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The emergence of new industries between path dependency and path plasticity

The case of Japan's software and biotechnology industry

Cornelia Storz

Frankfurt Working Papers on East Asia

IZO | Interdisciplinary Centre of East Asian Studies
Goethe University Frankfurt am Main
www.izo.uni-frankfurt.de

No. 2
October 2009
ISSN 2190-7080

Frankfurt Working Papers on East Asia 2/2009

Edited by
IZO | Interdisziplinäres Zentrum für Ostasienstudien
Interdisciplinary Centre for East Asian Studies
Goethe University Frankfurt am Main

ISSN number (Print) ISSN 1869-6872
ISSN number (Online) ISSN 2190-7080

Executive editor of the series: Thomas Feldhoff

IZO | Interdisziplinäres Zentrum für Ostasienstudien
Interdisciplinary Centre for East Asian Studies
Goethe University Frankfurt am Main
Senckenberganlage 31
D-60325 Frankfurt am Main
T: +49(0)69 798 23284
F: +49(0)69 798 23275
E: izo@uni-frankfurt.de
H: www.izo.uni-frankfurt.de

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Abstract

In contrast to the US and recently Europe, Japan appears to be unsuccessful in establishing new industries. An oft-cited example is Japan's practical invisibility in the global business software sector. Literature has ascribed Japan's weakness – or conversely, America's strength – to the specific institutional settings and competences of actors within the respective national innovation system. It has additionally been argued that unlike the American innovation system, with its proven ability to give birth to new industries, the inherent path dependency of the Japanese innovation system makes innovation and establishment of new industries quite difficult. However, there are two notable weaknesses underlying current propositions postulating that only certain innovation systems enable the creation of new industries: first, they mistakenly confound context specific with general empirical observations. And second, they grossly underestimate – or altogether fail to examine – the dynamics within innovation systems. This paper will show that it is precisely the dynamics within innovation systems – dynamics founded on the concept of path plasticity – which have enabled Japan to charge forward as a global leader in a highly innovative field: the game software sector as well as the biotechnology industry.

Acknowledgements

The author kindly acknowledges the excellent research assistantship provided by Fabian Kraft, Phil Höhn, Katharina Sturm, Caroline Siber. Support from the Japan Society for the Promotion of Science (S08744) was of special importance in data collections. Akira Baba, Stefan Klonner, Kai Reimers, Sebastien Lechevalier and Federico Riboldazzi provided insightful comments on earlier drafts of the manuscript. Thanks go also to Sebastian Schäfer, Ramona Hinter and Per Larsen for their comments. Usual disclaimers apply.

Cornelia Storz (University of Frankfurt)
Faculty of Economics and Business Administration and
Interdisciplinary Centre for East Asian Studies
Goethe University Frankfurt am Main
Grüneburgplatz 1, 60323 Frankfurt am Main, Germany
Email: storz@wiwi.uni-frankfurt.de

1. Introduction

This paper deals with a basic question: What role does path dependency play in the emergence of new industries? The argument to be proposed is that the path dependency approach has to be combined with the path plasticity approach in order to have an explanatory power vis-à-vis the emergence of new industries. Clearly, the institutional setting, as well as the path dependent accumulated knowledge stocks are decisive for a firm's strategy, but the system within which firms proceed in fact offers far more leeway for action than is typically perceived at first glance. This is due to path plasticity, a concept which refers to the variety of institutions and knowledge stocks present at the periphery of a system. I will elaborate this argument using the case of two new industries that have emerged in Japan.

Software and biotechnology epitomize new industries. The emergence of these new industries was not expected in Japan: Japan's innovation system was perceived as unable to bring forth major technological innovations as evidenced by its focus on medium high-tech industries such as electronics, transportation or machinery (Anchordoguy 2000; Goto 2000; Kondo and Watanabe 2003; Nezu 2004; Porter et al 2000). However, these new industries exhibit an above-average rate of start-up and growth and have attracted considerable amounts of venture capital investment. In some areas, such as the game software sector, Japan has in fact become a world market leader. One explanation provided for the emergence of these new industries is that Japan reformed its national framework so drastically, that it now enabled a new and more appropriate framework. Recent papers point to the blossoming of American-type organizations such as technology licensing centers at Japanese universities, increasing number of specialized venture capitalists, and the rise of now popular terms such as "Bit Valley" (as an allusion to "Silicon Valley" for the Shibuya District in Japan; Baba et al 2000; JETRO 2007) to indicate that what indeed took place is that new industries resulted from the implementation of the Silicon Valley model and the extinction of the "old-fashioned" J-model.

However, what we observe is quite different: We do not find a Silicon Valley model in Japan, but very much an adherence to established structures. In game software for instance, many of the core settings such as the industrial organization or the labor market, retain distinct features of the traditional J-Model (reference to Aoki's J-firm 1986, 1990a, b, 2001). At the same time, new institutions and knowledge stocks have also been introduced, yielding an institutional setting different from the traditional J-model. The outcome is definitely not a Silicon Valley No. 2.

This paper tries to understand what at first glance appears as contradictory evidence. It argues that new industries emerge due to two forces: path dependency and path plasticity. Path dependency is a consequence of increasing returns to network effects: "What is at stake here is much more than simply today's choices being influenced by the current institutional matrix derived from the past. Instead, there is something about the way that the institutional framework has evolved that constrains choices to shape the long-run direction of economies" (North 1995: 22). Thus, there is an interplay between institutions and actions in a dynamic time frame (North 1997). Since institutional systems are not just a collection of decoupled, but a set of interrelated and complementary institutions, institutional systems as a whole possess path dependent properties (Amable 2004).

A rigid interpretation of path-dependency has rightly been challenged (Herrmann 2008), and many recent papers extend the applicability of this concept by including institutional change into the concept of path dependency (Hall and Thelen 2009). Path-dependency exists in various types of activities and favors some while constraining others (Ackermann 2001, Arthur 1994, Narula 2002). The types of activities which are relevant to this paper are those related to innovation. Innovative activities embedded in path-dependent institutional systems can thus be characterized as activities that constrain or incent respective innovative activities.

The concept of institutions and path dependency also explains why, how and under what conditions new industries emerge: When one takes into account that sectors are not homogenous, but incorporate heterogeneous subsectors with different technological properties, then one expects the emergence of that subsector which shows the best match or "fit" to the specific national institutional setting. As a consequence, specialization within a sector takes place according to the system in which firms are embedded (Casper and Kettler 2000; Casper, Lehrer and Soskice 1999). The respective national innovation system in which firms are embedded offers thus far more leeway for new industries than may be expected at first glance, since the technological characteristics and the necessary institutions differ between subsectors. This explains why the emergence of new industries in the Japanese framework is not an anomaly, but results from specific requirements that the subsectors have from the already existing institutions and their accumulated knowledge stocks.

The argument on specialization in sectors according to the institutional framework is important in that it presents new leeway for entrepreneurial action, and it allows predictions about the pattern of new industry emergence. It also explains why firms strategically adhere to dominant institutions. The existence of these institutions has exactly been the reason why firms have specialized in these subsectors: they offer "matching" competences and knowledge stocks. I build on the ideas advanced in these studies that sectors (and subsectors) do not emerge arbitrarily, but in a path dependent way. However, according to the varieties of capitalism approach, the institutions and the knowledge stocks upon which firms in new sectors resort to, are thought to be more or less identical to those of the dominant innovation system (Casper and Kettler 2000; Casper and Whitley 2002). Thus a newly emerging subsector is expected, in a pronounced way, to be embedded in a mini replica of the national innovation system relying on the same institutions and the same knowledge stocks as the dominant industries.

I differ from this past research in that, despite recent progress (Hall and Thelen 2009), these studies insufficiently address the role of the periphery. The focus on certain "economic models" or "national innovation systems" excludes – necessarily – the existence of a periphery. The periphery however, may contain valuable institutions and knowledge stocks which are different from those in the dominant model. New sectors require new knowledge, and it cannot be expected that the new knowledge called for in a new industry must necessarily be identical to the dominant knowledge stock. Taking the role of the periphery into account, I also consider new entrepreneurial opportunities which arise from configurations beyond the dominant national innovation system. I term this property of innovation systems "path plasticity". Path plasticity is a consequence of the wide range of institutions and knowledge stocks in systems, including the systems' periphery. The inclusion of the periphery thus leads to more options for the emergence of new industries.[1]

For this reason, I maintain that it is necessary to combine the approaches of both path dependency and path plasticity in order to explain the emergence of new industries: Institution-based approaches which stress the role of path dependency help to explain how dominant institutions incent particular innovation activities, and why specialization takes place inside sectors. However, they tend to overlook the role of the periphery and thus neglect the heterogeneity in national innovation systems, and the thereby resulting entrepreneurial option to form unique and distinct subsystems. The approach of plasticity helps to explain why sectors beyond dominant knowledge stocks emerge, and how new subsystems are created.

The identification and selection of peripheral and dominant configurations that match a sector's needs is a critical entrepreneurial function and may, following Kirzners interpretation, be described as the entrepreneurial function of identifying coordination gaps (Kirzner 1978). As a result of these processes, new industries are constituted from dominant and peripheral configurations. For example, in the Japanese game software industry, the peripheral skill of drawing granular, attention-calling comics were accumulated in private clubs at the periphery of Japan's innovation system, and were more or less meaningless to the dominant industries. It became, however, critical to the emergence of the Japanese game software sector, but only when it was combined with Japan's dominant competences in entertainment electronics and chips production.

The analysis of the emergence of Japanese software and biotechnology industry, as well as the examination of the role of path dependency and path plasticity in the emergence of these industries, was undertaken with a two-fold empirical investigation. First, sector specialization was identified using data on IPOs and information on the firms' websites. This method is standard for analyzing the pattern of new industries in the varieties of capitalism approach (Casper and Kettler 2000; Casper, Lehrer and Soskice 1999; Casper and Whitley 2002). Additionally, since Japan possesses a less developed

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[1] Plasticity may be of special importance for so-called coordinated economies to which Japan belongs, since their stronger coherence may – this is at least an often formulated thesis (Sako 2007) – reduce the variety in a system.

capital market, these data were complemented by membership information available through the leading software and bio business association[2] JISA (Japan Information Service Association), CSAJ (Computer Software Association of Japan) and JBA (Japan Bioindustry Association). The second source of data was gained from a total of 58 interviews conducted between 2006 and 2009 with firms, key actors, namely analysts, business associations, key persons in ministries, public and research institutes in the new industries. The targeted interview partners belonged to the Japanese game software sector. Eight of the 14 top Japanese game developers, as recorded in the Top 50 Developers of 2008 (gamedevresearch 2008), were interviewed, in several cases multiple times. The remaining 14 firms were smaller, more domestic oriented developers. Accordingly, part of the research in this paper is exploratory and qualitative (for method see appendix 1).

