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Simone Strambach

Philipps Universität Marburg

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Prof. Dr. Dr. Thomas Brenner
Deutschhausstraße 10
35032 Marburg
E-Mail: thomas.brenner@staff.uni-marburg.de

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Path dependency and path plasticity: the co-evolution of institutions and innovation - the German customized business software industry

Simone Strambach[1]

Section Knowledge Dynamics, Sustainable Innovation, Global Change, Institute of Geography, Philipps-University, Marburg.

Abstract:

Path dependence and the co-evolution of technology and institutions is a key concept to understand the dynamics of structural change at the level of firms, sectors and multi-level spatial scales. The concept of path dependency is often used in economic geography to explain the economic specialisation and long-standing success as well as crises and economically unfavourable development of regions. The understanding of the institutional dynamics within a well-established technological and institutional development path of territorial settings is a central but to a large extent also an open issue.

The paper focuses on the role of institutions and modes of institutional change in path dependent processes of innovation, knowledge accumulation and competence building in innovation systems. Processes of institutional change are mainly seen either as incremental, leading to continuity of the present technological path or as abrupt and disruptive, leading to the breakdown and replacement of institutional settings. By using the notion of 'path plasticity' the paper argues that paths are not coherent in themselves. There is 'path plasticity', which describes a broad range of possibilities for the creation of innovation within a dominant path of innovation systems. Plasticity results among others from the elastic stretch of institutions and institutional arrangements and their interpretative flexibility through actors. Associated with this approach, the paper takes a closer look at path plasticity, its relation to institutional change and the role of geography.

Empirical evidence is provided by exploring the evolution of the German software industry. Although comparative disadvantages are caused by the established institutional setting of the national innovation system, a sub-sector of this industry - *customized business software* - was able to become internationally competitive. The *customized business software* industry can be seen as an example of innovation and successful change in what is described as non-favourable institutional settings.

[1] Corresponding Author: Simone Strambach, Philipps-University Marburg, Deutschhausstraße 10, 35032 Marburg, Germany. E-Mail: simone.strambach@staff.uni-marburg.de.

1. Introduction

Path dependence and the co-evolution of technology and institutions is a key concept to understand the dynamics of structural change at the level of firms, sectors and multi-level spatial scales. On the research agenda of evolutionary economic geography, path dependence appears as one of the core components, although there are unresolved issues by its application in economic geography (Martin/Sunley 2006, Boschma/Martin 2007).

Institutional change and institutional dynamics within path dependent developments is one of the under-explored areas. The paper argues that for an evolutionary approach in economic geography there is a need to recognise and conceptualise institutional arrangements and institutional change in greater depth. Especially for the understanding of long-term dynamics of economies in space and time, it is necessary to make them an integral part of the analysis and to explain how institutions play a role in dynamic developments of evolutionary paths.

The concept of path dependency is used in economic geography to explain the economic specialisation and long-standing success as well as the crises and economically unfavourable development of regions. The contribution of institutions, 'institutional thickness' and the place-specific institutional settings are made responsible for positive lock-in effects and the ability of regions to adapt continually to a changing economic environment. On the other hand, the place-specific institutional endowment and institutional inertia is also utilized to explain why some regions are victims of their past economic success or cannot escape previous lock-ins (Grabher 1993). The understanding of the institutional dynamics within a well-established technological and institutional development path of territorial settings is a central but to a large extent also an open issue (see also Maskell/Malmberg 2007).

In recent years, the concept of 'path creation' assumes that paths can be deliberately created by actors in case they are able to mobilise the necessary resources for the breakthrough (Garud/Karnøe 2001). Taking into account that modes of institutional change underpin path dependency and path creation, both approaches have different perspectives. The concept of path dependency emphasizes the institutional functions supporting continuity by stabilising behaviour and guiding actions of actors, while the concept of path creation focuses on the 'creative destruction' and underlines the breaking of institutional stability and the creation of new institutions for further innovation.

The paper sheds light on a different mode of institutional change using the notion of 'path plasticity'. Path plasticity does not contradict path dependency or the option of deliberate path creation, but argues that paths are not coherent in

themselves. There is 'path plasticity', which describes a broad range of possibilities for the creation of innovation within a dominant path of innovation systems (Strambach/Storz 2008). Plasticity results among others from the elastic stretch of institutions and institutional arrangements and their interpretative flexibility through actors. It is not always necessary to break through path dependency or to 'lock out': Instead the paper argues that even innovation with a minor degree of complementarity within the well-established institutional setting of technological development paths may come into being through the interpretative flexibility and the crawling nature of institutions that results in incremental change. Geography does play an important role in processes of exploring and exploiting plasticity within a well-established institutional setting through place-specific characteristics, processes of localised learning, and through mechanisms of knowledge spillover and proximity economies.

The paper intends to make a contribution to the evolutionary economic geography approach focusing on the role of institutions and modes of institutional change in path dependent processes of innovation, knowledge accumulation and competence building in economic systems. It is organized as follows: Section 2 takes a closer look at the connection of institutions, institutional change and innovation on the basis of evolutionary approaches focussing on novelty and using institutions from a macro level perspective to explain rate and direction of innovation in long term economic change. In section 3 path plasticity and its relation to institutional change and the role of geography is discussed. In section 4 empirical evidence is provided by exploring the evolution of the German software industry. Despite comparative disadvantages caused by the established institutional setting of the national innovation system, a sub-sector of this industry - *customized business software* - was able to become internationally competitive. The *customized business software* industry is an example of innovation and successful change in what is described as non-favourable institutional settings. Section 5 draws conclusions and discusses challenges for further research in evolutionary economic geography.

2. Path dependence and co-evolution of institutions and innovation

Institutional analysis is only loosely related to theories of economic evolution (Essletzbichler/Rigby 2007). Nevertheless, in recent years, the need to bring economic institutions into evolutionary theory, and more generally, the need to connect institutional economics with evolutionary economics for the advancement of the theory is highlighted (Nelson 2002, Pelikan 2003).

Path dependency is a central concept in both evolutionary and institutional economics, although evolutionary and institutional economics differ in their perspectives on the connection between institution and innovation (Boschma/Frenken 2006).[1] The focal orientation of evolutionary economics has been on technological change and the role played by institutional factors in the selection and establishment of technological trajectories and the creation of new technologies (Dosi et al. 1988, Nelson/Winter 1982, Dosi 1982). Evolutionary economists see the primary function of institutions in moulding the technologies used by a society or shaping technological change itself. The orientation of new institutional economics favours the study of the set of factors that mould and define human interactions, both within and between organisations. Explaining the ways in which institutions and institutional change affect the performance of economies over time is the broader and central objective of institutional economics. The concept of path dependence has also been established as a key concept in the discussion about institutional change. Dynamic increasing returns, sunk costs, dynamic learning effects, coordination effects, and self-reinforcing expectations are the main mechanisms that lead to path dependence in both technological and institutional change (Arthur 1989, David 1993, North 1990).

Within economic geography, institutional approaches do not constitute a unified paradigm (Essletzbichler/Rigby 2007).[2] Both institutional and evolutionary approaches have found entrance to explain economic development and the uneven distribution of innovation at multiple territorial levels. In the following, a narrow understanding of institutions is proposed by defining them as formal and informal rules guiding actors' perceptions and activities. Institutions should be differentiated from (non-market) organisations (North 1990). Institutions as the 'rules of the game' are composed of what Scott (2001) named the 'three pillars': the regulative, normative and cultural/cognitive. These depend on different bases of compliance, evoke different logics of actions and offer multi-level bases of legitimacy (Scott 2001).

[1] It is worth to mention that the understanding of institutions is also differentiated in the areas of evolutionary and institutional economics.

[2] For a broader overview in economic geography see Martin (2000)

For long-term dynamics of economic systems, the relationships between institutions, institutional change and innovation play an important role. Evolutionary approaches concerned with long-run economic development place emphasis on institutions or institutional arrangements and their co-evolution with innovation as important social phenomena on the meso or macro level to explain path dependent developments and disparities in the rate and direction of innovation performance. They provide insights on the relationship between institutions and innovation leading to path dependent processes at different spatial levels.

2.1 Institutions and innovation in a multi-level view

Innovation activities are distributed very unevenly in space both within and between national economics. Despite the ongoing globalisation of the economy, it has become increasingly apparent that there are distinct differences between nations in rates and types of industrial innovation and the variation of innovative sectors contributing to economic performance. International empirical comparisons that use indicators like R&D, patents, export specialization or international trade flows, underline the relative stability of specific innovation profiles and the comparative innovation strength of national economies over time. Furthermore, national specificities in production and trade correspond with distinct differences of the national knowledge base (Archibugi/Pianta 1992, Guerrieri 1999, Montobbio 2004). It seems that the institutions which support the innovation systems remain country-specific, even the systems themselves are becoming internationalized and more intertwined (Carlsson 2006).

