Philipps-University Marburg
Department of Technology and Innovation Management

Discussion Papers on Strategy and Innovation

Discussion Papers on Strategy and Innovation 07-03

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Discussion Paper 07-03
Marburg, August 2007
ISSN 1864-2039

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Abstract

The present discussion paper investigates the market dynamics in the early phase of an industry's life cycle. The industry life cycle model is so widely accepted and its basic premises so taken for granted that it has become conventional wisdom in business. However, a number of facets of the concept are still poorly understood mainly because of the lack of empirical evidence. E. g., while it is widely recognized that firms in the initial stage of the life cycle exist under conditions of significant uncertainty and ambiguity, little is known about the factors and processes that feed the establishment of a dominant design and that lead to sales take off and growth of the market. The present discussion paper develops a more detailed framework for the infant stage of an industry and subdivides the early life cycle stage for a new industry into three distinct, sequential time periods. Our more detailed perspective on the early stage benefits the analysis of which factors influence the emergence of a dominant design and attract a critical mass of customers. In our analysis we place an additional focus on systemic industries. By definition, industries are systemic in nature when the products are complex and composed of many interdependent elements, subsystems, modules, parts and services. In industries with complex products firms must rely on external suppliers and partners. We back our theoretical considerations with an empirical investigation into the mobile payment industry. The mobile payment industry is characterised by a highly systemic architecture and is still in the initial stage of the industry life cycle.

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1. Introduction

The industry life cycle model is so widely accepted and its basic premises so taken for granted that it has become conventional wisdom in business (see e. g. McGahan et al. 2004). However, a number of facets of the concept are still poorly understood mainly because of the lack of empirical evidence. E. g., while it is widely recognized that firms in the initial stage of the life cycle exist under conditions of significant uncertainty and ambiguity, little is known about the factors and processes that feed the establishment of a dominant design and that lead to sales take off and growth of the market. The present discussion paper focuses on the early stage of the industry life cycle and develops a more detailed framework for this early phase. Following Agarwal and Bayus (2002, 2004) we subdivide the early life cycle stages for a new industry into three distinct, sequential time periods. Our more detailed perspective on the early stage benefits the analysis of which factors influence the emergence of a dominant design and attract a critical mass of customers.

In our analysis we place an additional focus on systemic industries. By definition, industries are systemic in nature when the products are complex and composed of many interdependent elements, subsystems, modules, parts and services. In industries with complex products firms must rely on external suppliers and partners. However, the division of labor in early stages of the industry life cycle is usually hampered by the lack of specialized suppliers (see Stigler 1951). We therefore center the vertical dimension of the industry structure in our analysis and try to answer the question how firms in systemic industries can resolve the dilemma of the lack of a capable supplier base.

There are only a few empirical studies which deal with the early stage of the life cycle in systemic industries (see Malerba, Orsengio 1996). In the empirical part we have selected the Mobile Payment industry as empirical object of investigation. The Mobile Payment industry is characterised by a highly systemic architecture and is still in the initial stage of the industry life cycle. However, there are considerable differences in the industry's position between different OECD countries. E.g., in South-Korea the Mobile Payment market is about to take off, whereas in Germany the industry is still in a very infant stage. We therefore conduct a comparative analysis of the industry's situation in both countries with regard to "success factors" that may catalyse the emergence of a dominant design and market take-off.

2. The Industry Life Cycle Concept in a Nutshell

The industry life cycle model is an attempt to characterize an ideal evolution of an industry over time. The industry life cycle model emerged from the product life cycle literature and from models about the diffusion of new products in the 1970s. It was enhanced during the 1980s by studies grounded in technology management (e. g. Foster 1986; for a detailed discussion see Baum et al 2004; Klepper 1997). The characteristics of the different stages of the product life cycle and the regularities concerning industry evolution finally lead to the concept of an industry life cycle (McGahan, et al. 2004). Klepper (2004) denominates the stage-based depiction of industry evolution as “the product life cycle view of evolution”.

Following the product life cycle model an industry’s life cycle is subdivided into different phases. The different stages describe a prototype of a market’s life cycle. Today there are several variations concerning the number and definition of the life cycle stages. Gort and Klepper (1982), e. g., distinguish between five different stages of what they call the “evolution of the market”. In contrast, Klepper in his 1997 synopsis of the literature on the industry life cycle concept uses a three stage model. However, common to all these variations of the life cycle model is the use of a more or less consistent set of indicators and structural parameters to define and describe the individual stages:

- *Size of market/demand:* Total volume of the market;
- *Size of production:* Total output produced (in terms of units);
- *Growth rates:* Change in market volume/number of units produced over time;
- *Number of competitors:* Number of firms producing in the industry
- *Market entry rate:* Number of firms entering the industry in relation to the number of firms that exit the market;
- *Survival rate:* Probability for firms to “survive” in the industry within a certain period;
- *Concentration ratio:* Percentage of control that the largest firms in the industry have of that industry’s assets, profits, sales etc. (Alternative indicators: Herfindal index or entropy measures);
- *Types and degree of innovation:* Product- versus process innovation, radical versus incremental innovation;
- *Dominant design:* Number of competing product / process design concepts.

In the following we portray the industry life cycle concept with a standard four stage model in a nutshell (for a similar four stage approach see e. g. McGahan et al. 2004):

1) **Initial stage:** The first stage – also called embryonic (Klepper 1997) or fragmentation (McGahan et al. 2004) phase – begins with the commercialization of a new product. The industry is characterized by low market volume and a high level of uncertainty. The product design in the industry is rather primitive. So far, no dominant design for the industry‘s main product has evolved. During fragmentation, firms experiment extensively with different product technologies and use unspecialized machinery. The market faces a high entry rate and competition is based on product innovation. The length of the initial stage de-

pends on the speed by which it takes for competitors to copy the initial innovator's products and technologies and on the speed by which a dominant design is established.