The remainder of the paper is organized as follows: The second section presents the relevant actors and structure of the Japanese software and biotechnology industry. The third section focuses on two stylized economic models, the Silicon Valley and the Japanese model (J-model) and their impact on innovation activities. The fourth section develops a framework for the emergence of new sectors, referring to the concepts of path dependency and path plasticity. The fifth section applies the concepts of path dependency and path plasticity to the Japanese case. The sixth section discusses theoretical implications, limitations and areas for further research. The paper ends with a conclusion.

2. Evidence: The Emergence of New Industries and the Case of Japan

The following section briefly outlines the Japanese software and biotech sector with data on market structure, venture capital investments, IPOs and exports.[3]

At first glance, Japan appears to be absent from the world market for software: Among the top ten software firms, there is only one Japanese firm (Softbank; OECD 2006a: 53). However, indicators that the industry is more successful than commonly perceived include IT investments and IPOs: About 35-40% of total Japanese venture capital is invested into IT (including software; data for 2004 and 2008; own calculation according VEC 2004-

[2] Measured in number of firms, staff employed and market share.

[3] It may be argued that the game software sector upon which this paper focuses is “too small” in order to be relevant. However, what is the concrete level at which an industry becomes significant? High-technology exports (to which new industries mostly belong) account for only 24.5% of all OECD exports, which means that the rest of exports is composed of medium high technology and, with the largest share, non-R&D exports (OECD 2006b). This is the reason why some authors (Fagerberg, Mowery, Nelson 2006) argue that the economic importance of high tech industries should not be overstated. Although we will bear this in mind, we believe that the ability of an economy to give birth to a new industry is an indicator of its dynamics, independent of the size of the sector. Compare for the impact of the software industry on other industries CESA (2008a).

2008), a figure broadly comparable to the U.S. (own calculations based on NVCA 2008).[4] In terms of IPOs, about 17% of all IPOs are firms in the software sector (own calculation, based on 2008 Mothers and Hercules indexes that track Japan's smaller companies).[5]

Furthermore, there are two subsectors, the game and the embedded software sector, where Japanese firms belong to the leading players in the world market. In this paper, I will concentrate on the game software industry due to the better availability of data.[6] In terms of consumption, Japan’s game market is the third largest national market. In terms of production, Japan has a much stronger global position: Japanese game software firms ship 65.9% of their game software products to foreign markets; the most important markets are the U.S. (46.9%) and the European Union (44%) with a minor role of Asia (4.1%) (CESA 2008b: 103, 125; Eurotechnology 2009). The increasing export of software contrasts sharply to the increasing deficit in business software (CESA 2008b: 103). In the ranking of the top 50 developers, 14 are Japanese and 22 are U.S. American firms (gamedevresearch 2008). Among the 50 most sold games titles in the U.S. market in 2005, 13 are from Japanese game developers (Enterbrain, 2006: 339). In contrast, the market share of American game software firms on the Japanese market is negligible (CESA, 2005: 71; Eurotechnology, 2005: 125).[7] The game software sector is the only subsector where Japan’s balance of software trade is positive (OECD 1998: 31-32).

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[4] The categories of the VEC reports and of the NVCA report are slightly different. Whereas VEC includes software in the category of information technology, NVCA reports software explicitly. Similar to Japan, the share of venture capital investments in the software sector shrank in the U.S., from 23.8% to 18.2% between 2004 and 2007 (NVCA 2008).

[5] Mothers was founded on the Tokyo Stock Exchange in 1999; Hercules on the Osaka Stock Exchange in 2000 (until 2002: Nasdaq Japan).

[6] Embedded (or bundled) software is embedded in “hard” products such as factory automation, electrical equipment, transportation-related fields (e.g. engines), audio or visual equipment (Nakajima 2003). The quality of manufactured products and the defect frequency has substantially to do with the quality of the embedded software. Due to the bundled property of embedded software, it is presently not possible to grasp this sector separately, thus leading to a “significant mis-measurement” as the OECD (2006a) states in a recent report on ICT trade since equipment trade is overstated and software trade understated (compare for classification OECD 1998: 13-15). This holds especially true for countries with strengths in embedded software such as Japan. Thus, there are only estimates using indirect indicators such as the dominance of national standards. These data suggest a dominant Japanese position. According to ERTL (2009), embedded operating systems based on the Japanese standard TRON have a market share of 41.4%. These data are confirmed by Midford (2006). However, it is not entirely clear whether this dominance is also commercially used. Since there is a strong need to learn new processes and metrics for managing the development of software in order to have more reliable software, it is estimated that this subsector will gain more importance in the future (McKinsey 2006), which explains several related new governmental initiatives in Japan (Vinnova 2005).

[7] Since 2001 (until then Japan had a leading position), the size of the game software market was the largest in the U.S. with 8,211 million U.S. dollars, followed by Japan (3,959 million; Asia Pacific in total: 9,593 U.S. dollars) (data for 2004; PWC, 2005; Enterbrain, 2006: 3). In the domestic market there has been a certain phase of decreasing dynamics of the Japanese market from 2000 on, and a slight recovery from 2004 on (CESA 2007; DCAJ, 2007; Dentsû, 2006). Since most firms are not listed, it is difficult to get exact information on their profitability, but evidence from leading firms suggests a high one: Nintendo recorded an average return on equity (ROE) of 25% from 1986 to 1996, while Sega had an average ROE of 15% over

Game software is produced by so-called game software developers which may, as in the case of Sony Computer Entertainment (SCE) or Nintendo, be at the same time console manufacturers. Some developers also publish their games (they are therefore also called publisher), while others rely on the production, marketing and distribution capabilities of larger firms. This paper uses for both the terms “developer” or “game software firms”. Game software firms develop different game genres, such as role playing, action or simulation games (Storz 2008). This paper focuses its analysis on the top Japanese developers according to the Top 50 Developers of 2008 (gamedevresearch 2008; appendix 2). These developers deliver to international markets to different degrees; the strongest positions are held by Nintendo, SCE, Sega, Namco Bandai, Konami, Square Enix and Capcom.

The Japanese bio industry, which is the second new industry I will focus upon, is comprised of start-ups and branches of large firms. It contrasts in its structure to the U.S. which mainly consists of small start-ups and university-industry alliances. Japanese firms often diversified from traditional into modern biotechnology via intrapreneurship in the 1980’s (Nakamura and Odagiri 2002; Budde 2008; Kurata 2008: 10), as for example, Japan Tobacco or Kirin Brewery. Totally, there are about 800 biotech firms, including 586 start ups (as of 2006; JBA 2007a; compare also Tsukamoto 2008: 14).[8]

Currently 12.1% of Japan’s venture capital is invested into biotechnology (own calculation, based on VEC 2004, 2005, 2006, 2007, 2008) which is still somewhat lower to the U.S. value of 18% (own calculation based on NVCA 2008). On average, every second Japanese venture capitalist intends to increase its biotechnology investment in the future by up to about 50%, indicating at least a strong conviction of further growth opportunities (METI 2002). Between 2004 and 2007, the share of biotech-related IPOs to all IPOs (on Mothers and Hercules index) was on average 5.2%; in 2008 it rose to 12.5% (own calculation, based on data of Mothers (2008) and Hercules (2008)). As in the

the same period, although there has been a major crisis due to the failure of Sega Saturn; these ROEs are far above the Japanese average (Porter et al 2000: 99). The overall growth expectation in Japan is, with 6-7% (PWC, 2005: 371, 379, 386) much higher than for traditional manufacturing, making game software one of those industries which have gained special consideration by the Japanese Ministry of Economy, Trade and Industry (METI; compare the so-called Nakagawa Report). The Media and Content Industry Division in the METI has been created in order to foster the game software industry. One of the important councils is the Content Industry International Strategy Research Committee (Kontentsu Sangyô Kokusai Senryaku Kenkyûkai). METI supports the game software industry as a part of the digital entertainment industry. Finally, other indicators also suggest a leading role for Japan, e.g. the increasing Tokyo attendance to video game expos in contrast to a falling attendance at the expo in Los Angeles (Miller 2008: 233).

8 In contrast to the U.S. with 1.415 bio ventures (Tsukamoto 2008: 19). The top ten of the Japanese bioindustry are Eiken Chemical, Precision System Science, AnGes MG, Soiken Holdings, Medinet, Pharma Foods International, OncoTherapy Science, Effector Cell Institute, LTT BioPharma and Trans Genic (JBA 2007b). Among the top 20 firms in biotechnology, there are only 2 Japanese firms (Takeda, Asteras; Tsukamoto 2008:16). The number of bio ventures increased by 20.8% in 2007 (compared to 2004; 122 firms) and by 48.1% (compared to 2002; 282 firms; JBA 2007a: 7). The growth rates for start-ups in bio in 2004-2005 have been, at 12.6%, higher than the total growth rate of start-ups with 9.2% (own calculations according JETRO 2007).

software industry, American firms also dominate the world market in biotechnology: about 80% of the worldwide turnover is realized by American firms, Europe and Canada follow with 14% and Asia-Pacific (including Japan) with 4% (Ernst & Young 2008).[9] Japan's biotech industry thus still lags behind the U.S., but is making efforts to catch up.

3. The Silicon Valley and the J-Model: Which Role for Innovation?

3.1. Institutions, Innovation and Path Dependency

Institutions define the incentives and constraints that lead either to investments in certain assets, to the sharing of knowledge or to the acquisition of certain skills, competences and knowledge stocks.[10] The design of institutions and of inter-institutional interfaces influence the rate and direction of innovative activities, the way in which people relate to each other, how they exchange and use their knowledge, and which competences and skills they acquire (Johnson 1992; Asheim and Isaksen 2002; Malerba 2006; Edquist 1997; Lundvall et al 2000). As a consequence of institutional complementarities, institutional systems possess path dependent properties, and thus also the embedded knowledge stocks, competences and skills (Metcalfe and de Liso 1995, Coombs and Hull 1997, Fagerberg et al 2008). Path dependency is an important explanation as to why, despite the ongoing global integration of production processes, the specialization and comparative strengths of nations remain relatively stable (Nelson and Rosenberg 1993). The national institutional framework does not determine the precise structure of business strategies, but due to its property of being a stable system and following an identifiable path in its evolution over time, it influences the governance costs of particular alternatives (Casper and Kettler 2000: 6). Innovation systems thus systematically shape innovative activities (Nelson 1996) – which knowledge stocks are acquired, in which assets actors invest, or to which degrees knowledge sharing takes place. Since accumulated knowledge stocks are the most critical resources for innovation activities, the labor market, human

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[9] A somewhat different picture emerges when the Japanese definition of biotech is used which also includes traditional biotechnology sectors: Then, the Japanese market has a volume of 1.3 billion Yen, the European market of about 2 billion Yen, and the American market of 3 billion Yen (JETRO 2007; Walke 2007). However, this classification is not compatible with international statistics.