Approaches dealing with the interrelatedness of institutional settings, innovation and competence building over time, such as the systems of innovation *(national, regional, sectoral)* and concepts in the political economy, like the Varieties of Capitalism (VOC) place emphasis on the stabilising function of institutions in the connection between institutions and innovation. These strands of literature, even though developing relatively independently and focusing on different analysing units, have in common the view of the co-evolutionary nature of innovation sometimes more implicitly than explicitly. It is argued that institutions contribute to path dependence of existing systems by reducing uncertainty in innovation processes. The important role of formal and informal institutions is rooted in their shaping of individual and collective learning processes, seen as the foundation of the innovative outcome on the micro level. They operate as selection mechanisms on different levels by setting incentives and constraints. Doing this, institutions have a substantial impact on both the support and restriction of various types of innovation and future learning, hence contributing to specialised knowledge accumulation and competence building over time (Lundvall 2002 et al.). The strands of work as aforementioned mainly highlight the selective and

retentive impacts of institutional settings in innovation processes contributing to path dependency as discussed in the following.

Responsible for the distinct differences in the institutional structure at the national level is it s co-evolution process with the production structure of innovation systems. The interdependence of economic structure and institutions as well as their mutual reinforcement over time determine the modes and outcomes of production and learning (Lundvall/Maskell 2000, Lundvall et al. 2002, Edquist 2005). The evolution of the economic structure determines the evolution of the institutional set-up and vice versa. As an outcome of the dynamic interplay of these two dimensions over time, the systemic contexts differ. In reverse, this also provides the explanation for country-specific performance and specialization.

The question how these co-evolution processes unfold is hardly worked out in detail and the role of institutional change has not been satisfactorily addressed. The majority of studies analyzing the relationship between innovation and institutions assume that institutions might be slow in adapting to changes of economic structure. Due to the complex co-evolution processes of economic structure and institutions rooted in history, the rather implicit than explicit basic assumption is that the institutional set-up of countries is relatively stable (Nelson 1993, Pavitt 1998). It is assumed that only feedback from radical and basic innovations have the potential to substantially change the institutional setting of national economies (Freeman/Perez 1988). But such radical innovations tend to remain outside of the dominant development path.

Research on sectoral systems of innovation also emanates from the relative stability of national institutional settings which influence innovation processes and trajectories of sectors by providing tangible and intangible resources. Industrial sectors tend to vary systematically with regard to their knowledge bases, knowledge processes and associated sector specific institutions. According to the sector considered, different sets of actors and institutions have an effect on innovation and economic performance (Malerba/Orsenigo 2000, Malerba 2005). In turn, that may explain why diverse institutional settings are co-existing within a national institutional framework. On the other hand, it became obvious that the international performance of countries in a particular sector is mediated by national and regional institutions and non-firm organizations (Montobbio 2004). Even though the dimensions of sectoral systems are not necessarily national, but local, national or global as well, it is assumed that national institutions and organizations may in the long run attract those industries most compatible with them (Malerba 2006).

An explanation for the relative stability of institutional arrangements at the national level compared to the change of sector specific institutions is provided by institutional approaches like the Varieties of Capitalism (VoC) (Hall/Soskice

2001), National Business Systems (Whitley 2000) or Social Systems of Innovation and Production (Amable 2000)[3].

They deliver insights into two mechanisms: institutional coherence and institutional complementarity, both contributing to the slow change and relative *stability of institutional settings at the national level.* Compared with studies of national innovation systems, they are characterized by a more elaborate institutional analysis and differentiation of institutional arrangements. The Varieties of Capitalism approach treats the respective objectives not as a random collection of institutions, but rather as a pattern of interconnected relationships between the different elements of the institutional structures, which as a result define its coherence (Amable 2000). Emphasis is placed on the complementary nature of institutional configurations within the economy, which make some institutions more efficient through their interaction with others. It is assumed that the general logic of coordination is probably similar across different key institutional configurations (Casper et al. 2005). Institutional complementarity, which links together different institutions and modes of organization in a certain architecture, contributes to coherence. While the innovation system approaches place emphasis on the differences in the institutional endowment that explain why it is difficult to change a path, the VoC approach highlights particularly the mechanisms of institutional complementarity and coherence.

The question why in the same national institutional framework several regional innovation systems can emerge and how these are interlinked and intersect with the national one is payed little attention in the literature strand of the VoC approach. Economic geography provides a richness of theoretical and empirical contributions that underline the region as an important organisational level for variety processes and territorial-specific selection processes which close down varieties by contributing to path dependency. Agglomeration and localisation economies and dynamic localised learning processes are assessed as main mechanisms leading to region-specific characteristics and localised capability building. Untraded interdependencies and idiosyncratic context conditions evolve over time, fostered by knowledge spillovers and proximity economies that are especially important for tacit knowledge transfer (Cooke 2005, Gertler 2003, Malmberg/Maskell 2006, Storper 1997). These mechanisms and processes give explanations for institutional variation at the regional level and the distinct regional institutional endowment. The question how institutional variation and institutional change at the national and regional level is interrelated and in turn, how these processes affect innovation at the firm and the sectoral level in a path, is in large parts an open one.

[3] The Varieties of Capitalism (VoC), the National Business Systems (NBS) and the Social Systems of Production and Innovation (SSPI) have strong communalities even though they slightly differ in their institutional analysis. The following analysis concentrates on the VoC approach.

2.2 Interplay between institutions, competencies and demand

The strands of institutional approaches with different analytical levels stress the co-evolution of institutions and innovation over time and provide complementary insights into path dependent processes of economic systems. Especially the interplay between institutional settings, competencies and demand seems to be constitutive for the path-dependent development of innovation systems. The national innovation system concept emphasizes the production structure and user–producer relationship for innovative developments and competence building over time. Research on sectoral systems of innovation shows that innovation processes are determined by sector-specific institutions and in addition it became obvious that national and regional institutional configurations mediate innovation processes of industrial sectors. Studies based on VoC tend to neglect these influences and pay little attention to the influence of home markets and the quality of the demand side for the emergence and diffusion of innovation. Focusing on institutional configurations at the macro level to explain the behaviour of agents in innovation processes on the micro level, this strand of literature goes beyond the national system of innovation approach in two areas: The development of institutional typologies based on a more systematic and comparative institutional analysis and the consideration of the active role of agency.[4] Research based on VoC succeed in specifying institutional configurations in their impacts in terms of the room for strategic choice left to firms. The complex institutional configurations, their complementarity as well as their interconnectivity provide comparative institutional advantages for agents. Comparative studies provide empirical significance that firms are able to use strategically named 'comparative institutional advantages' in developing innovation. These selection processes gradually result in specific knowledge accumulation and competence-building of firms, indicated by different national innovation profiles. However, the approach also has some major limitations because the mainly used institutional typology of coordinated and liberal market economies appears robust for some countries – particularly for the US and Germany – while for other countries this appears weaker. Furthermore the co-existence of region-specific institutional settings within a wider national institutional setting is not taken into account.

In sum, the analysed approaches complement each other in their focus on institutions and the way these reproduce stable patterns of behaviour. The complex interplay of different institutional configurations that has evolved and the pattern of interaction between complementary institutions are resulting in a

[4] An archetype of distinct institutional frameworks is that of the Coordinated Market Economies (CME), which characterize for example Germany, Sweden or Japan, or the Liberal Market Economies (LMC) typical for the US, UK or Canada. These economic systems differ substantially in their organization and the governing of key institutional configurations: the financial system, the industrial relations system, labour markets, the education and training system, and inter-company relations (Hall/Soskice 2001, Soskice 1999, Whitley 2002).

dominant path of national innovation systems in a particular space-time context. Additionally, they share the view of the relative stability of institutional arrangements at the national level compared to the institutional variations and change at the sectoral and regional level. In path dependent developments, primarily the stabilisation and selection function is highlighted by setting incentives for knowledge accumulation and specific competence building - the basis for innovation. There is a lack of discussion in the reviewed strands with regard to institutional change and institutional dynamics within path dependent developments. Additionally, little is said to how institutional dynamics and institutional change are related to positive and negative lock-in effects of path dependent developments. Processes of institutional change are mainly seen as either incremental, leading to continuity of the present technological path or as abrupt and disruptive, leading to the breakdown and replacement of institutional settings. Innovation creates the need to break from the established institutions when new knowledge bases are incompatible with the dominant institutional configurations of a path. This dichotomy underestimates institutional dynamics and institutional change within path dependent developments that can contribute to positive unforeseen feedback or unexpected impacts over time. The plasticity of institutions and institutional arrangements contribute particularly to 'path plasticity' that will be outlined in the following section.