2) **Growth stage:** The emergence of a dominant design marks the beginning of the second stage and provides the major prerequisite for the 'take-off' of the market (alternative denominations are 'shakeout' or 'intermediate stage'; see e. g. Klepper 1997). Utterback (1994, 24) defines a dominant design as follows:

> *„A dominant design in a product class is, by definition, the one that wins the allegiance of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following. The dominant design usually takes the form of a new product (or set of features) synthesized from individual technological innovations introduced independently in prior product variants."*

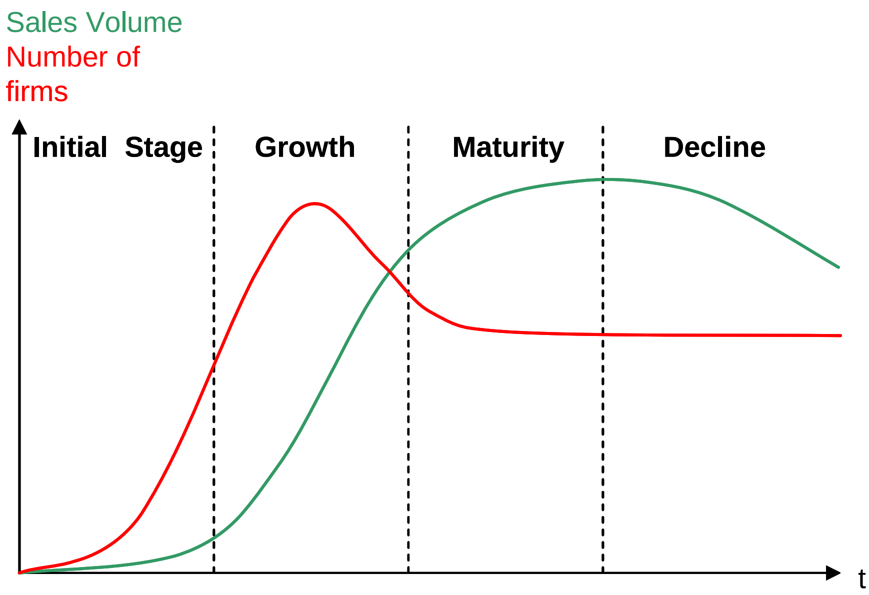
   A dominant model emerges when a firm in the industry has identified a way to operate the business efficiently and promoted the model among customers and suppliers. As the "dominant design" emerges the uncertainty abates. The emergence of a dominant design is critical to industry evolution because of the opportunity to generate economies of scale and scope. The sales volumes grow. The output faces high growth rates and the product design begins to stabilize. The rate of product innovation decreases as production processes become more refined and specialized machinery is used. Growth in sales provides incentives for firms to enter the industry. Stage two is characterized by a sharp increase and rapid growth in the number of competitors. However, at the same time many firms exit the industry if they cannot adopt the dominant model or cannot access the emerging network of customers and suppliers (see Thompson 2007).

3) **Mature stage:** In stage three, also called shakeout phase (see e. g. Klepper 1997), the output growth slows down as the limit of technical opportunities for product and process innovations is reached. In systemic industry settings technical standardization and codification of formerly tacit knowledge promotes vertical specialization (see McGahan et al. 2004). The mature stage is characterized by a decline of the entry rate. New entrants take over supplier roles or focus on market niches. At the same time the increase in competition forces the shakeout of producers. The industry faces a balance of exits and entries. Surviving firms face a profitable and stable phase: the market shares are fixed and management, manufacturing and marketing techniques become more refined as innovations are less significant.

4) **Decline stage:** In the end of the industry life cycle the aggregate sales volume drops, the industry's relevant market is shrinking. As the rivalry between competitors heats up, the entry rate becomes negative and the number of competitors is decreasing.

Figure 1 visualizes the conventional concept of the industry life cycle.

Figure 1: A standard four stage model of the industry life cycle



In summary, the evidence for a broad range of industries suggests that many of the features of the industry life cycle concept are widespread. Output growth tends to decline over time, entry is generally concentrated early, shakeouts are common, early entrants tend to dominate their markets and product innovation peaks in premature stages. Empirical evidence also suggests some minor departures from the industry life cycle archetype in a number of industries including the post-shakeout rise in innovation in automobiles beginning in the 1960s and the distinctive longevity of the very latest entrants in automobiles, tires and typewriters (see e. g. Klepper 1997). Admittedly, a sizable minority of products follow life cycle patterns that depart significantly from the archetype, with entry remaining robust and the number of firms not under-going a shakeout.

Although the concept of an industry life cycle is widely accepted and can be used in most industries it lacks important detail information. The characteristics of industries vary during their evolution and firms face big problems in improving their performance through using knowledge about the industry evolution (see McGahan 2000). A prominent starting point for the sophistication of the industry life cycle concept is the type of innovation that initiates the new life cycle (see e. g. McGahan 2000 and Henderson, Clark 1990). The notion that there are different kinds of innovation that trigger a new industry life cycle with different competitive effects and an idiosyncratic impact on the precise characteristics of the industry evolution, is an emerging theme in the literature on technological innovation.

Another popular research avenue in industry evolution has proved to be the structural complexity of the industrial setting (see e. g. Sheremata 2004 and Shapiro, Varian 1999). Especially in technology intensive industries neither the demand side nor the supply side of an industry are usually characterized by a simple, homogenous setting. The structural complexity of an industry is largely determined by two factors: (a) by network effects on the demand side and (b) by the systemic nature of the production system on the supply side of the industry. A network market is a market for a product (or service) where the value of the product increases with the number of adopters. Network effects imply that the behavioural patterns of the demand side deviate from the conventional patterns described by Rogers (1995). A systemic production system refers to the supply side of industries whose products consist of many interdependent elements, subsystems, modules, parts and services. Systemic industries are characterized by an intensive division of labor between different economic actors.

Both, network effects and complexity on the supply side have severe influences on the establishment of a dominant design. Depending on the type of innovation network effects and systemic production systems may act as barriers or catalysts for the emergence of a dominant design and thus for the market take off. In fact, compatibility is a critical characteristic of innovation in complex industrial settings that may change the dynamics of competition (Sheremata 2004). However, many researchers treat innovation as if it were simultaneously radical and incompatible or incremental and compatible. Traditional principles of innovation strategy, while helpful, need to be supplemented to account for the peculiar economics of network effects and complex production systems (Shapiro, Varian 1999, Sheremata 2004).

Although the complexity of industries has proved to be a prominent avenue of research in evolutionary economics, most insights and findings have not been applied to the sophistication of the industry life cycle concept. A major drawback of most industry life cycle concepts is that they take on a too narrowly defined perspective on the evolution of industries. As mentioned above, the industry life cycle model is an attempt to characterize an ideal evolution of an industry over time by the use of several key parameters such as structure, growth, volume, competition etc. With regard to the industry structure one may differentiate between two different dimensions of evolution: Changes in the horizontal and vertical structure. However, most of the literature on industry life cycles focuses primarily on the evolution of technological change and the horizontal structure of the market. This is mainly due to the fact that the industry life cycle was derived from traditional product life cycle concepts (see Klepper 1997). Little attention is devoted to how the vertical structure of firms might be expected to change over time. A great deal of work has been done on vertical firm structure in recent years, but it does not directly address the evolution of vertical firm structure in new industries. An exception is historical work of Stigler (1951). Stigler suggests that as industries evolve (and grow) firms will become increasingly specialized.