[10] There is such a debate on the concepts of knowledge, competence and skills that it is impossible to identify a coherent theory or to arrive at a definition capable of accommodating all the different ways the terms are used (Elleström, 1997). Knowledge is the result of an interaction between intelligence and situation (as the opportunity to learn), including also tacit knowledge (More 1980). Competence includes objective competences, understood as performance measured in standard tests, and subjective competences, understood as skills to master tasks and to solve problems relevant to performance (Sternberg and Kolligian 1990). Skills are combinations of mental and physical qualities useful to industry which require considerable training to acquire (More, 1980: 15). Being well aware of the nuanced conceptions of knowledge (compare critically Malerba and Orsenigo 2000) we use in the simple term "knowledge", and include competences and skills.

resource management (HRM) practices, and the science system are often defined as core institutions in national innovation systems.

Concepts of national innovations systems do not exclude or deny the existence of other sub- or meta-systems such as regional (Cooke 2004; Grabher 2004) or sectoral systems (Malerba 2006) but argue that complex institutional complementarities in an innovation system induce, despite the ongoing global integration of production processes, a relatively stable specialisation profile of nations, even if some single nations may drastically change their institutional settings (as e.g. Norway, compare Amable 2004). Starting with the binary classification of Hall and Soskice (2001) into coordinated and liberal market economies, the tripartite classification of Schmidt (2002) and Amable (2004) with the concept of social systems of innovation and production, all have elaborated the idea that institutional settings in market economies influence industrial specialisation and innovation activities in distinct ways. Based on these contributions, I refer to two stylized economic models, the Silicon Valley and J-model. This does not mean that they are governed by a single and unique principle (Amable 2004), but that these models incent innovation activities and industrial specialisation in distinct and different ways.

3.2. The Silicon Valley Model as a Framework for Innovation

The Silicon Valley model – other terms use are "new economy business model" (Lazonick 2005), "entrepreneurial business model" (Casper 2003), "Wintelism" (Borrus and Zysman 1998), market-based model (Amable 2004) or H-mode (Aoki 1990a) – is a highly stylized economic model with a distinct institutional setting providing incentives for certain types of innovative activities while constraining others. More precisely, it could be called an "A-model for new industries", indicating that the Silicon Valley model does not stand for a certain regional agglomeration, but for an American innovation model. It is comprised of the following institutions (Casper and Whitley 2002; Casper and Kettler 2000; Lazonick 2005):

- *Financial system:* Firms may arrange financing from a number of sources, but due to the necessity of high-risk financing, venture capital firms are of special importance for the emergence of new industries. The Silicon-Valley Model is a capital-market based system, closely linked to markets for corporate control.

- *Educational system:* Links between universities and firms are strong, and knowledge transfer from universities into firms is developed. Unlike Japan, there is no or only a weakly developed apprenticeship for vocational skills.

- *Industrial organization:* The industrial organization is characterized by a vertical specialization of firms in the process chain. Technical modularity also enables organizational modularity. The degree of competition is high.

- *Labor market:* The labor market is open, and staff mobility is high. This is embedded in a liberal labor law with few barriers for employee turnover.

- *Human Resource Management:* Open labor markets affect human resources development: Managers in high-tech firms may face dismissals or organizational failures, but have, at the same time, to motivate and attract experts. Special incentive systems in remunerations (e.g. a high share of stock options), performance bonuses and in the organization of careers (fast career tracks) work as a compensation.

- *Science and education system:* Collaborations, especially in the form of technology licensing offices, including an array of incentives and resources, and academic start-ups, play an important role.

Such a framework favors the emergence of radical innovations and sectors linked to it, such as information technology or the pharmaceutical sector. Given high technological uncertainty of new industries, it is difficult to predict which investments will be effective, so that firms need to be able to change strategies at short notice. The open labor market facilitates such strategies. Together with the open industrial organization and a competitive science system, it also facilitates the exploration of new sectors. The system thus enhances competence destruction, mobility, diversity, and risky behavior.

These properties indicate why American firms have been successful in opening up new industries: the institutional setting in which they operate is appropriate for new industries.[11] Vice versa, when these institutional conditions are not given, organisations may choose not to commit themselves to radical new innovations. This is the case of Japan where the institutional setting differs quite strongly.

3.3. The J-Model as a Framework for Innovation

I begin with a thumbnail sketch of the characteristics of the Japanese innovation system, which I call, in allusion to Aoki's J-firm (1986, 1990a, b, 2001) the J-model of innovation (compare also Itoh 1987; Lam 2002; Porter et al 2000). Other authors refer to it as the mesocorporatist model (Amable 2004). The sketch necessarily has to be rough and neglects dynamics in the 1990s.[12] These subsequently outlined institutions can be

[11] This stance does not exclude that other economic approaches which also analyze conditions under which innovation emerges – market structure, competition and/or demand – are important for understanding the puzzle of emerging sectors (Klepper 1996). For the role of demand in the emergence of Japan's game software industry compare Storz (2008).

[12] In selected institutional settings, drastic reforms took place, especially in the education system where former public universities were privatized, in the science system where TLOs were established and in the venture capital market which was comprehensively deregulated (Storz and Schäfer forthcoming a). However, in the venture capital market, capital movements are still weak.

interpreted as dominant institutions since they are the most strongly represented group of institutions and reflect the essential logic. Its highly stylized characteristics are:

- *Financial system:* The Japanese financial system is basically a credit-based financial system, based on banks. The venture capital market is, in international comparison, dramatically underdeveloped; its share of GDP is lower than in Hungary or Greece (OECD 2004: 7; Storz and Schäfer forthcoming 2009a).

- *Education system*: The education system has been described as "broad-based egalitarianism" (Lam 2002: 72) in which training recognizes the value of vocational training besides academic education (Koike 1995; Soskice 1997). Specific skills are developed within the corporation, often in the form of job rotation in firms during a time frame of 10-15 years.

- *Industrial organization:* The industrial organization is characterized by "quasi disintegration" between the core firm and affiliated firms as Aoki (1986) has called it ("*keiretsu*"). Typical institutions are long-term relationships and the transfer of employees between firms and supplier associations.

- *Labor market:* The labor market is relatively closed. The average tenure, of 12.2 years, is much higher than in the U.S. with 6.6 years (WER 2005: 191), so that long-term employment is a social norm. The labor law is relatively strict and favors internal solutions instead of "hire-and-fire" policies (World Bank 2006).

- *Human Resource Management:* Recent changes notwithstanding, seniority wages and promotion opportunities within the firm (or the firm group) dominate the way of promotion for regular employees (*seishain*). Performance-based payments mostly take place in form of bonuses. One distinguishing focus of training lies in the intermediation of integrative skills and a strong capacity of employees in information processing and communication. The internal hierarchies by grades (*kyû*, *gurêdo*) work as incentive schemes for regular employees who compete for promotion between ranks (Aoki 2001; Rebick 2005).

- *Science and education system:* The Japanese education system has been described as "broad-based egalitarianism" (Lam 2002: 72) in which training recognizes the value of vocational training besides academical education (Koike 1995; Soskice 1997). Until recently, patents from universities, academic start-ups or transfer organizations were not part of the science system. Sako (2003) shows that none of the recent IPOs, even in the more risky-oriented capital markets, is an academic spin-off. Due to these properties, most researchers ascribe the science systems a peripheral or at least weak role to Japan's innovation system (Nakamura and

Odagiri 2002: graph 7), also due to the fact that the existing linkages have been mostly informal in nature.[13]

This institutional setting encourages distinct innovation activities: It facilitates horizontal inter- and intrafirm coordination as well as information processing activities across task units, based on inter- and intrafirm knowledge sharing mechanisms (e.g. employee transfer, diffuse job demarcations[14]). This setting is supportive of the development of complex industrial goods requiring highly skilled workforce and good coordination activities. These skills are related to sectors where coordination is necessary, and where competence is localized and cumulative such as machinery, transportation or electronics (Nonaka and Takeuchi 1995; Aoki 2008; Porter et al 2000). The fact that Japan shows a positive specialization in multidisciplinary scientific fields, which contrast to the U.S. with a negative specialization, may also be attributed to its ability to coordinate across boundaries (based on Science Citation Index; ISI 2008: 364-369).

Recently, the focus on coordination was interpreted as a weakness in giving birth to "real" new ideas and to explorative strategies, going beyond mere combination and coordination. Growing pessimism arose that the Japanese innovation system will be insufficiently competitive in the future (Collinson and Wilson 2006; Goto 2000). It was argued that the Japanese innovation system is "the direct result of the nation's rapid and successful economic development in the previous four decades" (Lazonick 1999) with a "failure of institutions" (Anchordoguy 2000) and a "system conflict" (Chen and Watanabe 2007: 34). Inappropriate and strongly path dependent institutions were interpreted as constraints to the henceforth competitiveness of Japan. In the following sections, I will discuss how the Japanese innovation system surprisingly favored the emergence of the software and biotechnology industry.

[13] Kodama and Suzuki (2007) argue that Japanese universities have always been part of Japan's innovation system, but that links have been more informal (e.g. by co-authorship or by co-application) and that "active" (as e.g. TLOs, academic spin-offs) research cooperation are only sparsely prevalent. One illustrative example of our case studies is a professor of a leading university who cooperated for years with a leading beer producer. The chair received donations for research for many years (*shôgaku kifukin*) and agreed upon assigning the intellectual property rights which resulted out of his research to his client. One of his PhD students was later in need of these rights since he planned to start a biotech venture. After some informal negotiations, the firm transferred the patent back to the chair. This may be an extreme case but it illustrates the personalized character of research cooperation and the high degree of informality.

[14] Diffuse job demarcations induce overlapping interfaces which may be interpreted as inefficiency. However, overlapping interfaces also facilitate the development of a common cognitive frame and the assimilation of different knowledge stocks (compare Storz and Schäfer 2009b).

4. How Can We Explain the Emergence of New Industries? Path Dependency and Path Plasticity

The emergence of new industries is addressed through two interrelated concepts: path dependency and path plasticity.

To begin with path dependency. Institutional complementarities have consequences for the analysis of economic models since they contribute to their stability: Changing an institution in the model – for example HRM practices – may only make sense when complementary institutions – for example the labor market or the financial market – are changed as well. This may be compared to a network effect since the diffusion of one institution in one area depends on the diffusion of other institutions in different areas. One can thus predict relatively long-term periods of stability. This also means that homogenization of innovation activities through globalization and other external forces are lower than it has been expected. The stability of an innovation system is also related to the question of competitive advantage, continuing a long-standing tradition in economics of identifying the sources of comparative advantages in country level variables (e.g. Ricardo with its theory of comparative advantages; compare for an overview Nelson 1996). Comparative advantages were attributed to the Silicon Valley model whose institutional setting was found to be the reason why the U.S. was successful in giving birth to new industries: It gave the "right" incentives (Castells and Himanen 2002; Casper and Whitley 2002). Contrasting institutional settings were interpreted as disadvantageous, and due to path dependencies, these disadvantages were expected to last (Anchordoguy 2000; Collinson and Wilson 2006).