3. Path plasticity and institutional change

Processes and modes of institutional change within a given path are still insufficiently understood. Apparently the institutional dynamics within a well-established technological and institutional development path is an important condition for avoiding undesired effects of stability, or reducing what Martin (2006) describes as 'negative lock-in effects'. Negative lock-in effects emerge when processes, structures and configurations built up as a result of positive 'lock-in' become a source of increasing rigidity and inflexibility (Martin 2006, Martin/Sunley 2006:415). Garud/Karnøe (2001) place emphasis on the strategic, deliberate and mindful *action* of actors that enable the break out of path dependence and institutional stability. They focus on the micro level in which powerful actors can strategically create new institutions, push innovation and create new paths.

The notion of 'path plasticity' does not question path dependency or the option of deliberate path creation. It is introduced here to make the point that there is 'plasticity' within a well-established institutional setting of technological development paths, which enables innovation even with only a minor degree of compatibility come into being without necessarily breaking out of a path. Path plasticity is used here to set the focus on the continuity of dynamic change, while path creation puts emphasis on the 'creative destruction' and the mode of disruptive institutional change.

The term 'plasticity' was first introduced by Alchian/Woodward (1988:69) who used plasticity in the theory of economic organisation to show that resources and

investments are plastic. They indicated that there is a wide range of discretionary, legitimate decisions the user may choose, thus claiming that this is underestimated in transaction cost theory, especially with regard to the moral hazard and principal agent problem. Zysman (1994:261) used the term 'social plasticity' to make the case that technology is a socially created constraint. Thus strategies and tactics for approaching technological problems will vary from place to place. Strambach/Storz (2008) argue there are two sources of plasticity of innovation systems for which they use the notions numerical and functional plasticity. Systems are configurated by a multitude of elements. The notion numerical plasticity is understood as the sum of these elements in relation to the whole system, and is seen as a precondition for functional plasticity. The latter refers to the way configurations can be moulded to produce new uses and can be adapted to new functions or purposes. According to Strambach/Storz (2008) there is numerical and functional plasticity in any given innovation system. They consider the institutional and structural variety proved by the literature on regional and sectoral innovation systems in recent years as evidence for the high degree of numerical plasticity in national innovation systems.

In the following, the paper builds up on this differentiation and develops more specific on the plasticity of institutions and institutional arrangements and their contribution to the plasticity of paths. Geography does play an important role in the exploration and exploitation of institutional plasticity through proximity effects and place-specific characteristics.

3.1 Plasticity of institutions

Besides their action-guiding function highlighted by the work on systems of innovation, institutions simultaneously act as enablers, while actors can use institutions as tool kits in a myriad of ways to solve innovative problems. They are able to recombine and convert or reinterpret institutions for their new objectives or transfer institutions to different contexts. By doing this, actors shape and form institutions and are themselves becoming influenced by the institutions. Giddens (1984) points to this fact with the notion of 'duality of structures'. The plasticity of institutions results from the interpretative flexibility of their meaning. The selection impact of institutions based on the establishment of incentives and constraints is dependent on the assessment of actors. The space for interpretative flexibility of institutions differs with regard to different kinds of institutions and is defined by their sanctions for deviation.

Formal, regulative institutions such as laws or standards provide little room for the flexible interpretation of their meaning compared to informal, normative rules like values or norms. The deviation from the latter is associated with social sanctions whereas the deviation from regulative institutions is mostly legally sanctioned, which reduces the room for interpretative flexibility, yet by no means removes it totally. Sanctions generally enhance the probability that actors commit and follow one dominant interpretation, but others do not cease to exist.

One important feature of place specificities is the intersection of multiple institutional configurations which produces a rich environment for variation. The overlapping of various firm- and industry-specific institutions and their intersection with national institutional settings provides a repertoire of already existing institutional compositions in idiosyncratic context conditions evolved over time. Actors are able to use these pre-existing institutions for the creation of new solutions in ways that may lead to evolutionary change. Geography fosters processes of exploring and exploiting institutional plasticity. Spatial proximity often combined with other types of proximity (Boschma 2005) and localised learning of individual and collective agents (Malmberg/Maskell 2006) facilitate both the exploration of the interpretative scope of institutions as well as the closing down of the varieties of meanings and the coming through of an interpretation as the dominant one. Whereas particularly social and cognitive proximity (Boschma 2005) may facilitate the consolidation of a dominant meaning among actors through shared understanding, unanticipated encounters and neighbourhood effects (Malmberg/Maskell 2006) may lead to opening the space for the interpretative flexibility of an institution by getting to know a variety of different actors' meanings. Institutional forms arising from such processes must not be necessarily completely new, they are rather novel combinations of earlier institutional components. These are paved together by communities of actors reconfigured and combined into various hybrid forms to serve new or modified goals. In localised learning processes aspects of meaning and legitimacy from earlier institutions are transferred to the novel combinations which in turn facilitate their coming through. The exploration and exploitation processes of institutional plasticity to achieve new purposes departure at the micro level, but contribute to institutional change and institutional dynamics within path dependent processes. Plasticity of path does not only exist at the micro level through the interpretative flexibility of institutions, it is also based on the elastic stretch of institutional configurations at the macro level.

3.2 Plasticity of institutional configuration

Institutional complementarities and coherence are obviously important mechanisms for the stability of path dependent developments by generating disincentives to radical change. But it is often neglected that the composition of institutional configurations is not static, but rather simultaneously providing a flexible scope for change. Amable (2000) points to the institutional hierarchy, the relative importance of one or a few institutions for the coherence and dynamic of the institutional architecture as such. Taking into consideration the institutional hierarchy, the transformation of one institution within institutional configurations must not necessarily destabilize the coherence of a whole architecture. That may explain why several regional innovation systems with region-specific institutions may exist and can be absorbed by the key institutional arrangements at the national level. But on the other hand, institutional change in one sphere can increase pressure and have a snowball effect on complementary institutions to change gradually. The accumulation of incremental change over time may lead to

what Streeck/Thelen (2005) describe as 'transformative change'. Institutional complementarity therefore plays an ambiguous role by contributing to the stability of path dependent developments and, at the same time, feeding into the plasticity of paths.

Streeck/Thelen (2005) argue that it is not clear at all whether the two basic models of institutional change – incremental and disruptive change – exhaust the possibilities, or even that they capture the most important ways in which institutions evolve over time. They refer to 'transformative change' of institutions as a type of change contributing to capturing current developments in the economy of modern capitalism. Different modes of gradual transformation of institutions such as displacement, layering, drifting or conversion and exhaustion are explored, resulting in institutional discontinuity.

The perspective of path plasticity lays emphasis on the interpretative flexibility at the micro level, which enables the slow evolution of institutions and the elasticity of institutional arrangements at the macro level, supporting institutional change and institutional dynamics. Plasticity allows institutional variations, the attachment of new elements to existing institutions, the slow rise of peripheral meanings to dominant institutions and their conversion by the redeployment of old institutions to new purposes (Streeck/Thelen 2005). Processes and modes of institutional change within a given institutional setting of a technological development path make possible that initially incompatible innovations may over time evolve in an innovation systems. In the following section empirical evidence is provided by the evolution of the German business software industry which has been developed despite the institutional disadvantages ascribed/caused by the dominant institutional configurations of the national innovation system.

4. The evolution of the software industry in Germany

The evolution of software as an independent industry is a relatively recent phenomenon. As a cross-sector technology, software has become a major integral part in processes, product and services. Software development and software services are provided for the market by firms in the primary software branch, but also by corporations in user branches, the so-called 'secondary industry branches', such as mechanical engineering, vehicle construction or telecommunications (Friedewald et al. 2001). A pronounced secondary software industry is a special characteristic of the German innovation system. Customarily such firms are differentiated with regard to their performance spectrum into providers of standard software, called '*packaged software*' and providers of *'customised software'.*

The software industry belongs to knowledge-intensive business services and as such it has sector-specific institutional characteristics:

- The intensive user-producer interaction and communication linked with the production of software goods. This is particularly necessary during the creation of customised software and IT services. Users are directly involved in the value added activities, because processes of knowledge exchange and knowledge sharing are necessary from both sides which determine the quality of the software good.
- Project organisation is the dominant form of work organisation in general and it is highly significant for the integration of external knowledge for the many small- or medium-sized companies. As in other European countries in quantitative terms the German software industry is dominated by small firms.
- High coordination costs due to the integration of myriad knowledge sources in the product and service development. The key function of formal and informal network relations, the role of references and reputation as coordinating mechanism for transactions and interactions.

