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Convergence of financial systems: towards an evolutionary perspective

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Abstract: This paper provides an evolutionary perspective on financial systems based on complex systems theory. This perspective is used to organize the discussion about the convergence and non-convergence of financial systems. Based on a notion of financial systems as configuration of complementary elements, it is suggested that the convergence of financial systems is best conceptualized as a path-dependent process of institutional change and innovation. The implication of the evolutionary perspective on the dynamics of financial systems is that neither convergence theories using a simple evolutionary argument of survival of the fittest nor divergence theories related to strong complementarities can provide much guidance for analyzing institutional transformations of financial systems.

1. Introduction

Only in the last decade has the notion of the financial system become a central element in the literature on comparative economics. Financial systems have received increased attention in both economic theory and economic policy. Following Gerschenkron's (1962) pioneering study on the differences of the financial systems between Germany and the UK, there is now a large body of literature on comparative financial systems. In this literature the differences between the USA, the UK, Germany, and Japan and the distinction between market- and bank-based systems has received much attention (e.g. Dosi, 1990; Berglöf, 1990; Allen and Gale, 2000; Rajan and Zingales, 2003).

The world of finance has changed over the past decades. The impact of globalization on national economies and technical change has led to the prediction of massive convergence pressures. Tendencies can be identified that seem to indicate that the differences between market- and bank-based systems are dissolving. In the US the Glass–Steagall Act which separated banking and brokerage has been abolished. In Germany the number of hostile takeovers has increased. Hostile takeovers are typical for market-based financial systems. For Japan there are clear

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indications of the demise of cross-shareholdings and the decline of the main bank system. In the US, proponents of a blockholder system seek the deregulation of controls on institutional investors, looking to encourage large shareholdings and more effective monitoring. In Europe stronger security regulations looking to encourage deeper trading markets are being implemented. Financial liberalization and deregulation has taken place in many countries over the past two decades. However, full convergence has not yet materialized, even if many countries have enacted reforms to push their financial systems into a more market-oriented direction. Each national financial system seems to be characterized by its own rules and conflicts. This suggests underlying systemic relationships between and within financial systems. The striking differences across countries raise the question: *why and how do these differences persist over time?*

The paper is organized as follows. Section 2 presents an evolutionary perspective on financial systems based on complex systems theory. We argue that the *NK* Model provides a useful conceptual framework for the dynamic analysis of financial systems. In Section 3 this framework is used to discuss the issue of convergence of financial systems. Section 4 concludes the paper.

2. An evolutionary perspective on financial systems

2.1. The evolutionary perspective: institutional complementarity and fit of systems

Financial systems are functioning when they contribute to the economic well-being of the countries. This points towards a systemic view on financial systems, as each of those national systems has its own checks and balances, conflicts, strengths, and weaknesses. In the following we present an evolutionary view on financial systems which uses the notion of complementarity (e.g. Aoki, 2001, Hackethal and Schmidt, 2000; Amable, 2003) and conceptualizes the financial system as a set of elements and connections that give rise to complexity (e.g. Potts, 2000).

The notion of complementarity figures prominently in modern comparative institutional analysis. The varieties of capitalism literature are largely based on the concept of institutional complementarities (Hall and Soskice, 2001; Crouch and Farrell, 2004). Institutional complementarity is usually explained in reference to game-theoretic models (Aoki, 2001; Schmidt *et al.*, 2002; Amable, 2003). While such models are appropriate for the analysis of institutional complementarity at the micro level, we think that the implications of institutional complementarity at the macro level are better illustrated with complex systems models, as such models capture the important facet of uncertainty about the precise functional relationships between elements.[1]

1 We do not think that the NK framework is a substitute for game theoretical analyses, we consider it a complement.

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Complementarity is an attribute of elements of a system (network, production process, or financial system) and arises if single elements of the systems interact in such a way to influence the overall performance of the system. An example of a system exhibiting complementarity is the personal computer (PC): the choice of 'best' components (CPU, motherboard, graphic card, software) does not necessarily imply that this PC works better than another with aligned but 'inferior' components. The PC with the 'best components' may even not work, for example, if the 'best' CPU cannot be put on the 'best' motherboard. Complementarity relationships within a system imply that the system is not completely decomposable. Taking the personal computer metaphor as example, the PC might work less well or better with another source of power, but it will not work without one.

2.2. *The NK and the generalized NK model*

Simon (1996) defines a complex system as one that consists of many elements that interact in a non-trivial way. Many recent discussions of adaptive complex systems in diverse fields of application have adopted the methodology developed by Kauffman (1993) for the study of biological evolution of complex organisms, which uses computer simulations to model problems of evolutionary adaptation in fitness landscapes. Kauffman's *NK* model provides an abstract formalization of the structure of interdependence between elements of a complex system. It is a particularly rich model for representing complex systems and provides a straightforward way of thinking about complementarity in systems.