Thus, the emergence of new industries in countries with an "inappropriate" setting (such as in Germany), was a challenge and difficult to explain: New industries should not have emerged. Although less analyzed, the same is true of Japan where new sectors that were not expected actually emerged. The explanation was provided by taking into account the different technological properties of new industries which had henceforth been neglected, namely the heterogeneous technological requirements within a sector. It was concluded that software or biotech should no longer be treated as a homogenous sector, necessitating Silicon Valley-like institutions, but rather, as heterogeneous sectors comprised of subsectors with contrasting technological properties (Casper and Kettler 2000). It was argued that due to its institutional setting, the Silicon Valley model indeed possesses competitive advantages in new, risky industries, driven to speedy introduction to the mass markets and pushing through quickly a dominant design. On the other hand, Germany and other, comparable economic models (in others words: coordinated economies) possess competitive advantages in organizationally complex technologies which require high coordination. Thus firms select innovative activities in those subsectors which fit the particular innovation system in which they are embedded: For firms in the Silicon Valley setting, the focus is on more risky, mass-market oriented products, whereas firms in other settings (also named co-ordinated market economies) focus more on organizationally complex products. In other words, firms specialize on subsectors with those technological properties which show a "matching" to the institutional framework in which they are embedded.

Let us now turn to concrete examples: Take the software sector where differing technological properties are called for the packaged versus customized software subsector and the biotechnology sector where the products versus the platforms subsectors each require different technological properties (Casper, Lehrer and Soskice 1999). In the Japanese case, one can expect a specialization in the organizationally complex technologies subsectors in the software and the biotechnology sector. This implies the use of the same institutions and competences which firms in the dominant sectors rely upon since they are the reason why firms possess strengths in the coordination of organizationally complex technologies.

This stance assumes that dominant institutions and competences can be adopted just "as they are", implying that new industries are embedded in something like a mini replica of the dominant national innovation system. To put it bluntly, it means that the institutional system in which firms are embedded is unchanging – independent of the point of time and independent of the sector. This implies not just a high degree of stability, but even rigidity.

This is where the concept of path plasticity becomes relevant: It acknowledges the wide range of opportunities present within systems, including those on the periphery, and recognizes the need for new knowledge in new industries (Porter 1980: 215-216).[15]

Amable (2004) has described systems with a hierarchy of dominant and peripheral institutions giving different incentives for behavior, arguing that institutions are less an optimal solution with certain functions than the result of negotiations between multitudes of actors. While dominance refers to the logic that systems follow in general (e.g. the Silicon Valley model), the configurations that exist at the periphery may follow a different logic. Based on this idea and applying it to the case of national innovation systems, path plasticity can be conceived as being the consequence of the wide range of institutions and knowledge stocks in a national innovation system existing due to the systems' periphery. Peripheral institutions incent the accumulation of knowledge stocks which are different from the dominant knowledge stocks. This periphery may be located at the border of the respective national innovation system or even beyond its borders.

True, the periphery does also possess path dependent properties. However, from the perspective of the dominant innovation system, the periphery enlarges the options for firms in the dominant national innovation system, in that it allows new directions and new corridors for innovative activities. For instance in the case of resource shortage, alert

[15] Needless to say, innovation also includes implementation and among other things, developed financial systems. Further, we can distinguish between different grades of novelty: The more peripheral knowledge is used for a new industry, the newer the industry is in its character. This includes that new industries may also emerge inside the dominant system, namely by combining different dominant knowledge stocks, as it takes place e.g. in the case of humanoid robots. Thanks go to Sebastien Lechevalier for letting me think about this.

entrepreneurs may draw upon the periphery in order to create a system which better serves their purpose. It is thus especially the periphery which enables entrepreneurial processes of searching and selecting new institutions and new knowledge stocks and of combining and adapting them. This process may be described as a coordination process, carried out by entrepreneurs who are more alert than others. The entrepreneurial function is then to fill the gap in a specific subsector by "matching" it with a peripheral knowledge stock. The property of being plastic thus enlarges entrepreneurial opportunities considerably (compare our figure in appendix 3).

5. Path Dependency and Path Plasticity in the Emergence of the Japanese Software and Biotech Sector

5.1. The software and biotech industry and their subsectors

New industries are industries which are based on new knowledge stocks (Porter 1980: 215-216) and are held on par with high-tech industries, due to the critical role and high input of R&D. We will focus on the software and the biotechnology sector which are at the core of the so-called new industries.

The definition of software varies according to the source, but in official classifications it is generally grouped with computing services and divided into packaged and customized software (OECD 1998). Packaged software includes commercially available programs for sale or lease from system vendors and independent software vendors; these programs are sold as products and written in a generic form, for the use of many different customers (OECD 1998). The Internet economy is associated with packaged software.[16] On the other hand, customized software is software based on customer's specifications. It may entail the development of an entirely new application, or the customization of an existing packaged software product.[17] Compared to packaged software, customized software additionally has to address the issue of coordination, namely the integration of different knowledge stocks such as technical standards, product architectures and organizational knowledge stocks. Often, these knowledge stocks are based on firm and sector-specific knowledge so that customized software necessitates the integration of heterogeneous knowledge stocks. Since the J-model is favorable to organizationally complex technologies, a specialization in customized software can be expected in Japan.

[16] Packaged software is also called standard or application-based software; in Japanese: *pakkêji software*. It includes graphic application software (CAD/CAM), multimedia and entertainment software, or software for running computer networks.

[17] Customized software is also called custom-built software or integrated software; in Japanese: *juchû software*, *ôdâ mêdo software*. It includes enterprise (e.g. customer relationship management, system integration, sector specific tools) and network application software (e.g. security software and document management; compare for classification Casper 2003: 247-8, OECD 1998).

Biotechnology, our second case, encompasses the application of science and technology on living organisms. It is classified into "modern" and "traditional" biotechnology. The latter includes traditional methods of material transformation such as fermentation while the former started in the 1950s, when the first genome was explored (Nakamura and Odagiri 2002). The classification is however ambiguous and makes international comparisons difficult. Analogous to the software industry, the biotechnology industry can be divided into two subsectors with different technological characteristics: these are products and platforms. Typical products in red biotechnology are therapeutics, vaccine and diagnostics, in green biotechnology transgenic plants and novel food and in white biotechnology environment-related products (classification according sector's experts; compare also Casper and Whitley 2002; Casper and Kettler 2000).[18] In contrast, platforms, or, more precisely, bio-engineered platforms are enabling technologies which support research and production processes of biotechnological products. They are licensed mostly to large biotechnology firms. Based on platforms, the license holder develops new products or rationalizes its production process (compare Lange 2006). Compared to products, the technological and financial risks are moderate.[19] Once again, since the J-model is favorable to organizationally complex technologies, a specialization in platforms can be expected in Japan.

5.2. Path Dependency: Specialization Patterns in New Industries in Japan[20]

5.2.1. The Case of Japan's Software Industry

The process of identifying and categorizing the specialization in Japan's software sector was undertaken by reviewing IPO data from firms listed on the Mothers and Hercules index as well as membership information from JISA (Japan Information Technology Services Industry Association) and CSAJ (Computer Software Association of Japan).

First, based on the specialization of firms listed on the Mothers and Hercules index, selected firms were reviewed through their respective websites. The classification into customized or packaged software was mostly clear cut. In ambiguous cases, Japanese experts were consulted. According to the analysis, 31.3% of the listed firms specialize in

[18] Products are also named substances. Red biotechnology, related to medical treatments, is the commercially most attractive group; green biotechnology is related to agricultural and white biotechnology to environmental uses.

[19] Examples of platforms include plants, animals, and engineering and information technologies.

[20] If not otherwise mentioned, the following sections are based on case studies (compare for methods appendix 1).

customized, and 51.6% on packaged software (compare appendix 4).[21] These results contradict to our expectation. Table 1 summarizes the results.

Next, software firms were classified according to their specialization as reported by JISA (2007) and CSAJ (2008). This classification was also straightforward since the listed categories are compatible with our classification into packaged and customized software. According to these data, Japanese firms predominantly specialize in customized software: In the case of JISA, this is 75.7% of the members (JISA 2008:1; compare appendix 5), and in the case of CSAJ, 47.2% (CSAJ 2008; compare appendix 6). The results of JISA and CSAJ are confirmed by the industry service of METI (2009).

Table 1 Specialization of Japanese software

	JISA	CSAJ	IPO (Mothers, Hercules)
Customized software	83.4%	47.2%	31.3%
Packaged software	3%	17.1%	51.6%
Unclear	13.6%	35.8%	17.2%

Source: CSAJ (2008); JISA (2007); own calculation based on listed firms on Mothers/Hercules and firms' websites, compare appendices 3, 4 and 5.

Moreover, according to JISA data (2008), game software products are the most important single category in packaged software: Also, according to METI (2009), 45.7% of turnover of packaged software is realized by game software products.[22]

Thus, we can observe two patterns of specialization: First, a specialization in customized software and second, in the subsector of packaged software, a specialization in game software. We also see that the national framework does not determine the precise structure of business strategies, which is expressed in the share of firms specialized in packaged software which is, in the case of IPOs, even at 51.6%.

The reason for the overall specialization in customized software is evident given that it reflects the traditional strength of the Japanese innovation system: Compared to

[21] It has been argued that enterprise software, which is categorized as customized software by Casper and Whitley (2004: 97-99) should be considered packaged software. If we use this classification, we get different IPO figures (customized software: 21.9%; packaged software: 78.1%). However even if it is true that enterprise software is has now become quite standardized, it was, at the point of emergence, a customized industry. SAP is a good example of this Storz/Strambach 2008; Strambach 2008).

[22] CSAJ does not provide this information. While JISA (2007) reports on members, JISA (2008) reports on turnover, so that the information on members uses different categories. According to JISA (2008), 41.9% of total turnover in packaged software is realized by games. However, no data related to the number of firms is available.

standardized software, customized software needs to address the additional coordination problem of integrating heterogeneous knowledge stocks. Since the institutions in which these new Japanese firms are embedded facilitate coordinative capabilities, it becomes obvious why this particular sector is selected.[23]

The explanation for Japan's specialization in game software products requires deeper exploration. Game software is delivered to mass markets in the form of standardized products which is after all, a specialization pattern that can be expected from a Silicon Valley like innovation model. Yet, the binary classification - into packaged and customized software – may be too simplistic. It focuses only on the necessity of external coordination, and disregards the need of internal coordination, which is vital to the production of some packaged software products – for example game software products. Compared to "normal" packaged software, the development of game software is complex since knowledge stocks in the game software development are highly heterogeneous, and since the development process is multidisciplinary in nature. They include creative disciplines as well as more technical disciplines such as producers, programmers, artists, animators, graphic and character designers and story writers; in some cases also production, quality assurance and law (Kristiansen 2008). Thus, while in game software development external coordination is not exceptional, the need for internal coordination is high. Especially the inclusion of creative disciplines is different from the development of "normal" packaged software products which include only programming, at best also production and quality assurance.[24]

The specialization on subsectors with additional coordination efforts also explains why Japanese software firms – I will now focus on game software – resort to the dominant institutions of the J-model, I will concentrate on the industrial organization, the labour market and HRM strategies.

