in several new alternative technologies at once during the time of the major silicon shortage because they wanted to be sure that they capture a leading position when one technology would come out on top. It turned out that hardly any of these technologies became very successful and Q-Cells missed the right time to disinvest. All three companies had to depreciate entire companies from their books.

Second, during the rapid growth which retrospectively has been characterized as “not sustainable” and “unhealthy” by most respondents firms neglected to build up the necessary structures for managing big enterprises. As one Conergy manager summarized: “Every employee in this industry always wears shoes that are too large. This is obvious because of such a growth – again we started with five employees and grew on 3,000, on a billion euro enterprise within five or six years. Something like this is really rare and it can’t be sustainable because there can’t be eternal growth. When a normal company grows 5 to 10% per

annum, then is has a history and it develops step by step and it can professionalize everything little by little. This is possible but given the rapid pace […]" (Conergy_2). This lacking professionalization applied at least to controlling, legal and contract administration and sales and distribution structures. Additionally, due to this heavy growth there had been personnel movements to support the increased production, e.g. employees have been drawn out of research and development divisions to support production growth (Hoppmann et al., 2013).

Third, during the regime of the sellers' market companies neglected to serve their customers well. They often failed to deliver promised or even contracted amounts to their customers because they oversold. This became a problem when the market regime changed as they missed to tie in customers in the long run.

Fourth, people who strongly disagreed with the firms' prevailing strategic orientations and who suggested radical changes left the companies because they had not been able to assert themselves. For example, in 2004/2005 one of the Solon managers suggested selling the whole panel production during the industry boom although back then the production generated major revenues and profits. He was sure though that mere production could not be a sustainable positioning within this industry and he wanted the firm to focus entirely on the systems business. He wanted Solon to become the company with the lowest distributions costs through internet distribution, he wanted to realize intelligent energy and thermal cycles for building services, and he wanted to promote energy storages. All these approaches are highly relevant today in the face of the crisis but back then there have been strong internal resistances. He left Solon. By the same token, when Conergy was close to insolvency in 2007 the firm suffered from a long-term contract that was worth 7 to 8 billion dollars. Because of rapidly decreasing costs for raw material this contract soon became far too expensive leading to comparatively high production costs for Conergy. One manager who had been appointed to promote the firm's restructuring wanted to separate the well-positioned and successful system business from the production facilities and then sell it because Conergy's downstream business still was a very valuable asset. In his eyes it was the only valuable asset apart from the mounting systems business that did not play an important role though. Although the industry was still in its boom phase he reasoned that the industry will probably experience a development comparable to the chip industry so it would be reasonable to take a small loss now instead of taking a big loss later. After a few months he left the company because the internal resistance was too strong and he felt that the dominant coalition was not prepared for radical changes. Meanwhile Conergy became insolvent and the systems business including the huge distribution network was the first thing they could sell.

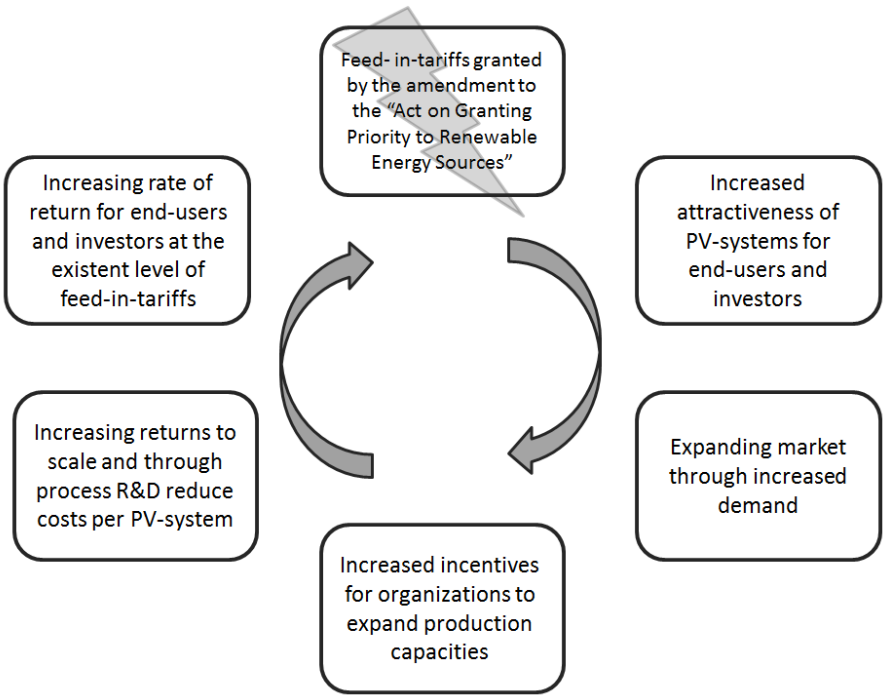
To sum up, they companies jointly missed to prepare for a post-boom era although in both data sources, interviews and company reports, there are several statements that show an awareness that the boom would not last forever. Almost every informant said that they knew that Chinese producers were