In the remaining parts of this paper we will highlight the two structural dimensions of the industry evolution: the horizontal and the vertical dimension. Our line of arguments aims at the following two questions:

1. What supply-side factors influence the acceptance of a dominant design in highly systemic industries?
2. What factors influence the emergence of a critical mass of demand for a radical new product concept that complements the emergence of a dominant design?

3. Characteristics of the Initial Stage of the Industry Life Cycle Concept

There are various denominators for the initial stage of the industry life cycle concept, such as exploratory, fragmentation, embryonic or, simply, early stage. Despite this plethora of denominators, the synopsis of the relevant literature reveals, at least at first sight, a remarkable concordance in the description of the basic characteristics of the initial stage (see e. g. Adner 2004; Agarwal, Bayus 2004; Klepper 1997; Marsili 2001; McGahan et al. 2004; Murray, Tripsas 2004; Adner 2004). The conventional features are as follows:

- **Lack of a dominant product / business design:** In the initial phase there is quite a number of competing product / process design concepts. Little is known about the new product desired by demanders. The early entrants into the industry are typically small and have experience in related technologies. Sometimes they are users of the new product, while in other instances they are spin-offs of incumbent firms. They often introduce major product innovations based on information about users' needs and /or technological means available to satisfy them (Klepper and Graddy 1990). The pre-dominant design stage is characterized by a broader variety in product architecture and low-volume-per model manufacturing in the industry. The emergence of a dominant product design indeed marks a significant watershed in the competitive nature of an industry (Christensen et al. 1998)
- **High degree of uncertainty:** Primarily because of the lack of a dominant business model design firms are confronted with a number of critical albeit transitory conditions. For one thing, the product design itself is quite unstandardized; its inputs, its processing, and its final specifications may cover a wide range (see Vernon 1966). In the initial stage, firms experiment extensively with different product technologies and business models in the hope of landing upon a profitable approach that dominates those of other firms (see McGahan et al. 2004; Murray, Tripsas 2004). As a corollary of the fact that the product design is still ‘primitive’ companies use unspecialized machinery to manufacture the product. Uncertainty also exists with regards to the ultimate dimensions of the market, the efforts of competitors to preempt the market, the specifications of the inputs needed for production and the specifications of the product likely to be most successful in the effort.

- **High degree of vertical integration:** According to Stigler (1951), the division of labor in the industry is comparatively low in the initial phase. Firms will tend to integrate vertically, because idiosyncratic parts and components cannot be purchased in the external market. A specialized external supplier base will only develop when the industry has reached a critical mass. In addition, the high degree of vertical integration in the beginning of the industry life cycle simplifies the operation and control of experiments to arrive at profitable technologies, product designs and business models. McGahan et al. (2004) quote Apple Computer as a prominent example for full vertical integration: Apple in the early years of personal computing made nearly all the components that it needed: monitor, printer, hard drive, motherboard and injection-molded chassis.
- **Low market volume**: First of all, for the customer the purchase decision is afflicted with the risk to bet on the wrong horse since the dominant product design is still about to emerge. Furthermore, the product design is still primitive and lacks convenience for the customers. The likelihood of malfunctions and the complex handling of the first product 'prototypes' require that the customers themselves are experts in the field. Customers must have detailed information about the product and its specification for the effective and efficient use. For these reasons, only a small group of customers that 'lead the pack' are willing and able to buy the product in this experimental stage. Being such a 'lead' or 'innovative' user has several prerequisites. Lead users have needs for innovations that are well ahead of those of the general market. Furthermore, the ability to understand and apply complex technical knowledge is needed and control of substantial financial resources is helpful in absorbing the possible losses from an unprofitable innovation (Rogers 2003; von Hippel 1988).
- **First mover advantages:** Based on the preemption of resources argument, a number of potential advantages associated with early entry into a new industry have been proposed, including establishing brand loyalty and high switching costs, locking up distribution channels and suppliers, setting up patent protection, capturing scale economies, and establishing technology standards. These possible first-mover advantages rely on a (temporary) monopoly of the pioneer over later entrants (Agarwal, Bayus 2004, 108). These theoretical arguments are backed by empirical evidence. Empirical evidence on first mover advantages and the link between market share and profitability suggests that the firms that ultimately capture the greatest share of the market and earn the greatest return on investment tend to be those that entered earliest. Of course, the reverse reasoning does not hold true. As pointed out above, early entrants face a greater uncertainty with regard to survival, not all first movers evolve to profitable incumbents.
- **High entry rate:** The prospect of a rapid growing market and low entry barriers in the beginning provides strong incentives for firms to enter the industry. In the course of the early

stage competition is rising constantly and is primarily based on product innovation. Needless to say that firms require a certain expertise to enter an industry, which implies that the number of firms that could potentially enter a specific new industry is limited. The number of entries is not counterbalanced by the number of exits. For one thing, firms leave the industry because they lack the stamina till the business becomes profitable.

A more detailed and closer look to this ‘conventional’ description of the characteristics of the initial phase reveals obscurities and inconsistencies between the structural parameters:

- **High entry rate versus high uncertainty/low market volume:** Why would an industry that offers a low market volume and is characterized by a high degree of uncertainty and risk attract a growing number of competitors? Why would a firm decide to enter in the initial stages of a new industry? The opposite scenario that the entry rate becomes negative in the case of persistent unprofitability is at least as likely as the scenario above.
- **First mover advantages versus high uncertainty:** It is irreproducible how a young industry that is characterized by a high degree of uncertainty (and associated costs) can offer first mover advantages.

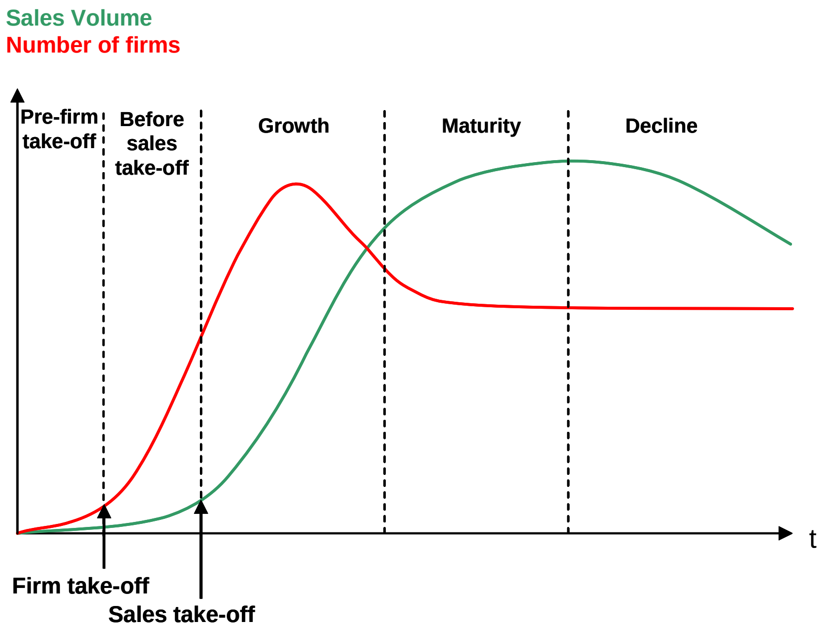
To resolve these inconsistencies and to gain more detailed insights into the characteristics of the initial stage of the industry life cycle a number of authors suggest to operationalize and subdivide the initial phase into various independent stages that are characterized with idiosyncratic structural features (see e. g. Agarwal, Bayus 2002, 2004 and Christensen et al. 1998). Agarwal and Bayus (2002, 2004) subdivide the early life cycle stages for a new industry into three distinct, sequential time periods:

1. **Pre-firm take-off:** The time between the pioneering market introduction of the innovation (commercialization) and a sharp increase or “take-off” in the number of firms;
2. **Before market take-off**: The time between the “take-off” in the number of firms and the take-off of the market (Sales take-off), and
3. **Post-market take-off:** The time after the sales take-off.

In this revised concept the take-off points in both, the number of firms and sales represent important landmarks in the early period of an industry life cycle, since each represent some resolution of uncertainty regarding the viability of the product innovation. Most studies on industry evolution lump the early entrants together as entering in the initial stage, i. e., they do not distinguish between the firms that enter in the initial "monopoly" period where there are at most very few firms competing in the newly created industry, and firms that enter in the following period characterized by a sharp take-off in the number of firms. Firms that enter in the very beginning (pre-firm take-off), face the highest level of uncertainty. After the first pioneering market introduction of the product (initial commercialization) the efforts of the early entrants are geared towards generating demand for the new product. These pioneers bring crucial new information, skills and product quality improvements into the industry. This is of crucial importance to overcome the primitive product and business model design in this ‘pre-natal’ beginning. Firms that enter in the second period (before sales take-off) have more information, since they benefit from a resolution of some of the risk and uncertainty, especially with regard to technology and business models. The entry rate increases, because reduction in risk and uncertainty stimulate profits expectations, while conventional entry barriers are still low (Thompson 2007). Geroski (2003) argues in a similar vein. According to him, entry rates are high for young product markets because initial participants expend few resources on the deployment of strategic entry or isolating mechanisms to protect their returns.

Firm take-off systematically precedes sales take-off. The second entry cohort is crucial to expand market demand, since their strategies may help develop consumer acceptance and any necessary supply chain infrastructure. Competition in this second stage is primarily based on product improvements with regard to functionality and quality. As the perceived product quality raises consumer acceptance of the product innovation increases. Marketing activities help to educate and inform potential consumers, especially early adopters (see Rogers 1995), about the benefits of a product innovation. Market take-off may be also related to the existence and evolution of an industry infrastructure. As suggested by Brown (1981), sales take-off of a product innovation may also be related to the existence and evolution of an industry infrastructure (complementary products and services), such as new distribution channels and pricing arrangements may be necessary. The combined efforts of the entrants in stage one and two help to create a dominant product and business model design. The dominant design is established when a critical mass of demand can be mobilized (sales take-off). This marks the transition to the post-market take-off stage that corresponds to the growth stage in the conventional life cycle model. As soon as a dominant design is established also those customers will opt for the product who preferred a different design in the beginning (Geroski 2003).
In the subsequent parts we use this refined five stage model of the industry life cycle. The differentiation between the pre-firm and before market take-off stages facilitates the analysis of supply- and demand-side factors that promote the market take-off in new systemic industries. Figure 2 visualizes the refinement of the conventional industry life cycle model.

Figure 2: Refined (five) stage model of the industry life cycle



4. The Dilemma of the Early Stage in Complex Industrial Settings: Systemic Industries and Network Effects

We define industries as systemic in nature when the products are composed of many interdependent elements, subsystems, modules, parts and services. For example, the aerospace or automotive industries are illustrative of cases of systemic industries. Needless to say, that those industries with simple products but complex production systems are also systemic in nature. This is typically the case for continuous process industries, such as chemicals or advanced materials. In these industries, a complex manufacturing production system is structured into different modules and subsystems (set of operations).

The complexity in products and/or production processes is reflected by a differentiated knowledge base that underlies the innovation efforts (see Stephan 2003). In systemic industries, firms must maintain a broad competence and resource spectrum to offer the product / service bundles on a stand-alone basis to the customer. However, with regard to resource constraints, companies in systemic industries will not operate on a stand-alone basis but tend to rely on external suppliers and partners in the value chain (see Stephan 2003). Empirical evidence shows that systemic industries are usually characterized by an intensive division of labor (see e. g. Burr, Stephan 2004; Stephan, Pfaffmann 2005).

The impulse to outsource parts of production to external suppliers creates a dilemma for firms in early stage of the industry life cycle. As Stigler (1951) pointed out, there are no capable external suppliers in the industry in the early stage. In addition, Bruisoni et al. (2001)

point to the fact that during the early stages of major product developments interdependencies among components and parts of systemic products were high and poorly understood. Teece (1976) argued that the degree of integration between firms and their external suppliers depends inversely on the degree of predictability of interdependencies across components. Interdependencies across components are predictable when a change in the design of one component entails a well-understood change in the design of other components, and vice versa. Teece (1976: 13) also argued that, in the presence of contingencies that cannot be perfectly predicted,

> *"co-ordinated activity is required to secure agreement about the estimates that will be used as a basis for action. Vertical integration facilitates such co-ordination."*

Only as the technologies and products mature, interdependencies become better understood and easier to predict and specialization in the industry will prevail. Therefore, organizational integration not only seems to be the only alternative available for firms (due to a lack of external suppliers), but at the same time is also of critical importance to achieve coordination in the innovation process.

So far we have distinguished coordination of activities via markets from coordination of activities within firms (organizational integration/hierarchy). Industries in which coordination via markets prevails are ‘decoupled’ industries. In contrast, industries with a high degree of vertical integration are tightly coupled industries. In between both extremes are loosely coupled industries. A distinguishing feature of loosely coupled organizations is the presence of ‘systems integrators’: firms that lead and coordinate from a technological and organizational viewpoint the work of suppliers involved in the network (Bruisoni et al. 2001; Burr, Stephan 2004; Pfaffmann, Stephan 2005). System integrators outsource detailed design and manufacturing to specialized suppliers while maintaining in-house concept design and systems integration capabilities to coordinate the work (R&D, design, and manufacturing) of suppliers. Systems integration appears, therefore, to be a particular type of coordination mechanism between markets and hierarchies. While markets satisfy the need for distinctiveness, and hierarchies the need for prompt responsiveness, systems integration reconciles them for specific products and technologies. The relationship between systems integrators and their suppliers is governed by contractual arrangements, ranging from the typical arm's-length contractual relationships and cost-sharing agreements to joint ventures and formal alliances.