A complex system is represented as a string of N elements, each of which can take on A_i possible values. Each element in the string is assigned a fitness value measuring the contribution of the element to the organism's overall fitness. The number of all possible strings among system elements is called the possibility space of a system. For a binary system consisting of four elements ($N=4$; $A_i=2$) the possibility space is equal to $S=2^4=16$. There are 16 possible constellations or types. Each element makes a contribution to the overall fitness. If the system exhibits complementarity, the fitness value of an element depends on the contribution of the other elements it is connected to. Kauffman analyzes how the interdependence between the N elements affects the search for maxima in the fitness landscape. The degree of interdependence is given by the parameter K, which is equal to the number of other elements with which each element is interdependent. Two extreme cases can be contrasted: on the one extreme we have $K=0$, we have minimum complexity since each element's fitness contribution is independent of all other and at the other extreme if $K=N-1$ we have maximum complexity as each element's fitness contribution depends on the values of all other elements. Kauffman's model assigns each combination a randomly drawn fitness contribution from the uniform distribution over the unit interval. When $K=0$, there is one draw for each element; if $K=N-1$, there is a draw for each element in each possible constellation of elements. The number of local optima increases rapidly when the interdependence parameter is tuned from $K = 0$ to $K = N - 1$ (Kaufman, 1993: chapter 2). Complex systems with high interdependence parameters are characterized by a rugged fitness landscape.

The workability of a system is dependent on the fact that the different elements fit together: a system can be considered consistent if its complementary elements take on values which make the system attain an optimum. This needs not to be a global optimum. Systems with complementary elements usually have more than one optimum. Following the metaphor of the fitness landscape, trial-and-error search on the landscape to reach an optimum can be considered 'hill-climbing'. When interdependencies grow, evolutionary dynamics based on local search and selection will allow climbing up to a local optimum near their initial position. The global optimum will be attained only when the initial conditions are within its basin of attraction, which becomes smaller as interdependencies increase. Note that the basin of attraction of local equilibria is positively correlated with their fitness. *NK* systems with complementarity display path dependence, as the local optimum that is reached depends on the initial position, and lock-in, as the attainment of a local optimum prevents agents from exploring other points. For weakly interdependent systems ($0 < K < N - 1$) the global maximum is (on average) higher than in systems where $K = 0$ or $K = N - 1$ (Kauffman, 1993: chapter 2). In systems with maximum complexity ($K = N - 1$) the average fitness value of local optima tends towards the average fitness value when the number of elements increases. Kauffman (1993) calls this the complexity catastrophe.

The *NK* model provides a framework to represent hard combinatorial problems and complex decision spaces, whose management and optimization require the co-ordination of interdependent elements. The search on a rugged landscape can be thought of as a formalization of Simon's concept of bounded rationality, which is related to costly decision making and bounded cognitive capabilities. Therefore, the *NK* model has already been used quite extensively in the literature on technical innovation and economic organization (e.g. Westhoff *et al*., 1996; Levinthal, 1997; Fleming and Sorenson, 2001; Frenken, 2001a).

A major limitation of the basic *NK* model is that one element is identified with one fitness component and that the interrelations need to be symmetric. The *generalized NK* model (1997) relaxes these assumptions. It describes a model of complex systems that contain *N* elements and *F* fitness components, where *N* need not be equal to *F*. In biological systems, for which both the *NK* model and its generalization were initially conceived, the *N* elements are an organism's genes and the *F* fitness components describe the organism's traits on which selection operates. The genes constitute the genotype of the system; the traits constitute the phenotype of the system. Change occurs at the level of the genotype, while selection operates at the phenotype level.

The way in which fitness landscapes are constructed for the generalized *NK* model follows the same logic as in the original *NK* model. The basic properties of the *NK* model, which relate the number and the fitness of local optima to

Figure 1. (a) A *NK* model ($N = 4$, $K = 1$) in a generalized representation. (b) A generalized, non-modular *NK* model with four elements, E_1, influences all fitness components. (c) A generalized *N–K* model with five modular elements (E_1–E_5) and two interdependent elements E_6 and E_7.

	E_1	E_2	E_3	E_4
C_1	X			X
C_2	X	X		
C_3		X	X	
C_4			X	X

(a)

	E_1	E_2	E_3	E_4
C_1	X			X
C_2	X	X	X	
C_3	X	X	X	
C_4	X			X

(b)

	E_1	E_2	E_3	E_4	E_5	E_6	E_7
C_1	X					X	
C_2		X				X	X
C_3			X				X
C_4				X	X	X	X

(c)

the interdependency parameter, *K*, remain intact. The main difference is that the number of elements (*N*) is not necessarily equal to the number of fitness components (*F*) and that the interdependence parameter (*K*) is not uniform across the elements.

The *generalized NK* model can be visualized by means of a matrix representation (Altenberg, 1997). Figure 1 presents three examples. In the matrices an *X* indicates that the element in the column influences the fitness component in the row. An empty cell indicates that there is no relationship. Panel (a) presents a basic *NK* model with four elements and four fitness components and $K = 1$, that is each element is connected to one other element. It is depicted as a matrix where each column represents an element (E_1–E_4) and each row represents the fitness components C_1–C_4 of the system. The matrices map elements into fitness components and capture the internal structure of the system. A matrix representation of an *NK* model with minimum complexity ($K = 0$) would be a matrix with only diagonal elements, and an *NK* model with maximum complexity ($K = N - 1$) would be a matrix where each cell is filled with an *X*.