expanding massively, that the feed-in tariffs would not be granted forever and so forth. Rational thinking supports the need for the existence of such awareness because growth rates of up to 100% per annum cannot be perpetual. Still, the companies did not act accordingly and thus had not been prepared as retrospective statements demonstrate: “How was the crisis evaluated? Well, first of all regarding the perception / Well, it was a certain – I have to acknowledge – a certain helplessness. […] Well, you came out of this sellers’ market and you found yourself in a situation that you could not handle” (Solon_3). “No, but we also had been neglectful to some degree. Well, this really was a mistake. But all of us made this mistake. Very few made the about-turn early enough” (Q-Cells_2).

A tentative model for path formation in the German photovoltaic industry

To explain how it may have happened that numerous companies from the German photovoltaic industry have undergone a development many other industries have experienced before (for a comparison with the German garment industry see Schüßler, 2009), i.e. a downfall due to lacking adaptation, but within an astonishingly short time span the amendment to the Renewable Energies Act in 2004 is argued to function as a catalyst to industry development. To take this law as a starting point for this process is in line with the view of most informants, e.g.: “This industry came into being in the first place BECAUSE there were these subsidies. WITHOUT the subsidies there had not been an industry” (Conergy_4). This amendment opened up the possibility for organizations to rapidly grow. Thus, this paper takes the position that due to the pace of the industry cycle shown in figure 1 the path formation process, i.e. the rigidification of the dominant logic, took place within only a couple of years. Most informants agree that speed was the main feature that made the photovoltaic industry so special. One Conergy manager illustrated this as follows: “The exception was this turbocharger element which made the industry extremely fast moving. This is like comparing car races: There are soap box derbies where everyone can follow because it goes slow. And there is formula 1 where everyone drives at a rapid pace and where you either have to be a good driver or you crash. […] And in industries like this one you have to be extremely careful that you don’t skid out of the turn” (Conergy_4).

Figure 1: Industry development cycle for the German photovoltaic industry (own figure)



The cycle is as follows: A high level of feed-in tariffs raises the attractiveness of photovoltaic systems for end-users and investors by making them highly profitable. According to Ackermann (2001: 60) increasing attractiveness of a product might have a self-reinforcing effect because it makes the market expand. This expanding demand brought the organizations to expand even more which in turn led to increasing returns, i.e. increasing returns to scale and increasing returns through process research and development. Increasing returns to scale simply lead to declining costs per output unit when the total number of output units increases. Additionally, increasing returns may arise from process research and development. That is "[f]irms reduce their average cost through process R&D, and the value of reducing average cost is proportional to the level of output produced. Consequently, larger firms profit more from process R&D, which confers a competitive advantage" (Klepper, 1997: 151). These increasing return effects reduced production costs per photovoltaic system which increased the rate of return for end-users and investors at the existent level of feed-in tariffs (or a reduced level that still promises high rate of returns), which increased the attractiveness and subsequently the overall demand and so forth. The flash in figure 1 is to indicate that the level of feed-in tariffs determined the speed of the whole cycle. In the worst case, a level that is too low may interrupt the whole cycle by reducing the attractiveness and therefore the demand for photovoltaic systems to a large extent slowing down the cycle while a high level accelerates the process. Announcements of a future reduction of the tariffs, for example, highly accelerated the process because everyone wanted to benefit from the old compensation level and then after the tariffs were cut the cycle widely paused. Even rumors about future reductions did have substantial effects on the cycle. This political instrument has been very powerful as the vast majority of organizations or rather their products was highly dependent on political goodwill and commitment to be profitable. Here it is suggested that this cycle heavily impacted on the pace of the industry development and on the pace of expectation