The markets for knowledge-intensive business services are characterised by the high volatility, uncertainty and ambiguity of projects, and marked heterogeneity of the competencies involved. The low formal constraints on market access allow for fast market entries, which, however, are accompanied by a high ratio of market exits.

4.2 Path dependency – the software industry in the German national innovation system

In international terms the software market is dominated by US-based firms. The German innovation system did not succeed in establishing itself in the new knowledge intensive service industries, like the software. According to Meyer-Krahmer (2001: 208) the information technology (IT) industry is characterised

by specialisation disadvantages and is lagging far behind the dynamism found in the US. Even though the software production in Germany has increased between 2003 and 2006 with a rate of 13.6%, it did not reach the dynamic level of Europe (16.4%) in these years (EITO 2006: 199/207). The international performance of countries in a particular sector is mediated by national and regional institutional settings. The complementary institutional arrangements of the dominant technology-oriented development path of the German innovation system is assessed as unfavourable for the emergence and success of the software sector (BMBF 1999/2007).

The main feature of the long term development path of the German ys national innovation system is its distinct industry-based innovation profile. In contrast to most other larger economies, the R&D intensive manufacturing industries maintained their macroeconomic weight within the national economy in the last 10 years. These industries aggregate a share of 39% of the added value of the overall economy. Nearly 60% of the country's total amount of export are R&D intensive technology goods (table 1). In 2004 Germany was the largest exporter of technology goods with a share of 14% in world trade, compared to USA with 13.2% and Japan with 10.7% (BMBF 2007).

Table 1: Trade in R&D intensive goods, Germany 2005

	Export	Import	Trade balance	Share in total exports	Share in total imports	Share of trade balance
	in billion €			in %		
R&D intensive goods	428,3	264	164,3	59,9	55,6	68,4
High- Tech	96,7	95,8	0,9	13,5	20,2	0,4
Aircraft and spacecraft	21,4	21,2	0,2	3	4,5	0,1
Telecommunications and sound-apparatus and equipment	20	18,3	1,7	2,8	3,9	0,7
Automatic data-processing machines	19,8	26,9	-7,1	2,8	5,7	-2,9
Electronics	12,6	13,7	-1,1	1,8	2,9	-0,5
Optics, medical technology,	12,3	5,5	6,8	1,7	1,2	2,8
Medicinal and pharmaceutical products	7	7,7	-0,4	1	1,6	-0,3
Radioactive goods, nuclear reactors	2,1	1,6	0,4	0,3	0,3	0,2
Pest control, pest management, crops science	1,5	0,8	0,7	0,2	0,2	0,3
Medium High- Tech	328,6	161,4	161,4	46	35,2	67,1
Motor vehicles, parts and accessories	147,1	85,2	85,2	20,6	13,1	35,4
Machinery	60,6	38,2	38,2	8,5	4,7	15,9
Chemical materials and products	49,1	16,9	16,9	6,9	6,8	7
Office machines and Electrical machinery	24	7,7	7,7	3,4	3,4	3,2
Medicinal	23,6	6,6	6,6	3,3	3,6	2,7
Medical technology, instruments, optical equipment	13,3	6,6	6,6	1,9	1,4	2,8
Rubber manufactures	5,4	0,6	0,6	0,8	1	0,3
Radio-, and telivision technique	2,9	-2,3	-2,3	0,4	1,1	-0,9
Railway vehicles	2,7	1,8	1,8	0,4	0,2	0,8
Non- R&D- intensive- goods	286,6	210,6	76	40,1	44,4	31,6
TOTAL Manufacturing	715	474,6	240,4	100	100	100

Source: BMBF 2007: 34, adapted

In international comparisons there is a common distinction at the level of industrial sectors in a horizontal dimension that classified industries in high-tech,

medium high-tech or advanced and in low tech industries. Of course innovation happens in all kinds of industries, but it is suggested that innovation processes and sector-specific knowledge bases have distinct differences. Radical innovations involving large expenditures on R&D and analytical knowledge base are more common for high-tech industries, while the development of incremental innovations based on cumulative knowledge bases characterises medium high tech industries. In the latter the German system has its strength.

Noticeable comparative advantages exist in medium-high-tech, also named advanced technology fields of the core industries - like vehicle construction, mechanical engineering, electrical engineering and the chemical industry. Patents, especially the RPA (relative patent activities) indicator is used to compare the new knowledge production of different economies. Inter-country comparison shows that Germany not only has the highest specialisation figure in advanced technology fields, but also that this specialisation expanded between 1991-2004.[5] The number of patents, export specialization and an above-average share in world trade of the automobile manufacturing, mechanical engineering, and electrical engineering sectors demonstrate Germany's strength in application-oriented advanced technology innovation.

Table 2: Structure of R&D expenditures by sectors, Germany and OECD 1991, 1997, 2003

	OECD			Germany			Germany's share in OECD		
	1991	1997	2003	1991	1997	2003	1991	1997	2003
	in%			in %			in %		
Services	14,3	14	24,1	2,4	5,4	8,5	1,8	3,3	3,1
High- Tech- Industry	42,3	44,7	39,2	34,9	33,9	30,2	8,8	6,5	6,8
Pharmaceuticals	6,8	8,1	9	5,6	6,5	8	8,8	6,9	7,9
Office, accounting and computing machinery	7,9	8,2	4,8	4,9	2,3	1,4	6,6	2,4	2,5
Radio, television and communication equipment	11,6	14,4	12,8	14,5	11,3	8,7	13,4	6,7	6
Medical, precision and optical instruments	5,6	6,4	7	1,7	5,2	7,1	3,2	6,9	8,9
Aircraft and spacecraft	10,3	7,5	5,7	8,1	8,5	5,1	8,5	9,8	7,9
Medium High- Tech- Industry	30,5	29,1	26,2	53	51,8	53,6	18,6	15,2	18,1
Chemicals excluding pharmaceuticals	8,4	6,5	5,1	14,2	12,2	8,7	18,2	16,2	15,1
Machinery and equipment, n.e.c.	5,5	5,9	5,4	10,5	11	9,9	20,6	16	16,3
Electrical machinery and apparatus, n.e.c.	5,5	4,4	3	10,3	3	2,8	19,9	5,9	8,3
Motor vehicles, trailers and semi-trailers	10,8	11,9	12,2	17,5	24,2	31,8	17,4	17,4	23,2
Railroad equipment and transport equipment n.e.c.	0,3	0,4	0,5	0,4	1,3	0,4	12,4	25,8	6,9
Medium- Tech		6,1	4,6	6,3	5,5	5		7,7	9,5
	11,6						8		
Low Tech Technology		3,8	4	2	2,2	2,2		4,9	4,8
Other Manufacturing	1,9	2,3	1,8	1,6	1,1	0,5	9,1	4,3	2,7
TOTAL	100	100	100	100	100	100	10,7	8,6	8,9

Source: BMBF 2007: 64, adapted

[5] In 2004, the RPA value for Germany (+16) was four times higher than the EU-15 average (+4) (BMBF 2007:45)

Particularly research based on the VoC approach has elaborated the role played by the key institutional configurations in the development of the specific innovation profile. The interdependence and complementary nature of the dominant institutional settings – the coordinated system of industrial relationships, the labour market institutions, the closely knit education and training system and the specific financial institutions - reinforce the international competitiveness of the core industries by contributing to the accumulation of specific competencies (Naschold 1997, Soskice 1999, Streeck 1997). The path dependent specialisation pattern of the national innovation system based on the co-evolution of the technological and institutional development path has not changed much in the last decade.

The downside of this specialisation pattern is the associated structural weakness of the system - namely the comparative disadvantages in top grade technologies characterised by more radical innovation processes and knowledge-intensive service industries. High-technology goods are of only minor importance in exports (table 1) and the patent applications in high-technologies are still under-represented in international comparison. The share of R&D expenditures in services and high-technology sectors is far below the OECD average both in 1991 and in 2003 (table 2). In services the share of R&D expenditures in 2003 was by average three times higher in the OECD as in Germany. Only in one of the high-tech industrial sector – the medical precision and optical instruments - the German R&D expenditures reach the OECD average (table 2). As underlined by empirical indicators, the German innovation system did not succeed in establishing itself in the new science-based industries characterized by radical innovation and knowledge-intensive service industries, like the software industry.

The interplay between institutional settings, competencies and the quality of demand was identified as constitutive for the path dependent development of innovation systems. How this co-evolving interplay affects the development of the German software industry will now be analysed in more detail.