In the Japanese industrial organization, two important institutions were retained: long-term transactions and sponsoring. While simple tasks in game software development rely on arm's length transaction, transactions with core suppliers, who carry out technologically and organizationally complex and demanding tasks, take place on a long-term basis. This resembles the traditional *keiretsu* structure where we find a pyramid structure with core suppliers at the top and market relations at the bottom of the pyramid. Sponsoring is kept in the form of sponsoring start-ups, which is a temporary investment of an employer into a start-up of a (former) employee, including material and immaterial support (e.g. commitment for purchase, consultation) whereby the support activities are withdrawn after a period of time. Totally, about 14% of start-ups are sponsored spin-offs,

[23] This goes in parallel with lower research intensity, so that although Japanese software firms are part of the new economy, they are not high-tech firms: The average share of R&D to turnover is 1.15% with only 2.2% of the firms investing more than 3% (JISA 2007: 19).

[24] To be more precise, game software is a "sub-subsector" of the subsector of packaged software. This raises the question whether the classification into packaged and customized software is valid and suggests a classification into coordinative and non-coordinative software subsectors.

so that on one side the majority of Japanese start-ups are still independent. On the other hand, the figure is much higher than in the U.S. (Storz and Frick 1999, GEM 1999: 8), and signals that innovative activities take place to a considerable degree through a diversification-like pattern. The institution of sponsored spin-off was transferred from the dominant system to the game software sector and became an important mechanism for the emergence of new developers. In this process, the support activities were enlarged, especially by consultations on intellectual property rights. Three of the interviewed firms support employees who want to become entrepreneurs by providing special legal advice, for example related to intellectual property rights. Other forms of support include providing guaranteed purchase orders. It can be assumed that these start-ups facilitate a smooth development process and posses high problem solving capabilities due to the fairly good knowledge of each other's technology. More technically put, the sponsor may have access to monopolistic information rents:

"The start-ups firms understand our needs, and we can rely on their quality. Both sides expect a certain stability of business. We use the same words, and that is important since there are many ambiguous things in game development. Often, nuances are important, such as that the graphic 'should express a feeling like….', or should be 'a little bit more cute' or 'a little bit more childish'. As a result, our common development process is smooth. Otherwise there would be the problem that not until the production starts we see what did not work well. This is very similar to the production process in the manufacturing industry. …There are distinct aspects in our game development which are typical for us, and it is important that our partner exactly understands what we want, independent from the formal description. This is also important for us as being the partner of the firm N. N. attaches importance to [crossing over series] similar looking characters". (firm T)

Also in HRM, firms basically adhere to long-term relationships. Administrative as well as the creative staff (including programming, testing) are engaged as regular employees (*seishain*) which can, in the Japanese context, be equalized with long-term employment and low mobility. Expect in one case, the predominant majority of employees in all interviewed firms are regular employees, and in most cases the share of regular employees between the administrative and creative staff is not very different. Three of the eight top firms interviewed even have a share of 85% of regular employed creators and three firms a share of 60%. Only one top firm had a share of 25% regular employees which can be ascribed to the smaller size of the firm which increases the difficulty to employ skilled creators. The turnover rate for regular employees is very low and was estimated to be on average about 2% for the top firms. According to CESA (2007: 55-56) 43% of the game software firms even tend to increase the share of regular workers, and a high - 56% share - does not intend to increase the proportion of part timers. These data are confirmed by Kohashi (2005). We thus do not find, as it is common for the Silicon Valley model, a high mobility between firms.

Although due to cost pressures and increasing development costs the segment of regular employees may be partially substituted by contract workers, long-term orientation remains the underlying principle. This is astonishing since it has been argued that mobility and diversity, including diversity in prior company affiliations, are important in order to get access to new external knowledge bases, this being a critical condition for innovation and creativity (Pelled et al 1999; Hambrick et al 1996; Beckman et al 2007). In contrast, HRM in Japanese game software firms very much resembles the HRM practices of the J-model in its structure.

As in the J-model, most game software firms also lack job descriptions and detailed skill maps. None of the interviewed firms had detailed job descriptions for regular employed creators. The composition of a new development team for games is not based on formalized skill maps, but on the person's match to the project. Creators are thus specialists – this explains why firms refrain from job rotation between creative tasks – but their skills overlap in many areas. The efficiency in the development process is thus considerably sacrificed and is relegated to being an important strategic task for management. At the same time, however, the abandonment of skill maps affects innovative activities positively: Since vacancies in teams are not assigned to concrete skill maps but to persons with specialized, but somewhat broad skills, in many cases these persons possess over-average (and in a strict sense) "unnecessary" competences and/ or too broad, overlapping competences. The competences of developers are thus often "higher" or "broader" than actually needed. This assignment of tasks should support the outcome in that competences and knowledge stocks beyond the standard (compared to projects based strictly on skill maps) are used for game development (compare Storz and Riboldazzi forthcoming):

"We do not have clear descriptions of single jobs, for example for programmers or designers…As a result, we leave many decisions to developers, for example how clouds should be designed, or whether for the background a storm is preferred. This has the advantage that during the development process the fascination of a game can evolve. It facilitates also coordination. Coordination is very intensive, during the whole development process: Something should look more childish, something more Japanese, something more mature…This intensive coordination needs a craftsman's ethos since many parts in a game have to be brought together. …" (firm B)

Besides technical skills, Japanese game software firms especially stress the importance of organizational skills. This finds its expression in the employment policies for administrative and creative staff: In contrast to the regular J-model, contract workers have the option of becoming regular employees. In order to become a regular employee however, technical skills are just a necessary, but not a sufficient condition: Contract employees must have also organizational skills in order to change from the status of a contract employee into the status of a regular employee.

"The normal path is that employees start as part timers, become contract workers, then their contract is, when they perform well, extended. The advantage of regular employees is that they are reliable persons, possess team spirit and solidarity; additionally, they have high-level skills. They differ from contract workers in these norms. Only employees with these norms may become regular employees, after they have been contract workers. Due to our senpai kôhai system [the elder people teach the younger] it is easy to assess who fits and who not. …Regular employees have a high identity with our firm….” (firm T)

The necessity of an “organizational fit” (compare Dokko et al 2008) which is equalized to commitment may be interpreted as identity in the sense of Akerlof and Kranton (2000) who use the term commitment similar to identity, and in this form as a substitute for monetary incentives. The incentive scheme for creators resembles very much the traditional J-model in that firms rely on the so-called grading system (*kyû*). A typical case is firm H where 6 ranks are established, each divided into 10-20 grades so that there are totally about 50 different grades. These grades are related to (slightly) different levels in payment, but not to different jobs, so that two persons may work in the same rank but with different tasks. In the grade system of the dominant model, employees compete for promotion between ranks; some flexibility has meanwhile entered the system due to the option of skipping 1 to 2 grades before achieving the next grade. Hereby, competition is embedded in seniority. The same is true for Japanese game software firms. The slow promotion pattern is embedded in a remuneration system which also resembles the J-model in its structure with basic loan based on performance, but also strongly, at least up to the section level, seniority. Consequently, there are almost no incentives for high potentials, may it be in the form of carreer systems or of compensation. It is also remarkable that in the case of outstanding performance, game software firms rely less on strong pecuniary incentives – the difference in salary between freshmen and the board is tenfold at the most – and more on social recognition:

“The difference in salary is about the tenfold between newly hired regular employees and board members. However, our main incentives are awards which we hand over once a year. The awards are addressed towards single employees as well as towards teams…We hand it over in a ceremony, and in special cases also by the director, and all of our 600 employees attend the ceremony.“ (firm HF)

With low mobility, low diversity and slow promotion pattern, the Japanese case differs considerably from the Silicon Valley model, characterized by efficient competence destruction, high mobility and strong incentives.

5.2.2. The Case of Japan’s Biotech Industry

In the biotech industry, we can also expect a specialization on those subsectors which are in need of good coordination capabilities. In order to analyze the sector’s specialization, I use IPO data and the member classification according to the Japan Bioindustry Association (JBA). For most of the data it was simple to determine whether firms' activities are oriented towards products or towards platforms. In ambiguous cases, experts were consulted.

First, in terms of IPOs, we find a strong specialization, with a majority, 64.9% of listed firms specializing on platform technologies (compare appendix 7). This corroborates membership data of JBA, showing 51.9% of firms having a focus on platform-related activities (JBA 2007a, compare appendix 8). Table 2 summarizes the results.

Table 2: Specialization of Japanese biotech firms

	JBA (business fields)	IPO (Mothers, Hercules)
Product	11.1%	21.6%
Platform	51.9%	64.9%
Unclear	37%	8.1%
Product/Platform	-	5.4%

Source: JBA (2007a), own calculation based on listed firms on Mothers (2008), Hercules (2008) and firms' websites, compare appendices 7 and 8.

The biotechnology sector in Japan can thus be characterized by a specialization on platform technologies. As in the case of customized software, platform technologies need additional coordinative effort since they are produced especifically for customers. This is a quite similar to customized and game software, which also needs close design matching.

It is thus not astonishing that Japanese biotechnology firms resort to those institutions that are supportive to coordination and knowledge integration and are part of the dominant J-model: Long-term employment, seniority, incentives in form of bonuses, grade systems and strong selection processes for regular employees. These institutions are somewhat adapted, for example by the introduction of new career systems, which enlarge the hitherto dual structure (of general and specialized career systems) by expert career systems. These are however minor changes, compared to the lasting principle of long-term employment (compare also Nakatani et al 2006; Wakabayashi et al 2008). If we assume that actors strategically select appropriate institutions, then we may interpret the transfer of the dominant HRM practices to the biotech industry as a strategic answer towards the additional need of coordination.

To summarize, we can observe two characteristics for the Japanese software and biotech sector: First, both sectors emerged within specific institutional constraints. This explains why only certain subsectors emerged, namely those subsectors needing additional coordination efforts and integration of heterogeneous knowledge stocks. Second, to a considerable degree we also observe an adherence to dominant institutions, probably since they facilitate coordination and the integration of different knowledge stocks.

5.3. Path Plasticity in the emergence of new industries in Japan

5.3.1. The Case of Japan’s Game Software Industry

I now turn to the role of path plasticity for the emergence of Japan’s new industries. Starting with the game software industry, I first focus on the most critical institutions, the education system and the industrial organization.