Loosely coupled organizations resolve the dilemma faced by firms in the early phase of the industry life cycle in systemic industries, at least for two reasons:

1. The loosely coupled organization ensures the necessary amount of coordination of activities in the innovation process: Systems integration involves close cooperation between all partners during all stages of the product and process innovation process. The systems in-

tegrator is aware of interdependencies and handles the integration of changes and improvements in internally and externally designed and produced inputs;

2. The joint innovation efforts of the systems integrator together with external partners and suppliers secure the development of a sophisticated specialized supplier population already in the early phase of the industry life cycle.

Apart from the resolution of the supply-dilemma the loosely coupled organization also offers a demand-side advantage for firms in systemic industries. The systems integrator usually not only coordinates a broad range of external partners and suppliers but also acts as customer interface (see Pfaffmann, Stephan 2001). The system integrator is the focal contact person for the customer. The systems integrator supplies the client with an integrated solution from one single source. E. g., in case of problems and product failures the client has not to contact a plethora of different troubleshooters but only a single actor in the value chain: the systems integrator. This increases convenience and acceptance of the new product design. Acceptance of the systemic product design at an early point in the industry life is of crucial importance especially for products that feature “network externalities”.

Network externalities are a second major source of complexity in an overall industry’s setting. Here the complexity stems from the front end of the industry – from the demand side. Network externalities or network effects are characteristic for markets (“network markets”) where the value of the product increases with the number of adopters. This change in value is called a “network effect” (Katz, Shapiro 1985). In non-network markets demand utility depends on the features of the product, not on the number of adopters. In network markets, however, consumers derive utility from two distinct sources: product attributes and network size (Sheremata 2004).

Proponents of the network externalities theory assert that incompatible technologies in emerging network industries/markets compete intensely, but when demand expects the installed base of one technology/product to become larger than any other, they adopt that technology (Sheremata 2004). Demand will adopt that technology to the virtual exclusion of others. This moment marks the starting point for the sales-take off phase in the industry’s life cycle. The emergence of a dominant design eliminates the technological uncertainty caused by incompatible competing solutions and makes the market “tip” (Cusumano et al. 1992; Postrel, 1990; Sheremata 2004). In case of network externalities each customer receives greater benefits, the larger the total number of customers using compatible products is, i. e. the larger the installed base of the selected design is (see Katz, Shapiro 1992).

> *“In fact, compatibility is a source of value in network markets – which changes the dynamics of competition.”* (Sheremata 2004: 359)

With network externalities one may distinguish between direct and indirect or complementary network effects (Rohlfs 2001). In a telecommunication network, e. g., direct network effects arise when consumers communicate directly with each other – e. g. with cellular phones. However, network effects also arise indirectly. In hardware/software (communication) networks the number of users of a base product (cellular phone) affects the number and variety of complementary products (such as additional services like text messaging or mobile payment solutions) which affects the value of the base product (Sheremata 2004). Analogues to the distinction between direct and indirect network effects one can distinguish between direct and indirect compatibility. The notion of compatibility captures how a product relates to others within a larger system and what it produces. Direct compatibility is achieved when a product accepts the same inputs as another to produce the same output. A standard specifies these inputs and outputs. Thus, direct compatibility captures the ability of a product to work with another product of the same type, e. g. in a communication network. Indirect compatibility captures the ability of a product to work with the same complementary products as another of the same type in a hardware / software network. Compatibility can be achieved through the cooperation and interlinking of rivals. Only under these circumstances network effects apply to the total industry output (Rohlfs 2001).

In complex and systemic production systems the issue of indirect compatibility is of critical importance as numerous interdependencies between subsystems and modules exist. Compatibility in such complex production systems (like in communication networks) is achieved by the setting of interface standards (Funk 2006). Here a second dilemma arises: who takes care of standard setting in complex production systems that are characterized by an intensive division of labor? Will loosely coupled industrial organizations also offer advantages with regard to standard setting? Can system integrators command the process of standard setting in such a complex industrial setting?

The empirical part of the paper will address these dilemmas of the early stages in the evolution of complex industrial settings. Answers on the questions raised above will be given from insights from the evolution of the mobile services and payment industry in Germany and Asia.

5. Empirical findings from the Mobile Payment industry

5.1 Technical Introduction to Mobile Payment Systems

Since the end of the 1990s, mobile devices like cellular phones have become more than a medium for comfortable and flexible communication. New business opportunities beyond communication have emerged, one of the most prospective being mobile commerce (M-Commerce). M-Commerce is defined as electronic commerce transactions over wireless devices that require a transaction of money through a wireless telecommunication network (Cheong et al. 2005). Mobile payment, in contrast, involves the wireless transaction of a monetary value from one party to another using a mobile device for the initiation, authorization or realization of the payment (see Pousttchi, Zenker 2003).

The use of mobile payment is not only possible in the conventional M-Commerce context (E-Commerce), but also in other contexts like purchases at a vending machine, transactions at the point-of-sale or transactions between several persons (Arthur D. Little 2004). In these contexts the use of cash money or credit cards becomes obsolete. It should be noticed that mobile payment does not substitute for the concept of credit cards. In fact the credit card becomes integrated into the mobile device. For this purpose, a chip (smart card) is attached to the mobile handset, which stores credit card or bank account information. The payment process is initiated through the use of RFID (Radio Frequency Identification), NFC (Near Field Communication) or Bluetooth, which enable the mobile device to make a transaction directly at the point of sale. The mobile device communicates with a vending machine, parking meter or the cash desk (Karnouskos 2004).

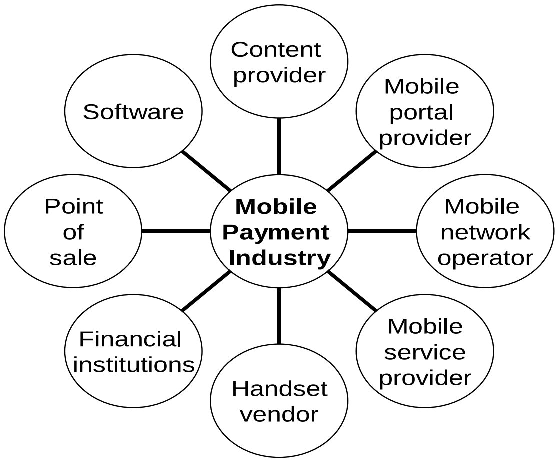
In the subsequent sections we will focus on mobile payment applications that take place in a non-M-Commerce setting (point-of-sale, person-to-person, person-to-machine).