Industrial organisation. The comparatively high degree of vertical integration of business-related service functions in international terms is an essential element of the competitiveness of the core industrial sectors of the national innovation system. This kind of institutional organisation fosters the *competence building* which produces complex, systemic technology- and service-intensive goods. The industrial firms of the key sectors use product attendant services for product differentiation and strengthening their market position. It is shown that the intensification and profiling of product-oriented services are regarded as core competencies for establishing comparative advantages (Stille 2003, Hornschild et al. 2003).

At the same time, the high degree of vertical integration is one factor that has hindered the development of new, more challenging, markets in the knowledge-intensive services sectors (Strambach 1997/2002a, BMBF 2006). The

development of software in Germany mainly takes place in the secondary industry branches, such as mechanical engineering, vehicle construction or telecommunications, and is oriented towards the customers of these industries (Friedewald et al. 2001). It is assumed that 80% of the German software engineers are employed in the secondary software sector (Broy et al. 2006). The long-established, above-average ability of industrial firms in Germany to practise mainly intra-firm software development has delayed the formation of a clearly competitive and specialised software branch like those in other countries (Casper et al. 1999, Lehrer 2000/2006).

Demand. The high demand of the industrial firms of the core industrial sectors and the large SME sector — often called the 'Mittelstand' — for individually adapted software solutions for their production and business processes, has contributed to the dominance of customized business software development. The production of *customised business software* is disadvantageous, because its use is limited to a particular enterprise and the ability to re-use parts of software developed for earlier customers is very small (Holl et al. 2006). The production of software primarily for individual customers and the resulting lack of uniform standards impede the development of economies of scale in the software industry. Further, these factors have helped to orient the business services sector towards the domestic market that increasingly faces pressure from foreign competitors (BITKOM 2007). In addition, the negotiation-oriented organisation of industrial firms does not allow the services firms to position themselves rapidly in the market and to reorganise in a flexible way.

Labour Market. The regulated labour market and the labour market institutions that characterise the German innovation system support knowledge accumulation and the competence building within firms. Similarly, it is evident that the lack of flexible labour market institutions, like those typical of LMEs like the USA and Great Britain, is a major competitive disadvantage for the software industry with its industry-specific institutions. The labour market institutions focusing on long term employment prevent firms from adapting quickly and make the transfer of experience-based and applied knowledge difficult. However, this mainly tacit knowledge bound up in employees and networks is particularly valuable for the project-based software industry and its innovation processes. In international comparisons especially, the rigid regulated working hours and the regulations relating to hiring and firing of employees are considered to be a major factor accounting for the lack of flexibility of the software firms (BITKOM 2007, Djankov et al. 2006).

Additionally, the legal requirement that employees must be represented in the decision- making negotiations, and their co-determination there, make these processes very time consuming. Organisational change and the introduction of organisational innovations, that are decisive for fast adaptation to the dynamic changing markets of the software industry, are hampered (Strambach 2002b). Casper/Vitols (2006) provide empirical evidence that the institutional

arrangements of the German coordinated market economy are inappropriate for supporting the competence building of project-based software firms. The institutional regulations cause disadvantages for German firms in the rapidly changing markets of high-technology and hamper the necessary fast market entry and exit.

Education System. The closely knit connections between industry and the university system and the interconnected further education and occupational training systems are considered to be a major strength of the German innovation system (Naschold et al. 1997, Soskice 1999, Streeck 1997). Overlapping, interrelated qualification structures of skilled workers, technicians and engineers have been built up by the dual training system which ensures the transfer of technology-oriented knowledge and technical capabilities to the production system. For the software industry, such interlocking structures are missing (Broy et al. 2006).

Furthermore, it is emphasised that the failure of the standardised education system to adjust to the dynamic changes and requirements of the software branch was a factor that slowed the growth of this industry. The complex voting processes within the corporate structures meant that it took a long time for changes in qualification requirements to be carried over into new job descriptions by way of new education regulations. The orientation of the education system towards clearly defined areas of activity and job descriptions means that there are no interdisciplinary application-oriented training courses and, subsequently, that there is a shortage of qualified employees (Friedewald et al. 2001, BITKOM 2007, BMBF 2007).

In sum, it can be stated for Germany that the national institutional settings and the co-evolved specific competencies in certain technology fields have resulted in a specialization of the production structure in the core industrial sectors that constitutes disadvantages for the genesis of strong, growing, new high-tech industries like the software industry.

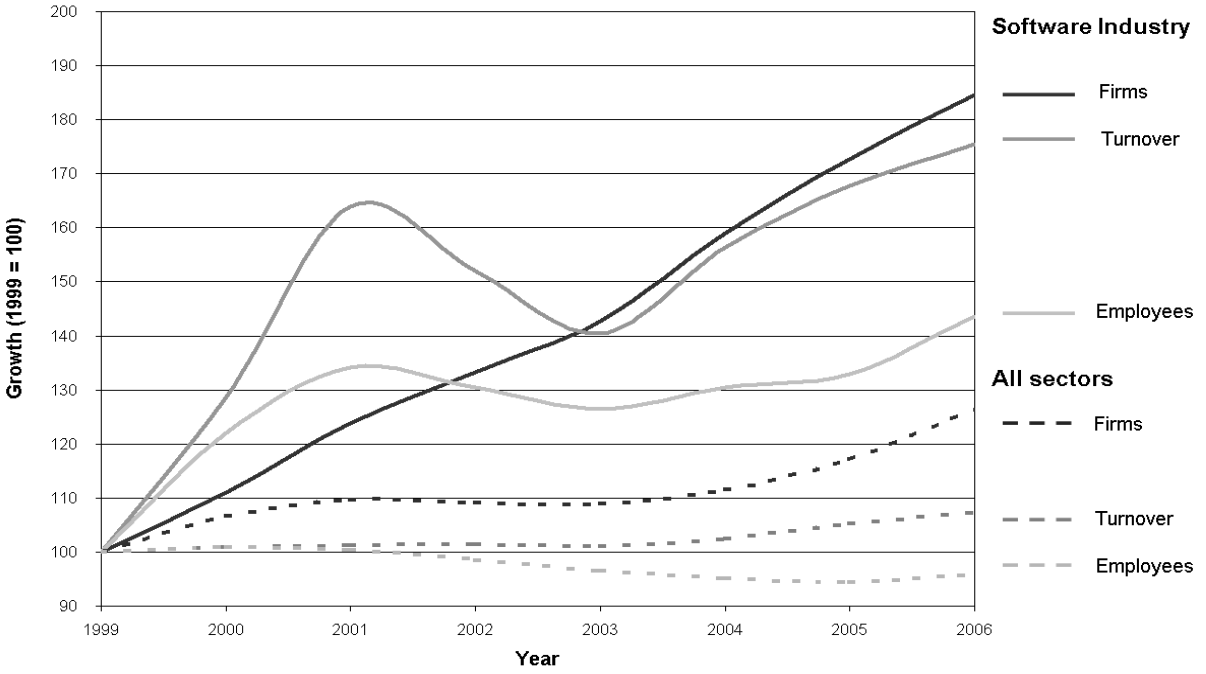
4.3 Path plasticity: the *customized business software* in Germany

Despite the unfavourable institutional environment caused by the institutional arrangements of the dominant path of the German innovation system for the software industry, a sub-sector - *customized business software* — has been able to position itself internationally on the world market[6]. The growth dynamic of the application software in Germany with a rate of 13.6 % outperformed that of the

[6] The paper is based on research supported by the VW-Foundation under the programme: 'innovation processes in economy and society' which is gratefully acknowledged. Background for the qualitative analysis is build on empirical interviews with 21 software firms and firms from user branches and intermediary organisations of the IT industry. I am especially grateful for the assistance in the empirical analysis from Benjamin Klement and Konstantin Schneider.

European Union in the years 2003 to 2006 whereas there is a lack of system software (EITO 2006: 199/207).

Figure 1: Development of the German Software Industry 1999 – 2006



Sources: own calculations based on employment statistic Bundesagentur für Arbeit and turnover tax statistic Statistisches Bundesamt (several volumes)[7]

In 2006 the broader sector computer and related services (Nace 72) consisted of 65,440 firms, over half of the firms focusing on software development. In absolute terms of 402,311 employees the computer and related services industry has got nearly as much employees as the chemical industry - one of Germany's core industrial branches. Around a third is working in the software industry, which is highly concentrated in Germany with only few large international companies and a large number of small and very small, mostly single, firms. The structural survey of the National Statistical Office for 2005 shows that 87% of software companies employ up to 9 employees. Only around 6% of the firms have more than 20 employees, but these are producing 80% of the turnover of the whole branch. Since the mid 90s the software branch has been characterized by a dynamic continuous growth of software companies. The number increased from 5,700 firms in 1994 to 19,000 in 1999 to 35,700 in 2006 (see figure 1 and table 3 annex). These firms generate a turnover of 24.1 billion Euro in 2006. Compared to the overall economy the software industry is proved to be highly dynamic in the years 1999 to 2006 with an impressive increase in firms (+84.5) and turnover (+75.5) (see table 3). Between 1999 and 2007 a number of

[7] Annotations: software industry corresponds to NACE 72.2 (Rev. 1.1), "all Sectors" corresponds to NACE A-O (Rev. 1.1) and the illustrated employees are employees subject to social security contributions.