formation. Below, some first trends and indicators are discussed comparing the time before the amendment and the time after the amendment.

Before the amendment to the EEG: interruptions in expectation formation

Although there have been several incentive and supporting programs before[5], it was not before 2000 that the industry took shape as the Renewable Energies Act was enacted by the German federal government. The era before the EEG had been described as follows by a Conergy manager: "It had always been an up and down. Back then there was no EEG or another major supporting program. The 1,000 roofs program was characterized by – it was phased out by that time. This was in the late 90ties and then the 100,000 roofs program came but it was a stop and go" (Conergy_1). Apart from these major programs there have been several supporting programs on a commune level. But these had not been reliable and large enough for firms to develop long-term expectations. One might imagine these programs like that: "In Lübeck there was a 50 kilowatts limit for the supporting program once. This was much back then. Yes, this was really much back then and then you went there and when the 50 kilowatts limit was reached the program stopped. This means that it was not possible that firms' structures develop from which you could say: 'I'm the market leader in Lübeck.' No. 'You did three systems? You two? Well, I did four. Great, well, whatever. But now off to the next city'" (Conergy_1). These stops and goes had real and severe consequences for the firms. In 1998, Solon was actually more than sold out for 1999 but the orders were provisionally invalid because they were subject to the condition that customers receive political support. When the red-green coalition won the election in 1998 and it was announced that the future government will set up the largest supporting program for solar worldwide, the 100,000 roofs program, each and every commune stopped their supporting programs. Thus, the day after the election the Solon managers went to the office and found the whole fax roll lying on the floor, full of cancellations because the customers were waiting for the new program to start. Some of the Solon managers had been so desperate that they talked about reversing the IPO because of an abolition of their business foundation (Solon_1). When the EEG was enacted in 2000 the situation was getting much better but still, most informants stated that the initial law did not promote photovoltaic properly. By that time photovoltaic systems still had been too expensive to generate a substantial demand at the given level of feed-in tariffs which was at 50.62 euro cents per kWh back then. This is why the years after the enactment of the initial EEG in 2000 firms still had to cope with periods of low or stagnant demand. One Solon manager described that after New Year's holiday they went back to the office and had orders that covered only the first week of the year (Solon_2). Because of these stops and goes and the uncertainty involved one of the Conergy manager's was "glad for a long time

[5] Stromeinspeisegesetz (energy feed in law) between 1990 and 2000; 1,000 roofs program between 1990 and 1992; 100,000 roofs program between 1999 and 2003. There has been a slack between the end of the 1,000 roofs program in 1992 and the beginning of the 100,000 roofs program in 1999 that was only filled by a few supporting programs (kostengerechte Einspeisevergütungen/cost-oriented feed-in tariffs) on a city or commune level which were largely uncoordinated.

to NOT produce because one might lean back for two or three months and say: 'Well, we have some personnel costs and the rent but we are barely able to shoulder these costs.' But if I had a large manufacturing with depreciations and so forth then we would have looked even more stupid" (Conergy_1). The market growth had been erratic: from 2000 to 2001 the market grew by 155.56%, from 2001 to 2002 by -1.74%, and from 2002 to 2003 by 30.09% (BSW, 2013). To sum up, one might argue that the situation with supporting programs before 2004 was not qualified to let the cycle depicted in figure 1 run smoothly for at least two reasons: First, the level of feed-in tariffs might not have been attractive enough. Second, there had been major interruptions in the cycle due to political uncertainty. Company growth had already commenced (see tables 2a to 2c in appendix A) but these interruptions in the cycle may have led to interruptions in the reinforcement process of adaptive expectations about future industry development as well.