5.2 Architecture of the Mobile Payment Industry

The mobile payment industry is characterised through a complex and systemic architecture. As defined above, industries are systemic in nature when the products are composed of many interdependent elements, subsystems, modules, parts and services. The mobile payment industry contains several different services (financial and communication services), physical assets and goods (mobile devices, infrastructure, terminals and accounting devices) that are based on a broad spectrum of technologies (information- and communication-technologies, software, semiconductors, encryption). Due to the systemic character of the product, the industry value-chain is characterized through a complex architecture. There are several different actors involved which have distinct roles and positions within the chain. A central characteristic in the mobile payment business is the complex relationship of all participating actors. The actors occupy selected stages in the value chain and can be competitors, customers or partners at the same time.

To dumb the structure of the M-Commerce industry down, one can divide the value chain into several actor categories (see Figure 3). The content providers' role is to develop the relevant content (e. g. songs, games …) demanded by customers. The content is determined by the service used. In mobile payment scenarios beyond the M-Commerce setting, the content provider is displaced through the point-of-sale or physical merchants in general. In most cases the functions of the mobile portal provider, the mobile network operator and the mobile service provider are integrated within the service carrier. The service carrier owns the communication channels and is in closest contact to the customer. He is responsible for the delivery of the content or bundle of content to the customer.

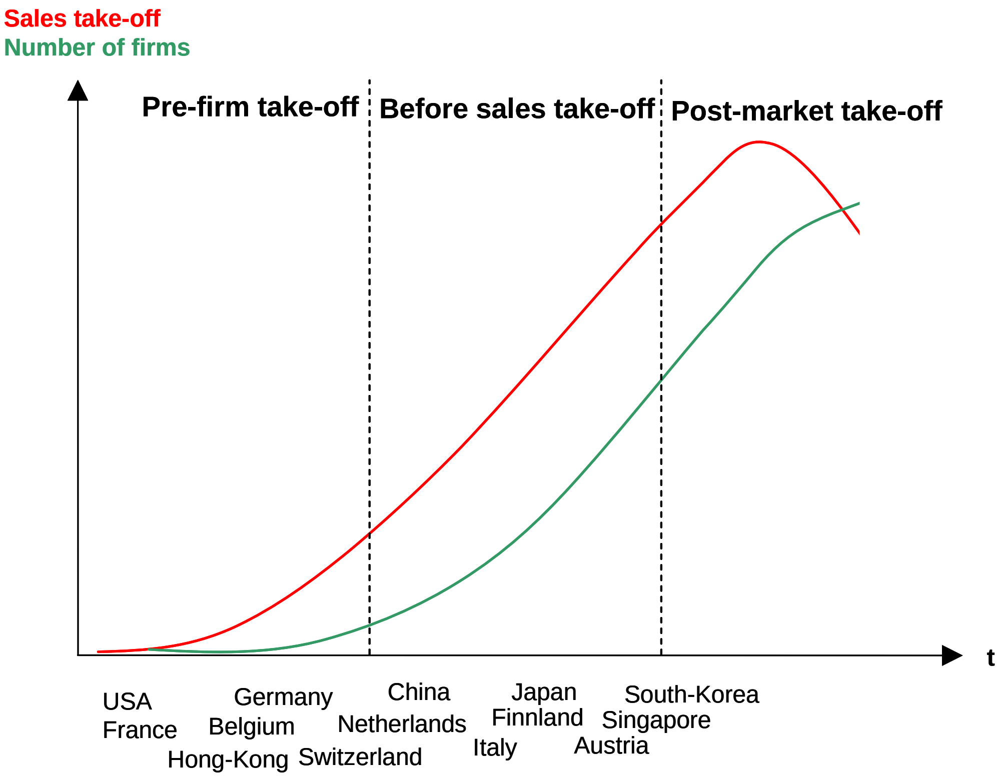
Figure 3: Actors in the Mobile-Payment industry



Today, the mobile payment industry serves a niche market. However, industry experts forecast the global market take-off to happen within the next decade. While the worldwide volume of mobile payment transactions amounted to 2.5 billion Euros in 2004, market researchers estimate a volume of 30 billion Euros for the year 2008 (Arthur D. Little 2004).

However, the global landscape in the mobile payment industry is far from being homogeneous. Countries (in the developed world) are in different stages of the industry life cycle. In the subsequent parts of this chapter we will take a closer look at the situation in Germany and South-Korea. While Germany is still in the initial pre-firm take-off stage of the industry life cycle, South-Korea is on the edge to the growth phase. We will analyse the major factors that contributed to the lead of South-Korea and the laggard position of Germany. Figure 4 gives an overview of the development stage of the industry in selected OECD countries.

Figure 4: **'Maturity' of the Mobile Payment Industry in Selected OECD Countries**



Source: Estimates by Arthur D. Little (2004)

5.3 Comparative Analysis of the Situation in South-Korea and Germany

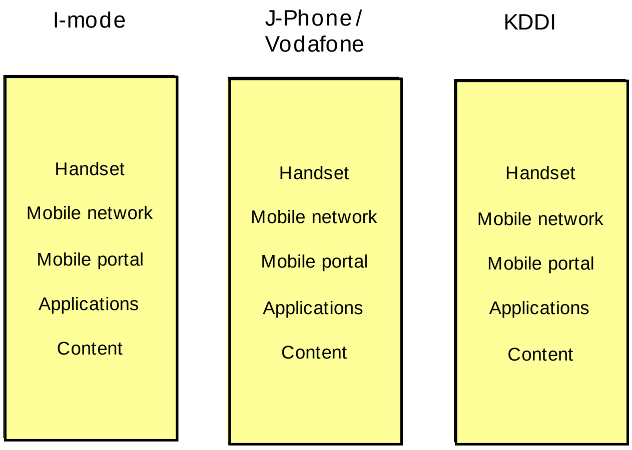
South-Korea is supposed to be the most advanced mobile market in the world. This is due to early heavy investments into third generation handsets and the CDMA mobile technology. The "Digital Access Index" ranks South-Korea 4th behind the Nordic countries Sweden, Denmark and Iceland. Although these three countries have higher penetration rates of cellular phones, it is striking that South-Korea is almost equal with regard to the number of internet users and has an outstanding high amount of broadband internet subscribers. With regard to broadband internet subscribers South-Korea ranks first in the world (see NCA 2004). The Korean government plays an important part in shaping the Korean status in information and communication technology (ICT). The government identified ICT as a strategic industry for the future and started infrastructure investments programs already in 1995 (see Lee 2003).