The perhaps most important peripheral institution to the emergence of the Japanese game software industry can be found in the peripheral education system where hundreds of drawing schools and clubs for *manga* (cartoons) are operated by private entrepreneurs, or by volunteers at (public and private) schools and universities. These teaching organizations have forerunners in the woodblock printing schools in the 18^{th}/19^{th} century as well as in the *manga* printing schools of the 1920’s. Since then, differentiated and highly specialised knowledge stocks of *manga* design have been developed. This long tradition led to an accumulation of idiosyncratic knowledge stocks in the design of characters and in story-telling which were meaningless to the industrial core technologies, and were located at the periphery of Japan’s innovation system. Currently, *manga* is quite an important industry with a turnover of about 248 billion Yen (SKKS, 2002), and has attracted numerous sketch artists, painters and authors. Also important is that Japanese media and electronic entertainment sector firms have been successful in the technical convergence of these design competences – from a printed to a digital form. The arrival of television in the ‘60s was grasped as an opportunity for the creation of new markets and famous *manga* stories were now being produced as TV series and animation films. Due to the rich tradition of manga drawing and the large pool of creative artists it is not astonishing that Japanese firms gain the most international awards from the International Game Developers Association (IGDA) in those categories that are related to design and digital representation; for example in the visual arts award category, Japan received five out of seven awards (IGDA 2008).

That these knowledge stocks could be transferred to the game software industry was afforded by the structure of the industrial organization, and took place in two forms, first by start-ups, second by employment: First, the industrial organization in the game software industry with its loose structure facilitated the utilization of these peripheral skills. Contrasting with the J-model, the leading game software developers refrain from strategic investments (except sponsored spin-off), which stands in sharp contrast to the more hierarchical organization in the industrial core industries, where makers such as Toyota and Nissan hold shares in their suppliers in the amount of about 30% and 25% respectively (Shintaku et al 2004: 21). The underlying reason for the abandonment of investments is to retain independence given that exlusive commitment to a single partner would be risky given that turnover in game software is highly volatile. Even if one takes into account the “informal” dominance of hardware producers by defining technical specifications (Yoden 1998), the industrial organization in the game software industry is thus much looser than in the J-model. This had the (unintended) effect that market entries became relatively easy, and led to numerous start-ups activities in the 80's and 90's; totaling about 200-300 firms. Firms could thus draw upon a pool of talent, in the form of alliances with or supply by these start-ups. Thus, in the Japanese game software sector we find a high level of entrepreneurship which indicates that the conventionally held norms of group-orientation, social harmony and collectivity have always co-existed with individualism (compare also Ibata-Arens 2005). It is only a slight exaggeration to take these entrepreneurs as a representative class of the Japanese society who, being skeptical about traditional norms, has always been looking for options outside the conventional working system. Second, the leading game firms could draw upon these knowledge stocks by employment, may it in the form of new appointments, or may it be in the form of mid-career employment (which would then be employed first as contract workers, later as regular employees).

The emergence of the game software industry is thus also coined by path plasticity, adding new institutional elements, which is an additional force to path dependency (compare appendix 9).

5.3.2. The Case of Japan's Biotech Industry

Closer inspection of the biotech industry indicates that the emergence of the Japanese bio industry is also essentially nurtured by peripheral knowledge stocks which have been accumulated in peripheral institutions. I have mentioned above that in the traditional J-model, the science system was only weakly linked to the industry, and played – at least in the form of formal relations – a minor role in Japanese firms' innovation activities. In biotechnology, however, the degree of interaction between industry and academia is high: About of 40% of total R&D in biotechnology takes place in Japanese universities, strongly contrasting to other new industries such as the information and communication technologies with a share of only 10% (Kurata 2008: 34). Cooperation is increasing as a recent survey of Okamuro (2009: 28) documents: Leading national universities have increased their cooperation with Japanese private firms, from 2363 cooperations in 1997 to 13654 cooperations in 2007, indicating a growth rate of 477.8%. Even more astonishing in the Japanese context is the increasing role of cooperations with small firms: While between 1989 and 1992 only 21.4% of all universities-biotech firm cooperations were with small firms, between 2001 and 2004, the share rose to 39.9% (Okamuro 2009: 28). These results are astonishing since they contradict the conventional perception of the Japanese science system being insufficiently linked with industry. Obviously, the science system, which has been at the periphery of the Japanese innovation system, became a core institution for the biotechnology industry.

The most important cooperating partners are, however, new bio ventures located in the U.S. International cooperation takes place more often than national cooperation (Gassel and Pascha 2000: 629; Odagiri 2007; Nakamura and Asakawa 2006). Japanese firms thus resort also upon the "Silicon Valley model". Definitely, due to the large and quickly growing U.S. market, licensing and marketing agreements play a central role but from the 1990s onwards, research contracts have increased significantly. According to Ozaki (2007: 132-133), only 13% of Japanese bio ventures do not cooperate with a non-domestic partner, while 87% report international cooperation (albeit in different intensity); a tendency which is confirmed by Gassel and Pascha (2000: 629). The most important reason for co-operation with U.S. firms is to reduce innovation time (1,5 on the Likert scale) and to gain access to complementary know-how (1,4) and to international technology (1,3) (Gassel and Pascha 2000: 630). The strong role of alliances is also a change towards the traditional institutional setting insofar as they are, in comparison to the J-specific *keiretsu* structure, closer to the market (Odagiri 2007). Thus, there are two peripheral institutions – the Japanese science system, and the U.S. science system - that strongly influenced the emergence of the Japanese biotech industry. Since biotechnology is a new and knowledge-intensive industry, we may assume that these peripheral knowledge sources have been of critical importance for the emergence of the biotechnology industry.

Similar to the game software industry, the development of biotechnology is thus also molded by path plasticity (compare for an overview appendix 10).

6. Discussion

6.1. Theoretical implications

The study has a number of theoretical implications. First, the study addresses the literature on path dependency. As my findings show, there is considerable leeway in action despite path-dependency and for this, my paper suggests that it is important to understand that path dependent systems can have considerable degrees of plasticity. Future research may want to focus on the conditions under which firms can ideally make use of plasticity.

Second, the findings have implications for the literature on innovation and creativity. The study on teams has emphasized the effect of career-related measures of intra-group diversity such as functional background diversity and prior company affiliation diversity on organizational outcomes (Pelled et al 1999; Hambrick et al 1996; Beckman et al 2007). Our findings do not say that diversity is unimportant, but do highlight that greater diversity may not be as essential a component for innovation and creativity.

6.2. Limitations and Further Research

In order to obtain preliminary data on the role of dominant and peripheral institutions for the emergence of industries, this study focused on case studies in the Japanese game software and biotech industry. It should be borne in mind that this is only one case in one country; in our figure in appendix 3, this resembles only two ramifications (reflecting two sectors). Findings may further be sensitive to industries, or the particular firms studied. Future research should explore these questions in other contexts. As is generally known, there is a tradeoff between cross-organization samples that are broadly generalizable and single or few organization samples that can have richer data and provide a high level of detail. Being exploratory in nature, this study chose the second option.

Another potential limitation of this study is that different types of games were not taken into consideration. If our argument applies, firms that produce games that are in need of higher coordination (e.g. simulation games) should resort more than other firms (e.g. role playing games) to institutions facilitating coordination and knowledge integration.

7. Conclusion

In this paper, I analyzed the emergence of two new industries in Japan: the software and the biotechnology sector. The paper does not intend to argue that the Japanese innovation system with its specialization on inter- and intrafirm coordination is more or less competitive than the Silicon Valley model with its strength in competence destruction and rapid adaptation, even if there are indicators that this may be the case as Japan's strength "to work across disciplines" (Porter et al 2008: 188) indicates. The paper also does not deny that there may be some need for reforms in the Japanese innovation system. On the contrary, the paper tries to explain why and how new industries – here the software and biotechnology industry – emerged in the Japanese innovation system despite its often criticized, too rigid and path-dependent structure.

Drawing on software and biotechnology cases, we found evidence why and how new industries in Japan emerged. We saw that the national framework does not determine the precise structure of business strategies, which was expressed in the share of IPOs specialized in packaged software. We also saw, however, that in more general terms (member data of associations and industry survey), firms tend to specialize: in software on customized and game software, and within biotechnology, on platforms. The common denominator in both these subsectors is the need for additional coordination efforts namely, external, inter-firm cooperation with customers in customized software and in bio platform technologies, as well as the internal, intra-firm integration of heterogeneous disciplines in the game software sector. The strong need for coordination also implies that career organization heterogeneity may be less essential for game development. As a result, the structure of these new sectors in Japan is distinctly different from the U.S. Our research is supported by papers on Germany, Sweden and the U.K. (Casper and Kettler 2000; Casper, Lehrer and Soskice 1999) which indicate that Japan's new economy is not an anomaly (Reinvest and Storm 2006). Rather it points to the fact that new enterprises resort to established institutions in the J-model, and especially institutions fostering long time horizons which facilitate horizontal inter- and intrafirm coordination as well as information processing activities across task units, based on inter- and intrafirm knowledge sharing mechanisms. In effect, the new firms in the game software and biotech industries in Japan do not resort to a Silicon Valley like innovation system: They draw upon and utilize different institutions.

Second, a focus on the dominant Japanese innovation system alone would exclude elements that critically supported the emergence of the selected industries. In both industries, peripheral institutions and the hereby accumulated knowledge stocks (*manga* design, advanced knowledge of ventures) played a central role in their emergence. Plasticity which is the consequence of the wide range of institutions and knowledge stocks in systems, including the systems' periphery, thus increased the options for the emergence of an industry and opened up new entrepreneurial opportunities. We agree with the interpretation of Kirzner (1978), who defines entrepreneurial function to be the identification and consequent matching of coordination gaps, in the case of this paper, between sectoral needs, relevant institutions and knowledge stocks in the dominant sphere and at the periphery of an innovation system. The paper shows that firms are indeed able to circumvent institutional constraints at the national level by alertly selecting the appropriate subsectors and by relying on critical peripheral institutions. We believe that firms and the actors within are not passive institution followers. Often, the literature seems to underestimate the creativity with which entrepreneurs search for solutions that better fit their interest, und overlooks the additional resources that the periphery offers such entrepreneurs.

It is due to plasticity that the institutional framework in which new firms are embedded differs from the dominant model, and does not simply resemble a "mini national innovation system". At the same time, however, one must recognize that firms also resort to and draw upon the dominant configurations, thus leveraging a comparative advantage. It is high time to take leave of path dependency as a rigid structure and, acknowledge the advantages that reside within path plasticity.