After the amendment to the EEG: continuous expectation formation

The amendment to the Renewable Energies Act in 2004 finally fulfilled the function as a major trigger for continuous expectation formation of companies within this industry because it further raised the level of feed-in tariffs for photovoltaic making photovoltaic systems highly attractive for end-users and investors at one blow[6]. The feed-in mechanism worked as follows: "When you look at normal markets you have to see: You need inverters. You need a photovoltaic system. You need a wiring. And when you add up these costs and compare them to the output of the electricity generation you will see: That doesn't pay off. Nobody would do that. Fine. Now people set a price through the EEG that suddenly allows for a profit margin and thereby a market EXPLODES. Insane!" (Conergy_3). "[A]nd when it really became the law in April 2004 we sensed relatively early what this actually meant. That is: The sky is the limit in a market that allows for rates of returns between 7 and 20%. If you guarantee – by law - such rates of return to a market then this market explodes" (Conergy_1). These rates of return thus made photovoltaic systems highly attractive for end-customers and for investors who became more willing to grant credits for sales financing and also of course for investors who financed large solar plants. These investors reduced the required portion of equity capital that was need for the financing of such solar plants successively. Demand increased rapidly. In Germany the installed photovoltaic capacity respectively rose abruptly by 348.98% from 147 megawatts in 2003 to 660 megawatts 2004. This had been the largest increase at all until now. In comparison, the year before it had risen only by 30.09% (BSW, 2013). This increased demand lead to increased incentives for the firms to expand their capacities: „After – as you said – the market was picking up in 2004 it was crucial to build up capacities as fast as possible. Unfortunately we had a sales

[6] Depending on site and architectural integration the feed-in tariffs granted by the amendment were between 45.7 euro cents per kWh and 62.7 euro cents per kWh. This had been an enhancement between 5 and 44% (Kewes, 2004). It has to be considered that due to the annual degression of 5% that started the 01.01.2002 the initial tariff had not been 50.62 euro cents anymore when the amendment was enacted in 2004. Instead the tariff had been cut to 45.7 euro cents.

department that always sold 20% more than we were able to produce. […] And, in principle, [Q-Cells] doubled the production capacities annually" (Q-Cells_2). Step by step other countries adopted supporting programs similar to the German EEG which for the firms provided the opportunity to grow even more. Early in 2012 feed-in tariffs had been implemented by at least 65 countries and 27 federal states (REN21, 2012). Hence, not only the German market exhibited these rapid dynamics but also other markets that adopted feed-in tariffs similar to the German supporting program. As a Conergy manager said: "We can see this over and over again. The next hype market – after Germany – was Spain, then Italy, then France but the cycles became shorter and shorter. In Germany the growth cycle lasts until today but has begun to flatten now. The Spanish cycle was even steeper and flattened faster again. Italy was like this (he used his hands to illustrate the development of the growth cycle) and flattened really fast and France was only bip – bip. There was not really a market although it was pretty sexy for a short time" (Conergy_2). From the company reports one can see that a major goal linked to the expansion of production facilities aimed at generating increasing returns to scale to substantially reduce costs for photovoltaic systems. Also, large parts of the investments in R&D aimed at improving processes and thereby at reducing costs. The overall long-term objective envisioned by firms had always been grid parity in order to no longer be dependent on politics.

During the booming years it seems that the cuts in the feed-in tariffs – although there have been several unscheduled cuts – had been moderate enough to not interrupt the cycle in figure 1 severely. Managers affirmed the smoothness of the cuts within the booming years: "[I]t had always been the question how far the feed-in-tariffs should be reduced. This had always been the point. That it HAD to be reduced was clear because you had raising efficiencies and the thing cheapened. But for the politics it had always been really, really hard to see: 'How much do I have to lower it?' And, in principle, the first years this was flowing relatively smoothly. Of course you always said: 'AHHH, that's TOO MUCH!' Absolutely clear. And the politics responded: 'Oops', but then they finally enquired: 'How much do we give for free-standing systems? How much do we give for rooftop installations?', and things like that. This had been the talk once they noticed: 'Gee! Farmers don't grow corn anymore. They let their fields for rent and install photovoltaic instead.'" (Conergy_3).