Three mobile operators are dominating the Korean market: SK Telecom (SKT), KT Freetel (KTF) and LG Telecom (LGT). Mobile payment procedures have been adopted early. Customers of mobile operators have the possibility of accessing carrier-based mobile payment services since the end of the 1990s. E. g., customers can pay for online-products in the internet through a transaction made via the billing-system of the mobile carrier. The transaction is authorised via SMS. In the year 2001 SKT implemented its service “Moneta”, which is based on a so called ‘smartcard’ technology. Smartcards are chip-cards with integrated memory and micro processor. Users can initiate payments using credit card information stored on the chip. The chip is not permanently integrated in the cellular phone but can be removed and changed through a slot. The credit card information is passed through using Bluetooth or RFID to a special transceiver, called “dongle”. By the end of 2003 about 400.000 dongles have been installed in shops, train stations, movie theatres etc. However, user rates were rather low at that time. The problem was a lack in standardisation and compatibility between the individual mobile payment solutions of the three competing operators. The mobile operators KT and LGT had their own mobile payment services called “K-merce” and “ZOOP”. Because of missing cooperation, the dongles from Moneta and K-merce were not compatible with the SKT solution. For that reason, a critical mass of customers was not reached. In 2003 the service carriers established compatibility between the systems. As a consequence, user acceptance increased considerably in subsequent years (Wallage 2003).

Today about 40% of the population use their mobile phones to access internet services. About half of the population (24 million) is using WWW-based online banking. Beyond online-banking, financial institutions implement mobile banking systems to support the development of the mobile payment business. The mobile operators cooperate with these financial institutions to make mobile banking and mobile payment more customer-friendly and secure for all parties involved. By the end of 2004, already 4 million Koreans used mobile banking services. Besides the mobile network operators numerous venture start-ups have entered the market, which offer a broad variety of mobile payment services.

The industry structure in Korea is characterized through a large degree of vertical integration (see Figure 5: Industry structure in Asia / South-Korea [Vesa 2003]). According to Funk (2006), service providers in Korea traditionally have a strong influence in the value chain, due to the fact that they defined national standards for analog and digital systems. Because Korea did not adopt GSM standards and standard-related SIM cards, handsets are not compatible with every service provider. This enables service providers to define phone specifications and standards for mobile Internet services.

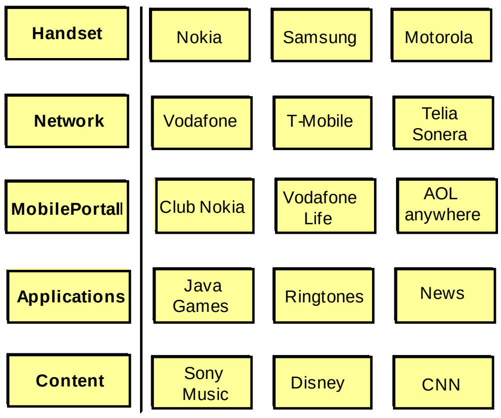
Figure 5: Industry structure in Asia / South-Korea (Vesa 2003)



In Germany, the government also supports the ICT evolution through publicly sponsored programs like "IT research 2006", Germany Online" or "Information Society Germany 2006". Like Korea, also Germany is characterized by advanced ICT infrastructure and related businesses, however, there are large differences with regard to the development of new mobile services like mobile payment, ticketing or banking. The mobile communications business in Germany is dominated by four mobile operators: T-mobile, Vodafone, E-Plus and O2. T-mobile and Vodafone operate their own mobile payment systems while E-Plus and O2 acquired the Japanese „i-mode" service from NTT DoCoMo. I-mode offers mobile internet access and enables web-based payment transaction. While E-Plus has established the i-mode system in Germany with limited success (only 3 per cent of all E-Plus customers actually use the service), O2 only implemented the service in Great Britain and Ireland but abstained from establishing it in Germany. T-mobile operates the "M-wallet" and Vodafone its "m-pay"-system. T-mobile's M-wallet is a mobile payment software that is installed on the mobile phone. It enables customers to pay online-services like news, games and music on the operators' internet platform or on the internet sites of partner firms. The M-wallet can be used with bank accounts or credit card information which is stored in the M-wallet. To buy a product or service, the customer is asked to choose one of the stored payment instruments and to authorise the transaction through a special PIN or password. Currently there are also experiments to use the system in the field of mobile ticketing to buy parking or train tickets. Vodafone's m-pay service can be used to buy products and services on the operators' internet platform and on the internet sites of partner firms. The transaction is made via the operators' billing system. The transaction can be authorised via SMS and the payments are included in the monthly carrier bill. Additional mobile payment software is not required. Apart from the approaches of the big mobile operators there have been several attempts by specialised small service providers to establish mobile payment systems in the market (e. g. paybox). However, the survival rate of these small service providers has proved to be rather low. The implementation of smart-card based mobile payment systems that ease the use of mobile payment in other environments than M-Commerce scenarios are currently being tested. In April 2007 a new mobile payment project has been launched in 13 German cities. A consortium consisting of Siemens IT Solutions and Services, the Fraunhofer Institute in Dresden, DVB LogPay and the VDV (Association of German Transport Companies) will test public transportation ticket vending via mobile phones over a two year period.

The industry structure in Germany and most European countries is characterized through a vertically disintegrated, modular structure (see Figure 6). Competition takes primarily place on a horizontal level. The modular structure offers some advantages with regard to efforts in standardization. According to Ulrich (1995) standardization can only take place within a modular product (service) architecture. As standardization is a crucial factor for the take-off of the industry, the European and German industry structure should be supportive for the evolution of the mobile payment market.

Figure 6: Industry structure in Europe / Germany (Vesa 2003)



The comparative description of the mobile payment business in Germany and South-Korea has revealed a number of salient differences in the development and situation of the industry. In order to analyse and assess the situation of the industry in more detail we use the set of indicators and structural parameters that we introduced to describe the industry life cycle:

- **Entry rate:** The entry rate of firms is calculated by the number of firms entering the industry in relation to the number of firms that exit the market. In the case of Germany, three of the four major mobile operators run a mobile payment system, however only with limited success. One reason may be that the systems are largely incompatible. A number of other carriers have entered the market, but most of them failed. By now, there are a few systems that are operated on a national basis and a number of niche offerings that work on a regional basis (e.g. Crandy, Teltix). The examples of Simpay and Paybox show, that even big corporations and / or big initiatives may fail, because of the high uncertainty in the market, a missing critical mass of customers and technological systems that don't meet customer needs. The situation in Korea is different. Like in Germany all big mobile operators run national mobile payment systems. But the entry rate in Korea is much higher. Over the last years various venture start-ups entered the mobile payment value chain to sell their products and services to the mobile operators.