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Appendix

App1: Method

The analysis of dominant and peripheral institutions is based on case studies (interviews and documentary analysis), in order to get insights into the role of path dependency and path plasticity in the emergence of new industries in Japan. I carried out totally 54 interviews with 58 interviewees mainly in Japan. Most of the interviews are related to game software; 4 the interviews were carried out with actors in biotechnology (firms, business associations, key persons).

Related to the interviewed firms in the game software industry: In 2006, 19 firms, and in 2009, 7 firms have been interviewed. 4 firms are identical, so that totally 22 firms have been interviewed. 8 of these 22 firms belong to the top 50 developers as recorded in the Top 50 Developers of 2008 (Gamedevresearch 2008), 14 are more domestic oriented.

The following table gives an overview over the case studies:

Type of Interview Partner	**Number of interviewees**			**Number of interviews**		
	2006	**2008**	**2009**	**2006**	**2008**	**2009**
Game software firms (developer, including publisher)	19	-	7	16	-	9
Biotech firms	-	1	1	-	4	1
Analysts (game software)	1	-	-	1	-	-
Business associations (game software, bio)	5	-	3	3	-	3
Key persons in ministries, public institutes, research institutes (game software, bio)	16	-	5	7	-	10
Total	**58**			**54**		

Annotation: The interview in 2008 in bio has been carried out in Germany. In 2006, some group interviews with several firm members took place.

Analysis of IPOs was restricted to the two leading stock markets for young firms, Mothers and Hercules. Data on listings at Mothers (at Tokyo Stock Exchange) can be found at http://www.tse.or.jp/english/listing/companies/index_e.html (download 30.11.2008). Data on listings at Hercules (at Osaka Stock Exchange) can be found at http://hercules.ose.or.jp/e/e_index5.html (download 30.11.2008). For the sorting of specialization compare appendices 4 and 7.

Analysis of membership data was restricted to the leading industrial organizations in software and biotechnology, the JISA (Japan Information Service Association; www.jisa.or.jp ; download 25.2.2009), CSAJ (Computer Software Association of Japan; http://www.csaj.jp/nyukai/doc/profile2008.pdf; download 25.02.2009) and JBA (Japan Bioindustry Assocation; www.jba.or.jp; download, 25.2.2009). They are the leading business associations in Japan measured in number of firms, staff employed and market share. For the sorting of specialization compare appendices 5, 6 and 8.

Data on venture capital is supplied by the Japanese Venture Enterprise Center (VEC 2004, 2005, 2006, 2007, 2008).

App 2: Top 50 Developers of 2008

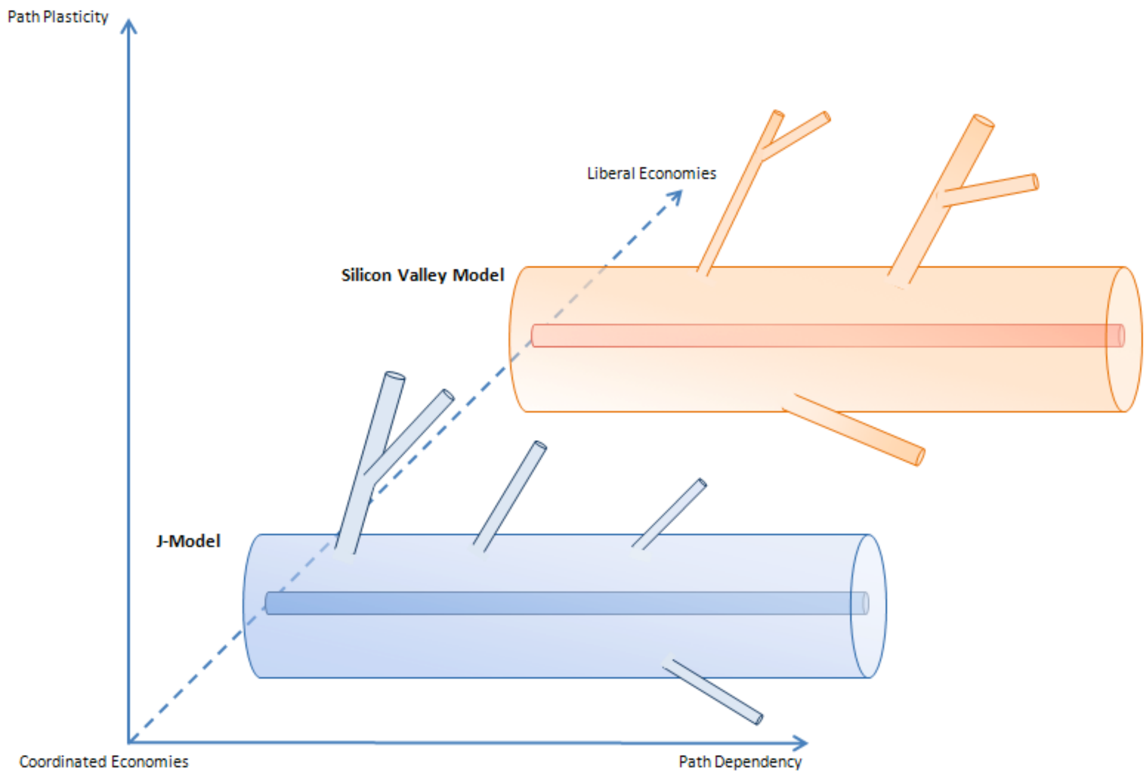
Rank	**Company**	**Country**			
#01	Nintendo Company Ltd.	Japan	#26	Bethesda Softworks	USA
#02	Infinity Ward	USA	#27	Naughty Dog	USA
#03	Blizzard Entertainment	USA	#28	SCE Studios Santa Monica	USA
#04	EA Canada	Canada	#29	EA Black Box	Canada
#05	Valve Corporation	USA	#30	Turn 10 Studios	USA
#06	Konami	Japan	#31	Traveller's Tales	United Kingdom
#07	Insomniac Games, Inc.	USA	#32	Relic Entertainment	Canada
#08	Capcom Co., Ltd.	Japan	#33	Beenox	Canada
#09	EA Tiburon	USA	#34	Level 5	Japan
#10	BioWare	Canada	#35	Tose	Japan
#11	Bungie	USA	#36	Codemasters	United Kingdom
#12	Ubisoft Montreal	Canada	#37	Maxis	USA
#13	2K Boston/2K	USA,	#38	Pawapuro	Japan

	Australia	Australia
#14	Harmonix Music Systems	USA
#15	Namco Bandai Games, Inc.	Japan
#16	Square Enix Holdings Co., Ltd.	Japan
#17	Game Freak, Inc.	Japan
#18	Epic Games	USA
#19	*Hudson Soft Company, Limited*	Japan
#20	Neversoft Entertainment	USA
#21	EA Redwood Shores	USA
#22	Crytek	Germany
#23	Nintendo EAD Tokyo	Japan
#24	EA Los Angeles	USA
#25	Realtime Worlds	United Kingdom

	Production	
#39	EA UK Studio	United Kingdom
#40	Firaxis	USA
#41	Amaze Entertainment	USA
#42	Massive Entertainment	USA
#43	Retro Studios	USA
#44	Sega of Japan	Canada
#45	Sports Interactive	USA
#46	Tecmo	United Kingdom
#47	Sumo Digital Ltd.	Canada
#48	Crystal Dynamics	Canada
#49	Obsidian Entertainment	Japan
#50	Big Huge Games	Japan

Source: Gamedevresearch (2008)

App 3: Path dependency and path plasticity



App 4: Specialization of Japanese software firms: classification of IPOs

Firm	Activity	Classification
AcrodeaInc.	Middleware, Licensing	Packaged software
ADMIRAL SYSTEMS INC.	Game software, Server provider	Packaged software
ADVAX Corporation	System development, Gastronomy	Customized software
Adways Co.Ltd.	Affiliate service software, e.g. JANet, Smart-C	Packaged software
Aeria Inc.	Online games, Mobile content	Packaged software
Alphax Food System Co., Ltd	Software solutions for gastronomy	Customized

		software
Aplix Corporation	Embedded Software, e.g. for mobile phones	Customized software
AZIA CO.LTD.	CRM-Software, Callcenter software	Packaged software
BeMap, Inc.	Mobile phone software (e.g. Navigation)	Packaged software
CAVE CO.,LTD.	Game software (cross platform)	Packaged software
CDS Co.,Ltd.	Consultancy and Support for 3D-CAD-Applications	Customized software
Celartem Tecnology Inc.	Digital data management software	Packaged software
Connect Technologies Corp.	Mobile phone software, e.g. Osaifu-KeitaiTM, MobileTransmotion	Customized software
CSI Co.Ltd.	Software for medical facilities, e.g. MI.RA.Is	Customized software
CyberStepInc.	Game software, Online games	Packaged software
DDSInc.	Karaoke software, Fingerprint verification software	Packaged software
DesignEXchange Co.Ltd.	Packaged software in design field, Mobile content	Packaged software
Digital Arts Inc.	Internet restriction-and access control	Packaged software
DIGITAL DESIGN Co., Ltd.	Communication software, e,g. FastConnector V3	Packaged software
DIVA CORPORATION	Bookkeeping software, e.g. DivaSystem 9.1	Unclear
DoubleClick Japan Inc.	Internet marketing and analysis software, e.g. ClickM@iler	Customized software
Drecom Co.Ltd.	CMS-Software, Blog software	Customized software
Duo Systems Co.LTD.	Software for medical facilities, System	Unclear

	consultancy	
eBASE Co.,Ltd.	Product information software, e.g. eBase	Packaged software
ecash corporation	Design and development of RFID-payment systems	Customized software
EIGHTING Co.Ltd.	Game software (cross platform)	Packaged software
ELMIC WESCOMINC.	Embedded software, e.g. TCP/IP modules and OS	Packaged software
e-Seikatsu Co.Ltd.	Development of database systems, Data exchange with CMS	Customized software
Estore Corporation	Webshop software, e.g.. Store Tool; Shopservice	Unclear
fonfun corporation	Mobile phone software (e.g. games)	Packaged software
FreeBit Co.Ltd.	Network /Internet software, e.g. Emotion Link	Unclear
FueTrek Co.Ltd.	Speech recognition software, Mobile phone speakers	Packaged software
GALA INCORPORATED	Message board software, Online games	Packaged software
GameOn Co.Ltd.	Online games, Mobile content	Packaged software
GDH K.K.	Online games	Packaged software
HUDSON SOFT COMPANY, LIMITED	Game software (cross-platform)	Packaged software
I-FREEK CO.,INC.	Mobile phone software (e,g. games), Mobile content	Packaged software
I'LL INC	System integration, Corporate websites	Customized software
IMJ Corporation	Mobile phone software, Mobile content (websites)	Packaged software
Information Planning	System integration, Individual credit	Customized