As this industry cycle lead to a high pace in industry growth firms considered a high speed in decision making a major competitive advantage: "The advantage of Q-Cells had always been rapid decisions. We had rapid decisions and rapid implementing. When we decided that we wanted to build a new production line then we needed nine to eleven months maximum until the launch of this line, site development included, building activities included, turnkey. We had been extremely fast" (Q-Cells_2). Also, Conergy stressed this issue: "This had widely been a booming atmosphere in which decisions had been made very

fast. […] We just sat next to each other and said: 'How should we do this now?' And this always was extremely quick" (Conergy_2).

In the second phase it seems that the industry cycle ran smoothly and very fast which might have contributed to an accelerated expectation formation regarding the proposed dominant growth and leadership logic among the firms. A Q-Cells manager described it as follows: "We always grew much faster than expected in the years until 2007. [...] It didn't matter which market forecast you considered, the demand was even stronger, markets grew, and they gave us this opportunity. And, in principle, this determined the speed of growth" (Q-Cells_1).

To sum up, these had been first indicators for the industry development cycle possessing different properties before and after the amendment to the EEG in 2004 having different impacts on adaptive expectation formation. The processes of adaptive expectations formation still need to be analyzed and the analyses especially have to be backed up by hard facts and numbers. Besides, it has to be analyzed how the major shortages in raw material during the boom phase confused with the cycle. Thus, these first thoughts on the cyclic dynamics are still very incomplete and lots of major gaps have to be filled.

Discussion

When finished, this research project might shed a light on the paradox of inflexibility in newly emerging contexts. How these rigidities might evolve and how processes like these might be influenced positively. To impede that dynamics develop a life of their own one could maybe consider a conscious implementing of breakpoints somehow. Additionally, when finished, this research intends to contribute to path dependence theory by carving out systematic differences between peculiarities in mature and emerging contexts. And lastly, by demonstrating in depth that dominant logics (or industry recipes or interorganizational macrocultures) might be the result of path dependent processes this paper might contribute to a further understanding of why it is so difficult to alter them again once established.

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Appendix

Appendix A: Selected firm operating figures

Table 2a: Selected operating figures for Conergy

Conergy	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Revenue (in m €)	73	122	284	530	752 (682)	706	1,006 (975)	601	914	754	474
EBIT (in m €)	-0.7	1	19	47	52 (2)	-210	-212 (-182)	-37	-14	-183	-84
Equity ratio (in %)	16	28	26	44	26 (22)	12	26	18	12	6	-32
Employees	167	194	347	724	1,480 (1,125)	2,317	1,773 (1,647)	1,429	1,569	1,461	1,144
Production capacity: c-Si wafer; c-Si cells; c-Si panels (in MWp)	0; 0; 0	0; 0; 0	0; 0; 0	0; 0; 0	0; 0; 0	300?[7]; 275?; 250 (at full capacity)	300?; 275?; 250 (at full capacity)	300?; 275?[8]; 250	300?; 275?; 250?	0; 0; 250?	0; 0; 250?

Table 2b: Selected operating figures for Q-Cells

Q-Cells	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Revenue (in m €)	17	49	129	299	540	859	1,251	802 (790)	1,354	1,023
EBIT (in m €)	1	5	20	63	129	197	205	-486 (-363)	82	-717
Equity ratio (in %)	3	19.6	30.7	70.4	69.3	70.8	66.2	33.1	40.5	2.8
Employees	82	207	484	767	964	1,707	2,568	2,780 (2,421)	2,379	2,304
Production capacity: c-Si cells; c-Si panels; thin film panels (in MWp)	17; 0; 0	50; 0; 0	136; 0; 0	234; 0; 0	336; 0; 0	516; 0; 0	760; 15 (actual output); 0	800; 0; 30	1,100; 0; 135	950; 130; 135

[7] When Conergy made the decision to build an integrated factory in 2006 the planned capacities for wafers had been 300 MWp, for cells 275 MWp, and for modules 250 MWp. The following company reports do not say something about capacities for wafers and cells anymore. Regarding modules they say that they might produce 250 MWp at full capacity.