112,712 (+64.15%) new jobs were generated, whereas a share of 23% of these are situated in Baden-Württemberg, which is the leading location of the German software industry. In this region 16% of the German software firms, 23% of the turnover and 24% of the employees are concentrated. Baden-Württemberg has the highest number of employees and firms in the software industry in absolute terms. Global players as SAP AG (Walldorf), SAS (Heidelberg), IBM Global Services Germany (Stuttgart) or Hewlett-Packard (Böblingen) have their location there. SAP is world market leader of business application software (BITKOM 2007)[8]. In recent years the OECD (2006: 68) stated that Germany is already a 'leading exporter of software goods'. The international significance of the customised business software is surprising, because - in contrast to the USA - there are no large hardware producers in Germany able to function as carriers for the software.

The concept of path plasticity may be able to provide explanations connected with the co-evolution of institutions, competencies and the demand. The paper argues that *plasticity of institutions and institutional configurations* have left actors room for strategic choice and make therefore an important contribution to 'path plasticity'. The institutional plasticity of the dominant development path of the German national innovation system and the ways German software firms have strategically used the room for manoeuvre to achieve their innovative developments, is discussed in the following.

***Institutions**:* In the service industries the labour markets in Germany are more open than those of the key industrial sectors. They have a lower degree of trade union organisation and, up to the foundation of Verdi in 2001, service industries were fragmented with many single trade unions. Flexible working organisations using freelancers, part time workers and personnel leasing are common in service industries. In particular the large manufacturing firms of the key industrial sectors have benefited by spinning off their IT-services, for instance Debis System House (formerly integrated in Daimler) and Siemens Business Systems. By using this strategy the large corporations have enhanced their flexibility and avoided the rigid working hour regulations and the collective negotiations legally required in manufacturing industries. As empirical studies have shown, the mainly small project-based firms of the primary software branch use a large amount of freelancing (Bertschek u.a. 2006). This kind of work organisation allows them to adapt more quickly to the dynamic market changes. At the same time, the flexible personnel management ensures that the firm accumulates internal knowledge through the long term employment of a core workforce.

[8] The terminology is not selective with regard to *customised business software* and the application software. Sometimes they are used synonymously, sometimes customised business software is aggregated under application software. In the following both terms are used synonymously.

Additionally, for small firms up to 5 employees the main regulations do not apply, so that temporary employment contracts, or flexibility options with regard to protection from being fired are legally possible. Such rather peripheral institutions within the dominant labour market arrangements are minor considerations in the discussions of the German national innovation system. But they are very important for the competitiveness of the mainly small software firms. Institutional change is occurring, triggered by the federal association of the ICT industry 'BITKOM' which is currently demanding these flexibility options to be extended to firms of up to 20 employees (BITKOM 2007).

German software providers also fall back on the institutions which are part of the dominant path of the innovation system and are adapting these to the requirements of the new sector. The institutional organisation in associations and the cooperation in networks are the two main instruments that are used by the software industry. The common interests of the associations has led to the integration of the heterogeneous but overlapping sub-sectors of the information industry - the telecommunications and media industries - into one single federal industry association BITKOM. This has allowed the actors to reach the critical size to initiate institutional changes within the key institutional configurations of the education system and the labour market to improve their framework conditions. The fragmented associations of the sub-sectors have not ceased to exist but have been complemented through the establishment of new ones at the regional and local levels. Such variety facilitates the exchange of specialised experience-based knowledge between partners operating in similar knowledge domains and therefore having more cognitive proximity. This in turn makes the absorption of knowledge easier (cf. Boschma 2005, Nooteboom 1999). It is beyond the scope of the paper to analyse this institutional change processes in detail, but it is worth to mention that the initiatives departure regionally from Baden-Württemberg and the chairman of the first regional business network named Baden-Württemberg connected (bwcon) became also later the first chairman of the national association BITKOM.

The furthering of collaboration and the co-operation in networks are regarded as institutional advantages of the dominant path of the German innovation system (Casper/Vitols 2006). Software firms producing customised software are confronted with a double pressure: the need to simultaneously provide highly specialised, knowledge-intensive expertise and comprehensive problem solutions (Strambach/Storz 2008). By collaboration they are able to deal with the problem of gaining access to a number of heterogeneous knowledge bases and to be able to combine and reconfigure these into composite knowledge products adapted to the specific customer context.

Long-term customer and cooperative relationships also support business software firms in creating the network externalities being very important for the success of *business software.* The accumulated experience-based application knowledge of the complex customer contexts generates high transaction costs

that are wasted by changing the provider. The large international industrial companies in the core sectors are an important interface for the penetration of the customised business software. These relatively new, mostly small, software development firms are unable to do this alone. Innovative, individual problem solutions are applied to the integrated firm-internal production systems by way of long term customer- and cooperative relationships with strong industrial export-oriented customer firms located in many parts of the world. In addition, the internationalisation and outsourcing processes of the industrial producers also support the development of innovative software solutions within the context of other firms through their wide networks of suppliers. Although the coupling of software and hardware that plays an important role in the USA is not available to the German software firms, the function of large industrial enterprises as carriers for the product distribution is nevertheless similar. *Business software* firms have been able to use the supposed competitive disadvantages of the institutional arrangements by converting them into advantages for innovative processes and thus to hold their own in international markets.

Demand. The quality of the demand is an important precondition for the development of customized business software in Germany. Second to the US, Germany is the country that spends the most on ICT, ahead of the UK and Japan (OECD 2006). The technically challenging demand for inter-operable software solutions able to communicate with existing systems and applications by both firms of the economically successful manufacturing branches and the large SME sector, foster the competencies for producing complex products across systems (cf. BITKOM 2007). In addition, the accumulated knowledge gained in the course of adapting existing legacy systems of clients contribute to this competence building. Legacy systems are a special characteristic of enterprises in the secondary software industry in Germany (GfK et al. 2000). Such systems contain applied knowledge that has matured and accumulated over many years. They were developed using what are now outdated methods and despite the existence of more efficient systems, they have not been replaced due to high costs of change. The adaptation of such complex systems supports the building up of experience-based knowledge by using multifaceted interfaces and technological platforms of different ages that have to be combined and integrated with new innovative systems and technologies. The mostly international operations of the user firms in the key industrial sectors imply a further challenge for the primary software firms developing high quality innovative and competitive business software .

Competencies. The presumed competitive disadvantages, namely the intensive interaction processes with demanding and quality-critical manufacturing customers and large number of individual software solutions that are being provided play a decisive role for the accumulation of the distinct competencies. The German firms are able to use these competencies favourably in innovation processes. Obviously they are able to find ways of overcoming the two main disadvantages resulting from the production of mainly customized business

software. The limited re-use of parts of the developed business software and the high degree of necessary interaction-intensive service activities used to implement the enterprise solution are a major limitation for tradability and achieving economies of scale.

An enabling factor is the transfer and adaptation of experience-based knowledge of engineering and industrial production and the business processes used in the complex production systems of the core manufacturing industries to both the software development and the service process. Software engineering and the so-called 'service engineering' (Streich/Wahl 2006) are means of enhancing the efficiency of developing customized software products by using modularisation and standardization. In turn, modularity and standardization permit a higher degree of labour division both in the software development and in the service process by creating possibilities for externalising parts to other specialised providers. Particularly in the last years growth has been strong in the IT outsourcing market in Germany and therefore raising questions about its laggard position (Lehrer 2006). The specialisation in software architecture and the design of highly complex and comprehensive solutions allows the German software firms to use their competencies in innovation processes favourably. Heinzl/Oberweis (2007) identify the systemic way of thinking and the engineering and process knowledge that has evolved over decades as a sustainable competitive advantage for the German customized business software.

5. Conclusions and challenges for further research

The paper contributes to the evolutionary economic geography approach by addressing the role of institutions and modes of institutional change in path dependent processes of innovation, knowledge accumulation and competence building in innovation systems. It argues that there is a lack of discussion regarding institutional dynamics within path dependent developments. Processes of institutional change are mainly seen either as incremental, leading to continuity of the present technological path or as abrupt and disruptive, leading to the breakdown and replacement of institutional settings. Especially when new knowledge bases are incompatible with the dominant institutional configurations of a path, it is argued that innovation creates the need to break away from the established institutions.