- **Number of competitors:** As already mentioned, the number of competitors in Germany is low. Also competition is far from being fierce, primarily because of different product designs which provide not overall but only selected payment functions and which are targeted towards different customer groups. While the systems of Vodafone and E-Plus only work in the M-Commerce context, T-mobile also enables payments at parking meters or mobile ticketing in cooperation with its partner Teltix. The number of competitors in Korea only gradually exceeds the number in Germany, but competition is high due to the use of equal technical systems which provide the same functions to the customers – the mobile payment solutions in Korea are direct substitute in the eyes of customers.
- **Degree of vertical integration:** The degree of vertical integration in Germany is considerably high. In most cases, mobile payment is only possible on the mobile operators' internet platforms. Only a few partner firms are involved. In most cases there is no hard- or software adjustment of the mobile phones. The product architecture is characterized through a high degree of modularity. All initiatives to cooperate with financial institutions failed. As consequence, billing and charging usually is processed via the operators' billing system. In South-Korea the degree of vertical integration comparatively low. Mobile operators usually have a lot of partner firms which provide mobile payment on their internet platforms. To make mobile payment with smart-card technology work, several hard- and software adjustments are required and realized by different hard- and software producers. Furthermore, in Korea there are various co-operations with partners from industries such as financial services, entertainment and transportation to meet the requirements of the more integral product design.
- **Dominant design:** So far, no dominant design has emerged in Germany. Firms still experiment with different technical solutions. Mobile operators are reluctant to technological solutions that use a Smart-Card in the mobile device and scanners to initiate a mobile payment transaction. The systems used often do not meet the customer needs. The solutions at hand are complicated and uncomfortable to use outside the internet context. In Korea firms established a dominant design in cooperation with strategic partners, above all the financial institutions. There is a clear tendency to use smart-card solutions. The success of these systems in Korea (and Japan) shows the predominance of this technological solution in comparison to the German approaches. The current operation of mobile ticket vending in 13 German cities on a test basis could therefore become a promising ap-

proach. Smart-card based systems provide a platform for the use of many different mobile payment services. At the same time they are secure and comfortable to handle.

The comparative analysis clearly indicates that the German mobile payment industry is in the first stage of the life cycle – the initial stage –while the Korean industry is transitioning to the growth stage. Although the modular design of the German industry would support standardization from a theoretical point of view and therefore provide the basis for market take-off, the industry in Germany is lagging behind the Korean evolution. In Germany we still identify a high uncertainty concerning future opportunities of the industry and the development of the market volume. The product design is primitive and vertical integration is still high. In Korea a dominant design has already emerged and allows the service carriers to offer efficient mobile payment solutions which become increasingly accepted by customers and suppliers. Vertical integration declines and there is an emerging network of suppliers, cooperation partners and customers. With regard to our differentiated, five-stage view of the industry life cycle one may conclude, that the German industry is still in the pre-firm take-off stage, whereas the South-Korean industry managed to “launch” the “market take-off”.

6. Lessons for the German Industry

Finally the question arises, why the Korean mobile payment industry is in a world-wide lead position and has advanced so much further than the German industry. To given an answer we will use the typology of industry life cycle triggers and identify the type of innovation that initiated the life cycle in the Mobile Payment industry. According to Sheremata (2004) mobile payment can be characterized as radical, compatible innovation. Through combining the mobile device with smart cards to store financial and biometrical information and the possibility to transmit this information the concept of the mobile handset has been changed radically. Through these changes, totally new possibilities of using the mobile device have been explored. Furthermore, these changes are compatible to the existing payment systems and the mobile telecommunications industry. The existence of mobile payments is crucial for the development of mobile internet services. Due to small screens on the handset, content providers face the problem of not being able to earn money from advertisements like in the “traditional” internet. New revenue sources can easily be tapped by the operators through the establishment of mobile payment systems (Haas, Waldenberger 2005)

Besides the use of new technologies, co-operative arrangements are a major success factor. The successful development of the industry in Korea was build on co-operations and compromises between different parties. Financial institutions, suppliers, customers and service carriers found a solution to balance efforts and costs of inevitable investments. For this purpose, the compatibility of mobile payment to the existing industries has been a decisive success factor. These co-operative arrangements have been fostered through the quasi-integral characteristics of the telecommunications industry in Korea. Due to this industry configuration, Korean service providers have been able to implement the required specifications for mobile payments while German service providers still struggle with inferior solutions without handset (hard- and software) specifications. As detailed out in part 4, an industry structure characterized by co-operative arrangements is advantageous in the early stage of the industry life cycle. Cooperation may trigger market take-off since it facilitates technological advancements in functionality and quality. Advancements in quality and functionality are basic determinants that initiate positive network effects (Haas, Waldenberger 2005). Although the German modular industry structure provides – from a theoretical perspective – a fertile ground for co-operative standardization processes, the quasi-integrated structure in Korea proved to be more fruitful. In Korea's industry that is characterized by the dominant market position of a few service carriers, critical coordination processes were organized more easily.

To speed up the evolution of the industry and to progress beyond the sales take-off point, German mobile payment firms should be aware of the following success factors:

- The development of the Korean market has benefited a lot from the more integrated service architecture (and industry structure) and a closer collaboration within the industry, which was triggered by the compatibility of mobile payment with existing industries.
- Investments in technologically advanced hardware and software solutions provided the basis for a higher level of customer convenience.
- In Korea, the business concepts put an emphasis on product-related services to generate a critical mass of customers.

Besides the technology and industry structure that supported the evolution of the Korean mobile payment industry, there has also been intensive and clearly focused government support in order to make the country a worldwide leading mobile service market.

7. Conclusions

Systemic industries are characterized by the interlocking of numerous components, technologies and assets as well as complementary services. In such an environment a dominant design will only emerge when all relevant stages and partners in the value chain closely cooperate and coordinate their activities. The product architecture has to match the needs of the underlying life cycle concept and has to be adjusted. The dominant design has to make it possible, to operate the business efficiently. In order to reach this aim, all industry partners have to cooperate and coordinate activities with regard to the allocation of investment costs and revenues. These compromises are crucial to the emergence of a critical mass of demand. The critical mass can only be reached under the condition, that the product design is standardized and compatible with the systems of the majority of service carriers involved. In order to strengthen the diffusion process, the services offered should address a broad customer basis. Mobile services that fulfill this requirement are, among others, mobile banking and ticketing. Train tickets on the mobile phone reduce transaction costs and increase customer convenience. The use of mobile payment in such popular service areas reduces the threshold to use mobile payment in other scenarios than the internet environment.

The strategic acceptance of co-operations and coordination activities with partner firms is crucial to implement a dominant design. To support industry development, the establishment of a dominant design is indispensible for firms to realize economies of scale. The probability of the emergence of a dominant design is heavily influenced by the underlying industry structure. After a dominant design has emerged, costs and prices will decline and a broader customer base – the early and late majority – will adopt the product. Network effects then further catalyze the diffusion process.

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ISSN 1864-2039