CO.LTD.	risk systems	software
Infoteria Corporation	XML- and other software, e.g. ASTERIA	Unclear
Jorudan Co.,Ltd.	Train schedule-software, e.g. Norikae Annai	Packaged software
MebixInc.	Software for medical facilities, e.g. Captool	Unclear
MEDIASEEKinc.	Mobile phone software, e.g. Wand readers; Mobile Content	Unclear
Nextgen,Inc.	IP-Telephony software	Unclear
Nextware Ltd.	Installation and Adjusting of ERP Systems	Customized software
NIHON FALCOM CORPORATION	Game software	Packaged software
NTT DATA INTRAMART CORPORATION	Web design software, e.g. Intra-Mart	Packaged software
PIPED BITS Co.Ltd.	Information management software, e.g. SPIRAL Messaging Place	Unclear
Primeworks Corporation	Software for mobile comic reading, Mobile content	Unclear
Realcom Inc.	System integration, individual ECM-software; Licensing	Customized software
Remixpointinc.	Video software, e.g. CorporateCAST	Packaged software
Sammy NetWorks Co.Ltd.	Game software, Pachinko-software	Packaged software
SIOS TechnologyInc.	System integration for Linux and Java	Customized software
Softcreate Co., Ltd.	System integration, Individual system development	Customized software
Softfront	Communication software, Middleware	Unclear
Software Service, Inc.	Medical information systems	Customized software

System D Inc.	Software for academic-institutions, e.g. Campus Plan	Packaged software
System Integrator Corp.	Software for e-Learning, ERP and shop creation	Packaged software
Systems Engineering Labouratory Co., Ltd.	System integration IBM, Sales of Packaged Software like LANSA	Customized software
Techfirm Inc.	System integration, Client-specific Software development	Customized software
Techno Mathematical Co.Ltd.	Digital Media New Algorithm (DMNA)-Software	Packaged software
Turbolinux, Inc.	Linux-OS, PHP developer tools	Customized software
YUKE'S Co., Ltd.	Game software (cross platform), Pachinko-software	Packaged software

Classification	**Number of Firms**	**Percentage**
Customized Software	20	31.3%
Packaged Software *Thereof game software-related*	33 *14*	51.6% *42.4%*
Unclear	11	17.1%
Total	64	100%

Source: Mothers (2008), Hercules (2008); firms' websites

Annotation: 29.7% of all listed firms specialize in game software: In packaged software, 14 of 33 firms produce (also) game software, and 19 firms do not produce game software. 19 firms out of totally 64 firms thus produce packaged software without additional internal or external coordination effort; this corresponds to 29.7%.

App 5: Specialization of Japanese software firms: Classification of JISA members

Software sector	**Number of firms**	**Percentage**	**Classification**
Information processing	35	9.4%	Unclear
IT outsourcing	25	6.7%	Customized
Network services	3	0.8%	Packaged
Software development	213	57.0%	Customized
Software products (development, sales) *Thereof game software*	8	2.1% *41.9%**	Packaged
System integration	74	19.8%	Customized
Unclear	16	4.3%	Unclear
Total	374	100%	

Customized	312	83.4%
Packaged	11	3.0%
Unclear	51	13.6%
Total	374	100%

Source: JISA (2007: 9)

*Annotation: While JISA (2007) reports on members, JISA (2008) reports on turnover. JISA (2007) does not contain information on game software, thus JISA (2008) had to be used, which reports, however, only on turnover. According to JISA (2008), 41.9% of total turnover in packaged software is realized by game software. No data related to the number of firms are available. The tendency for a specialization on game software in packaged software is also confirmed by METI (2009), according to which 45.7% of the turnover of packaged software is realized by game software products.

App 6: Specialization of Japanese software firms: Classification of CSAJ members

Software sector	Number of firms	Percentage	Classification
Packaged software (development, sales)*	117	17.1%	Packaged
Contract research	109	15.9%	Customized
Support service	86	12.6%	Customized
Web service	67	9.8%	Customized
System integration	44	6.4%	Customized
Consulting	56	8.2%	Unclear
Outsourcing	65	9.5%	Unclear
Dispatch of employees	17	2.5%	Unclear
Content production	17	2.5%	Customized
Data transfer	26	3.8%	Unclear
Else	81	11.8%	Unclear
Total	685	100%	

Customized	323	47.2%
Packaged	117	17.1%
Unclear	245	35.8%
Total	685	100%

Source: CSAJ (2008)

*Annotation: CSAJ does not provide information on game software, neither for number of firms nor for turnover.

App 7: Specialization of Japanese biotech firms: classification of IPOs

Firm	**Activity**	**Classification**
AMITA CORPORATION	Recycling, Biogas power plants	platform
AnGes MGInc.	development of genetic medicines, manufacture, using and sale of reagent kits, as well as the development of genetic inspecting methods	product
CareNet, Inc.	medical sales support, marketing research- and content service	platform
CLUSTER TECHNOLOGY CO., LTD.	inspection of medical containers.	platform
DNA Chip Research Inc.	apping and statistical processing of DNA chips, other services for bio-related companies	platform
Duo Systems Co.LTD.	development and sale of packaged software for the medical, pharmaceutical and welfare sectors	platform
eBASE Co. Ltd.	Databases meeting branch-specific requirements (also chemical industry)	platform
FUJIKOH COMPANY	recycling business (Construction-related, food-related, game machinery-related)	unclear
GNI Ltd.	drug discovery activities that utilize gene network technologies, genome research, clinical trial and bio-verification test business	platform
HONYAKU Center Inc.	Translations of medical/pharmaceutical text	unclear
Immuno-Biological Labouratories Co., Ltd.	sells autoantibody-associated test reagents, cell culture related test reagents and synthetic peptides (50%); disease-model animals (40%); medical drugs (10%)	unclear
Institute of Applied MedicineInc.	Provision of physicochemical and microbiology stability testing for pharmaceutical products, analyzes the gene polymorphism	platform
ITX Corporation	sale of optical medical apparatus and therapeutic devices; provision of medical information solutions and genomic drug discovery support	platform

	services	
JTEC CORPORATION	technical outsourcing	platform
LTT Bio-Pharma Co.Ltd.	medical industry	platform
Mebix, Inc	provision of clinical testing systems, clinical testing support services and medical equipment for the medical industry	platform
MEC COMPANY LTD.	Production and sale of chemicals, machinery and materials for electronic printed circuit boards	product
MediBIC Group	total support solution services, including development strategy planning consulting, data analysis and new-drug application support, to pharmacogenomics	platform
MediBIc Group	total support solution services to pharmacogenomics (PGx) tests, technology analytical services and software, selling research support, invests mainly in life	platform
MEDICAL SYSTEM NETWORK Co., Ltd.	pharmaceutical product Network business, the provision of systems, provision of dispensing pharmacy, medical examination; provision of business	platform
MediciNova, Inc.	acquisition and development of low molecular pharmaceutical products	product
MEDINET Co.Ltd.	Immuno-cell Therapy Total Support Service, operation and maintenance of customized medical management systems, medical engineering research and protein	platform
MEDISCIENCE PLANNING INC.	investigation of clinical trial implementation, as well as the monitoring and confirmation to the implementation; evaluation and discussion of the effectiveness	platform
MOSS Institute Co., Ltd.	collects, manages and analyzes clinical data; Cosmetic Testing and Evaluation; Pharmaceuticals Clinical Trial Consignment	platform
NanoCarrier Co.Ltd.	research, development, manufacture and sale of anticancer drugs	product

OncoTherapy ScienceInc.	development of low molecular drugs, antibody drugs, cancer vaccines, diagnostic agents and research test reagents	product
Pharma Foods International Co.Ltd.	provides egg yolk antibodies(IgY), gamma-aminobutyric acid (GABA), folic acid eggs, Bonepep and others; planning and sale of diet products, supplements and soft drinks, provision of research and development support services for food makers	product
Precision System Science Co., Ltd.	(DNA) extraction devices, physics and chemistry equipment	platform
R-TECH UENO, LTD.	production and sale of Rescula Eye Drops and AMITIZA capsules for chronic idiopathic constipation, research and development of pharmaceutical products;	product
Sogo Clinical Holdings Co.Ltd.	provides clinical research coordinator, clinical trials services for medical institutions, sale and the clinical trial of health food	platform
Soiken Holdings Inc.	evaluation test business and biomarker development business, marketing research and post-marketing research of health supplements, own cosmetic brand	platform
Sosei Group Corporation	research, development and sale of pharmaceutical drugs	product
TAKARA BIO INC.	R&D of biotechnology, the manufacture of research reagents, and the sale, maintenance and repair of physics and chemistry equipment, R&D of new drugs, the provision of gene therapy, development and sale of health food	platform
TAKEEI CORPORATION	provision of environmental solutions to recycle industrial waste	unclear
Techno Alpha Co., Ltd.	Filtertechnology	platform
TRANS GENIC INC.	Licensing of gene knockout mice-related information, as well as experimental animal-related entrusted business; development, production and sale of antibody	platform
Tri Chemical Labouratories Inc.	sells autoantibody-associated test reagents, cell culture related test reagents and synthetic peptides	unclear

	(50%); disease-model animals (40%); medical drugs (10%)	

Source: Mothers (2008), Hercules (2008); firms' websites.

Platform	24	64.9%
Product	8	21.6%
Unclear	5	13.5%
Total	37	100%

App 8: Specialization of Japanese biotech firms: business fields of JBA members

		Business fields; multiple answers	**Percentage**	**Specialization**
Red Biotechnology: Drugs /Therapeutics				
	Drugs	174	12.6%	product
	Medical Devices	19	1.4%	platform
	Tissue engineering	52	3.8%	product
	Functional Food	112	8.1%	product
	Else	52	3.8%	unclear
Green Biotechnology				
	GMO: Genetic Modified Organisms /Cloning	17	1.2%	unclear
	Surveys/Consulting	40	2.9%	unclear
	Else	42	3%	unclear
White Biotechnology /Environment				
	Technologies for saving /producing energy	12	0.9%	platform
	White Biotechnology (e.g. encymes, microorganism)	80	5.8%	platform
	Consulting	31	2.3%	platform
	Else	18	1.3%	unclear
Research Support				
	Customized labouratory devices	78	5.7%	platform
	Labouratory took kits	72	5.2%	platform
	Animal testing	19	1.4%	platform
	Plant testing	5	0.4%	platform
	Chips	46	3.3%	platform
	Bio-informatics	57	4.1%	platform
	Contract research (e.g. screening)	170	12.3%	platform

	Else	37	2.7%	unclear
Production Support				
	Contract research: Proteins	22	1.6%	platform
	Contract research: Peptides	17	1.2%	platform
	Contract research: DNA	21	1.5%	platform
	Else	41	3%	unclear
Service				
	Thinktank	14	1%	unclear
	Consulting	88	6.4%	unclear
	Else	43	3.1%	unclear
Total		1.379	100%	

Source : JBA (2007a)

Platform	14	51.9%
Product	3	11.1%
Unclear	10	37.0%
Total	27	100%

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