The evolution of the German *customised business software* points out that radical institutional change is not always necessary for the successful introduction of innovation even in non-favourable institutional settings of the dominant path. The success of this industry is an indication that paths are not coherent in themselves. Actors have harnessed the plasticity of institutional configurations by selecting peripheral and dominant elements to combine and adapt these for their requirements. Plasticity permits institutional variations and the conversion and redeployment of established institutions to new purposes by agents. The *customised business software industry* chooses hybrid solutions for dealing with disadvantages of the institutional setting. The advantages of the existing

institutional arrangements are not replaced totally by the introduction of new ones. By recourse to peripheral elements of the dominant path the firms achieve a higher degree of flexibility and retain established elements of the dominant path to advance knowledge bases. Hence innovation may not be the unavoidable result of 'creative destruction' that underlies the breaking up of institutional stability. Instead it can be the result of 'creative accumulation' (Malerba 2006: 4) and institutional dynamics in path dependent development. In other words, it can be argued that it is precisely the path dependent development of the German innovation system that has contributed to the genesis and the success of the *customised business software sector*.

Evolutionary economic geography could significantly contribute to provide new insights in long-term dynamics of economies in space and time by making institutions an integral part of the analysis. Beyond the use of institutions to explain inertia and stability, there is a need to specify institutions and institutional configurations in a more systematic way and to analyse their impacts on the dynamic interplay between actors and structures of the economic system in time and space. Geography itself does play an important role in the exploration and exploitation of path plasticity through proximity effects on processes of knowledge transfer and creation at the micro level. Additionally, place-specific institutional compositions provide a rich repertoire for variation that can be used by actors to recombine and adapt pre-existing institutional components for new requirements in order to achieve innovative solutions. These change processes may have impacts on macro institutional configurations of a dominant path of innovation systems by enabling the slow evolution of institutions and transformative change. How processes of institutional change and institutional dynamics are interrelated with innovation processes at multi-level spatial scales is an important question with several methodological and conceptual challenges, but also opportunities for the developing evolutionary economic geography.

6. References

Alchain, A. A. & S. Woodward. 1988. *The Firm Is Dead, Long Live The Firm: A Review of Olliver E. Williamson's The Economic Institutions of Capitalism*. In: Journal of Economic Literatur, 26: 65-79.

Amable, B. 2000. *Institutional complementarity and diversity of social systems of innovation and production*. In: Review of international Political Economy, 7 (4): 645-687.

Archibugi, D. & M. Pianta. 1992. *The Technological Specialization of Advanced Countries: a Report to the EEC on International Science and Technology Activities*. Dordrecht. Boston: Kluwer Academic Publishers; Commission of the European Communities.

Arthur, W. B. 1989. *Competing Technologies, Increasing Returns, and Lock-In by Historical Events*. In: The Economic Journal, 99 (394): 116-131.

BITKOM (ed.). 2007. *Zukunft digitale Wirtschaft. Volkswirtschaftliche Bedeutung der ITK-Wirtschaft. Strategische Wachstumsfelder. Empfehlungen an Politik und Unternehmen in Deutschland*. Berlin.

BMBF. 1999. *Bericht zur technologischen Leistungsfähigkeit Deutschlands 1998*. Bonn, Berlin: BMBF, Referat Öffentlichkeitsarbeit.

BMBF. 2006. *Bericht zur technologischen Leistungsfähigkeit Deutschlands 2006*. Bonn, Berlin: BMBF, Referat Öffentlichkeitsarbeit.

BMBF. 2007. *Bericht zur technologischen Leistungsfähigkeit Deutschlands 2007*. Bonn, Berlin: BMBF, Referat Öffentlichkeitsarbeit.

Boschma, R. 2005. *Proximity and Innovation: A critical Assessment*. In: Regional Studies, 39 (1): 61-74.

Boschma, R. A. & K. Fren ken. 2006. *Why is economic geography not an evolutionary science? Towards an evolutionary economic geography*. In: Journal of Economic Geography, 6 (3): 1-30.

Boschma, R. A. & R . L. Marti n. 2007. *Editorial: Constructing an Evolutionary Economic Geography*. In: Journal of Economic Geography, 7 (5): 537-548.

Broy, M.; M. Jar ke; M. Nagl & D. Ro mbach. 2006. *Manifest: Strategische Bedeutung des Software Engineering in Deutschland*. In: Informatik Spektrum, 29 (3): 210-221.

Bundesagentur für Arbeit. 2007. *Sozialversicherungspflichtig Beschäftigte nach Wirtschaftsgruppen – Deutschland*, several volumes. Nürnberg.

Bundesagentur für Arbeit. 2007. *Sozialversicherungspflichtig Beschäftigte nach Wirtschaftsgruppen – Baden-Württemberg*, several volumes. Nürnberg.

Carlsson, B. 2006. *Internationalization of innovation systems: A survey of the literature*. In: Research Policy, 35 (1): 56-67.

Casper, S.; M. Lehrer & D. Soskice. 1999. *Can High-Technology Industries Prosper in Germany? Institutional Frameworks and the Evolution of the German Software and Biotechnology Industries*. In: Industry and Innovation, 6 (1): 5-24.

Casper, S.; J. R. Hollingsworth & R. Whitley. 2005. *Varieties of capitalism: comparative institutional approaches to economic organization and innovation*. In: Casper, S. & F. v. Waarden (eds.). *Innovation and Institutions. A multidisciplinary Review of the Study of Innovation Systems.* Cheltenham. Northampton: Edward Elgar Publishing, 193-228.

Casper, S. & S. Vitols. 2006. *Managing competencies within entrepreneurial technologies: a comparative institutional analysis of software firms in Germany and the UK*. In: Miozzo, M. & D. Grimshaw (eds.). *Knowledge intensive business services: organizational forms and national institutions.* Cheltenham: 205-235.

Cooke, P. 2005. *Regionally asymmetric knowledge capabilities and open innovation Exploring 'Globalisation 2'—A new model of industry organisation*. In: Research Policy, 34: 1128-1148.

David, P. A. 1993. *Path-Dependence and Predictability in Dynamic Systems with Local Network Externalities*: *A Paradigm for Historical Economics*. In: Foray, D. & C. Freeman (eds.). *Technology and the Wealth of Nations: The Dynamics of Constructed Advantage.* London: Pinter Publishers, 208-231.

Djankov, S.; C. McLiesh; M. Klein; World Bank; International Finance Coorperation & International Finance Coorperation (eds.). 2006. *Doing Business 2007. How to reform: Comparing regulation in 175 economies*. Washington: World Bank Publications.

Dosi, G. 1982. *Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change*. In: Research Policy, 11: 147-162.

Dosi, G.; C. Freeman; R. R. Nelson & L. Soete (eds.). 1988. *Technical Change and Economic Theory*. London: Pinter.

Edquist, C. 2005. *Systems of innovation: Perspectives and Challenges*. In: Fagerberg, J.; D. C. Mowery & R. R. Nelson (eds.). *The Oxford Handbook of Innovation.* New York: Oxford University Press, 181-208.

EITO. 2006. *European Information Technology Observatory 2006*. European Information Technology Ob servatory (EITO); European Economic Interest Grouping (EEIG) (eds): European In formation Technology Observatory. Frankfurt.

Essletzbichler, J. & D. L. Rigby. 2007. *Exploring Evolutionary Economic Geographies*. In: Journal of Economic Geography, 7 (5): 549-571.

Freeman, C. & C. Perez. 19 88. *Structural crises of adjustment, business cycles and investment behaviour*. In: Dosi, G. (ed.). *Technical Change and Economic Theory.* London: Pinter Publishers, 38-66.

Friedewald, M.; K. Bl ind & J. E dler. 2001. *Softwareentwicklung in Deutschland. Eine Bestandsaufnahme*. In: Informatik Spektrum: 81-90.

Garud, R. & P. Karnøe. 2001. *Path creation as a process of mindful deviation*. In: Garud, R. & P. Karnøe (ed s.). *Path Dependence and Creation.* Mahwah: Lawrence Erlbaum Associates, 1-38.

Gertler, M. 200 3. *Tacit Knowledge and the Geography of Context, or the undefinable tacitness of being (There)*. In: Journal of Economic Geography, 3: 75-99.