[8] In 2009 the production could finally worked under full capacity.

Table 2c: Selected operating figures for Solon

Solon	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Revenue (in m €)	1.3	6	15	17	21	38	104	201	346	503	815	354	620
EBIT (in m €)	-2.5	-3.7	-4	-5.4	-3.1	-1.6	4	14	25	35	60	-199	0.4
Equity ratio (in %)	79	35	40	13	9	0.1	66.1	42.7	35.5	47.6	41.6	17.2	16.1
Employees	29	99	125	177	152	201	313	420	505	703	943	901	912
Production capacity: c-Si panels (in MWp)	n/a	2.5	3.75	4.2	20	30 (?)	90	100	120	210	450	435	412

Appendix B: Interview excerpts regarding symptoms of the joint underestimation of the imminent market changes

Table 3: Interview excerpt

Neglect of cost reduction issues	*Unnecessary hiring of employees*	"We hired people for everything although these things could have been assumed by current employees. This is how we could have reduced costs from the beginning but this rapid growth misleads people to spend money." (Solon_4)
		"[Conergy's workforce] had grown well beyond reasonable limits. It was the typical case that you hire people hoping that you will earn the corresponding revenues tomorrow." (Conergy_4)
		"Therefore I would say today in principle that you should not exceed a certain number of employees. […] You will end up in a death zone when you have too many employees because you are not able to operate flexibly anymore in the face of a fast growing environment." (Conergy_2)
	Expensive strategic acquisitions and investments	"They built a test plant for wafering and cristallization. The time it was working and the prices for wafers were decreasing simultaneously they immediately sold it again for very little money. But then, four weeks later, when they faced problems with this new supplier they realized that it would have been better to keep it after all." (Q-Cells_2)
		"Well these have been things about which I would say that they should have been done more systematically regarding – I say it in general – cooperation with other firms. We had a whole slew of investments in diverse firms which had been decided more or less on instinct." (Solon_4)
		"Well, we always said: ‚We want to produce ONLY modules and don't want to cover more of the value added chain because we want to pursue the best-in-class principle and want to buy the rest from somewhere else.' Simultaneously we bought a cell manufacturing and invested in a silicon production which actually lacks coherence." (Solon_3)

		"And the second problem was that Conergy quite simply made a huge mistake during the growth phase. That is to say, it bought in on many, many other businesses that had nothing to do with photovoltaic […]. Further, it also quite simply had been overstrained by the internal complexity it built up by then." (Conergy_4)
Neglect of building up essential business structures	*Controlling and contracting*	"Well, the company still was a very, very small and de facto a medium-sized enterprise that hardly had any controlling systems […]. Through PV [photovoltaic] and the additional acquisitions it catapulted itself to a size where you have to say quite simply that they hadn't been able to handle this complexity and size anymore." (Conergy_4)
		„In many countries – you can imagine when everything is exploding like that - there was no proper contract administration, there was no legal department. […] People sold solar systems, signed things, and just put them into a cupboard. […] Jurists had to come who had to read the contracts and who had to list the liability risks. Then accountants had to come and had to take the liability risks onto the books. […] In principle we started to do all the boring stuff to get such a company under control." (Conergy_3)
	Sales and Distribution	"Q-Cells' distribution department always had been much too small and when you asked any business economist what did he do? He looks at successful firms in Germany and sees that they have a much larger distribution department. Ok, but if you have a successful company one has to redefine what should be considered successful." (Q-Cells_3)
		"We had two people within the external sales force for the German market and a couple of people within the internal sales force [in 2009]." (Solon_3)
Neglect to serve customers well		„Customer care was simply not as it should have been. And when you annually had to tell 20% of your customers: 'Though we sold it to you, we can't deliver it', these customers had not been too happy." (Q-Cells_2)
		"They [the customers] knew that Solon was producing and that a very large delivery was going to Spain somewhere again and this was why you wouldn't get anything again when you were a customer here." (Solon_3)