GfK Marktforschung; Fraunhofer-Institut für Experimentelles Softw are Engineering (IESE); Frau nhofer-Institut für Syste mtechnik und Innovationsforschung (ISI). 2000. *Analyse und Evaluation der Softwareentwicklung in Deutschland: Eine Studie für das Bundesministerium für Bildung und Forschung*. Nürnberg: GfK Marktforschung.

Giddens, A. 1984. *The Constitution of Society: Outline of the Theory of Structuration*. Cambridge: Polity Press.

Guerrieri, P. 19 99. *Patterns of national specialisation in the global competitive environment*. In: Archibugi, D., Howells, J., Michie, J. (eds.). *Innovation policy in a global economy*. Cambridge: University Press, 139-159.

Hall, P. A. & D. W. Soskice (eds.). 2001. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford: Oxford University Press.

Heinzl, A. & A. Oberweis. 2007. *Industrialisierung der Softwareentwicklung: Eine Bestandsaufnahme*. In: Wirtschaftsinformatik, 3 (49): 157-158.

Holl, F.; K. Menzel; P. Morcinek; J. T. Mühlberg; I. Schäfer & H. Schüngel. 2006. *Studie zum Innovationsverhalten deutscher Software-Entwicklungsunternehmen* (= Entwicklungen in den In formations- und Kommunikationstechnologien, Vol. 2). Berlin: Eigenverlag.

Hornschild, K.; S. K inkel & G. Lay. 2003. *Höhere Wettbewerbsfähigkeit durch produktbegleitende Dienstleistungen: Betreibermodelle im deutschen*

Maschinenbau. Wochenbericht des DIW Berlin 49/03 (Discussion Paper). DIW Berlin.

Lehrer, M. 2000. *From Factor of Production to Autonomous Industry: The Transformation of Germany's Software Sector*. In: Vierteljahrshefte zur Wirtschaftsforschung, (4): 587-600.

Lehrer, M. 2006. *Two types of organizational modularity: SAP, ERP product architecture and the German tipping point in the make/buy decision for IT services*. In: Miozzo, M. & D. Grimshaw (eds.). *Knowledge intensive business services: organizational forms and national institutions.* Cheltenham. Massachusetts: 187-204.

Lundvall, B. & P. Maskell. 2000. *National states and economic development: from national systems of production and national systems of knowledge creation and learning*. In: Clark, G. L.; M. P. Feldman & M. S. Gertler (eds.). *The Oxford Handbook for Economic Geography.* Oxford: Oxford University Press, 353-372.

Lundvall, B.; B. Johnson; E. S. Andersen & B. Dalum. 2002. *National systems of production, innovation and competence building*. In: Research Policy, 31: 213-231.

Malerba, F. 2006. *Innovation and the evolution of industries*. In: Journal of Evolutionary Economics, 16: 3-23.

Malerba, F. & I. Orsenigo. 2000. *Knowledge, innovation activities and industrial evolution*. In: Industrial Corporate Change, 9 (2): 289-314.

Malmberg, A. & P. Maskell. 2006. *Perspective. Localized Learning Revisited*. In: Growth and Change, 37 (1): 1-18.

Martin, R. L. 2000. *Institutional approaches to economic geography*. In: Sheppard, E. S. & T. J. Barnes (eds.). *A companion to economic geography.* Oxford. Malden, Mass.: Blackwell, 77-94.

Martin, R. L. & P. Sunley. 2006. *Path dependence and regional economic evolution*. In: Journal of Economic Geography, 6: 395-437.

Martin, R. L. 2006. *Pfadabhängigkeit und die ökonomische Landschaft*. In: Berndt, C. & J. Glückler (eds.). *Denkanstöße zu einer anderen Geographie der Ökonomie.* Bielefeld: Bielefeld University Press, 47-76.

Maskell, P. & A. Malmberg. 2007. *Myopia, Knwoledge Development and Cluster Evolution*. In: Journal of Economic Geography, 7 (5): 603-618.

Meyer-Krahmer, F. 2001. *The German Innovation System*. In: Larédo, P. & P. Mustar (eds.). *Research and innovation policies in the new global economy. An*

international comparative analysis. Cheltenham. Northampton: Edward Elgar, 205-252.

Montobbio, F. 2004. *Sectoral dynamics and structural change: stylized facts and systems of innovation approaches*. In: Malerba, F. (ed.). *Sectoral systems of innovation, concepts, issues and analyses of six major sectors in Europe*. Cambridge: Cambridge Universtiy Press, 42-69.

Naschold, F. (ed.). 1997. *Ökonomische Leistungsfähigkeit und institutionelle Innovation: Das deutsche Produktions- und Politikregime im globalen Wettbewerb*. Berlin: Edition Sigma.

Nelson, R. R. & S. Winter. 1982. *An Evolutionary Theory of Economic*. Cambridge, MA and London: Belknap Press.

Nelson, R. R. 1993. *National innovation systems: a comparative analysis*. New York: Oxford University Press.

Nelson, R. R. 1994. *The Co-evolution of Technology, Industrial Structures, and Supporting Institutions*. In: Industrial and Corporate Change 3 (1): 47-63.

Nelson, R. R. 2002. *Bringing institutions into evolutionary growth theory*. In: Journal of Evolutionary Economics, 12: 17-28.

Nooteboom, B. 1999. *Innovation, learning and industrial organisation*. In: Cambridge Journal of Economics, (23): 127-150.

North, D. C. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge UniversityPress.

OECD. 2006. *OECD Information Technology Outlook*. Paris: OECD Publishing.

Pavitt, K. 1998. *The Social Shaping of the National Science Base*. In: Research Policy, 27 (8): 793-805.

Pelikan, P. 2003. *Bringing institutions into evolutionary economics: another view with links to changes in physical and social technologies*. In: Journal of Evolutionary Economics, 13: 237-258.

Scott, W. R. 2001. *Institutions and organizations*. Thousand Oaks: Sage.

Soskice, D. 1999. *Divergent production regimes: coordinated and uncoordinated market economies in the 1980s and 1990s*. In: Kitschelt, H.; P. Lange; G. Marks & J. D. Stephens (eds.). *Continuity and change in contemporary capitalism.* Cambridge: 101-163.

Statistisches Bundesamt. 2008. *Umsatzsteuerstatistik*, several volumes. Wiesbaden.

Statistisches Bundesamt. 2007. *Strukturerhebung im Dienstleistungsbereich: Datenverarbeitung und Datenbanken 2005*. Wiesbaden.

Stille, F. 2003. *Produktbegleitende Dienstleistungen gewinnen weiter an Bedeutung*. Wochenbericht des DIW Berlin 21/03 (Discussion Paper). DIW Berlin.

Storper, M. 1997. *The Regional World: Territorial Development in a Global Economy* . New York: Guilford Press.

Strambach, S. 1997. *Wissensintensive unternehmensorientierte Dienstleistungen - ihre Bedeutung für die Innovations- und Wettbewerbsfähigkeit Deutschlands*. In: Vierteljahreshefte zur Wirtschaftsforschung, 66 (2): 230-242.

Strambach, S. 2002a. *Germany - Knowledge-intensive Services in a Core Industrial Economy*. In: Wood, P. (ed.). *Consultancy and Innovation: The Business Service Revolution in Europe.* London: Routledge, 124-151.

Strambach, S. 2002b. *Organisational Innovations in different Systems of Innovation –the case of Germany and UK.* In: Schätzl, L. und J. Revilla Diez (eds.): *Technological Change and Regional Development in Europe*. Heidelberg: Physica Verlag, 250-272.

Strambach, S. & Storz, C. 2008. *Pfadabhängigkeit und Pfadplastizität von Innovationssystemen - die deutsche und japanische Softwareindustrie*. Vierteljahrshefte zur Wirtschaftsforschung, 77, (2): 1-20.

Streeck, W. 1997. *German capitalism - does it exist? Can it survive?* In: New Political Economy, (2): 237-256.

Streeck, W. & K. A. Thelen (eds.). 2005. *Beyond Continuity: Institutional Change in Advanced Political Economies*. Oxford.: Oxford Univerity Press.

Streich, D. & D. Wahl (eds.). 2006. *Moderne Dienstleistungen: Impulse für Innovation, Wachstum und Beschäftigung*. Frankfurt. New York: Campus Verlag.

Whitley, R. 2000. *The Institutional Structuring of Innovation Strategies: Business Systems, Firm Types and Patterns of Technical Change in Different Market Economics*. In: Organization Studies, 21 (5): 855-886.

Whitley, R. 2002. *Developing Innovative Competences: The Role of Institutional Frameworks*. In: Industrial an Corporate Change, 11 (3): 497-528.

Zysman, J. 1994. *How Institutions create historically rooted trajectories of growth*. In: Industrial and corporate Change, 3 (1): 243-283.