One fitness component may be influenced by several elements, while one element may influence several fitness components. The elements influencing and mediating the interactions of many others can be considered to represent the '*core*' of a complex system (Frenken, 2001b; Reinstaller and Hölzl, 2004). The higher the interaction between elements, the higher is the likelihood that a change in one element conflicts with the overall performance of the system. Panels (b) and (c) of Figure 1 illustrate the concept of the core. In panel (b) element E_1 forms the core of the system; in panel (c) the core consists of elements E_6 and E_7. In panel (c), if no core existed, then the system would just be a collection of very loosely linked elements. Elements affecting many fitness components simultaneously are critical, as a change may affect the performance of the system to a larger extent than elements influencing only one fitness component. An implication is that elements in the core are less likely to be changed than elements which are peripheral. In terms of the matrix in panel (c) of Figure 1, the peripheral elements are E_1–E_5.

2.3. The financial system in an evolutionary perspective

The financial system is one of the primary and outstanding examples for a complex institution governing the transfer of information, the set up of incentives, resource allocation mechanisms, and the supply of and demand for financial services. The environment of the financial system is formed by the system of law and product and labor markets, as well as by the relevant political and other economic institutions. As the knowledge of interactions and causation of single components has not developed enough to specify the elements of the financial system in a rigorous way, we use a preliminary and *ad hoc* definition to describe financial systems, which closely follows the seminal one put forward by Hackethal and Schmidt (2000). The financial system is defined as an ordered set of four components which provide specific functions and which are themselves complex systems consisting of a number of elements performing a number of functions:

1. *The patterns of industrial finance* represent the ways non-financial firms finance their investments.[2] Financing patterns are influenced by the saving decisions within an economy, and primarily defined by the relative importance of banks, markets, and other financial institutions for the finance of firms. Another important factor is the time horizon of finance: whether bank finance is primarily long term and control oriented or largely short term and 'at arms length'. The performance of this subsystem is measured by the ease and cost with which domestic entrepreneurs and companies with sound investment projects can obtain liquidity.
2. *The corporate governance system* is defined as the totality of the institutional and organizational mechanisms and corresponding decision making to resolve conflicts of interest between the different groups which have a stake in a firm. Corporate control refers to the ability of groups to determine broad corporate objectives; that is, to make decisions over strategic issues regarding the long-run success or failure of the firm and the distribution of the surplus. The distinction between insider systems of corporate governance and outsider systems of corporate governance is useful (Franks and Mayer, 1995). Outsider systems are the market-based systems characterized by a large number of listed companies, low levels of ownership concentration, and a few interlocking shareholdings. Insider systems have few listed companies, high levels of concentration of ownership, and a high proportion of cross-shareholding between firms. Elements making up the corporate governance system are the board system, ownership structures, the degree of ownership

2 The importance of financing patterns was first questioned in an influential study by Mayer (1988). Hackethal and Schmidt (1999) were able to show that these findings are due to the fact that internal funds are conceptually different from other financing sources. They devised a methodology based on gross flows and were able to show that financing patterns are different in bank- and market-oriented financial systems.

concentration, the existence of cross-shareholdings among companies, the degree of involvement of other stakeholders aside from shareholders (e.g. labor) in corporate control, the extent to which executive compensation is dependent on corporate performance, and the presence or absence of an external market for corporate control. The performance of the corporate governance subsystem is measured by the degree to which managers are disciplined to allocate funds efficiently.

3. *The financial sector* consists of financial markets and organizations (banks, insurance companies), exhibits certain structural features, and is shaped by regulatory practices and legal rules. The structure of the financial sector is largely determined by the selection of saving instruments used by households and the strategies of other economic actors; It is defined by the importance of capital markets, the degree of competition in the banking sector, the prevalence of universal or specialized banks, the degree of securitization, the organization of the pension system, and the relative importance of non-bank financial institutions. The performance of this subsystem is measured by the ability to manage both cross-sectional and intertemporal risks, which relate to the stability of the financial sector.
4. *The predominant system of business co-ordination and organization* captures the prevailing relationships between firms, employers, and employees and the government. It is often argued that the business co-ordination in bank-based systems is much more organizational and consensual than in market-based systems, where the market provides the dominant form of co-ordination. The characteristics are the prevalent concept of the firm, the degree of enforcement of property rights, the nature of inter-firm relations, the presence or absence of long-term implicit contracts between stakeholders, the time horizon of economic relationships, and management–labor relations. The performance of this subsystem can be measured by the speed with which conflicts and changes affecting the financial system are resolved, and by the degree to which the resolution of conflicts leads to efficient (and fair) outcomes.

These elements are closely connected, and more importantly there are conflicts between the elements. For example, there is a tension between the stability and efficiency of financial systems: competitive financial systems are characterized by arm's length finance, while stable financial systems are characterized by a few dominant institutions (e.g. Allen and Gale, 2000). Some elements in the subsystems also affect other subsystems serving many purposes, which may well stand in conflict with each other.

The most appropriate framework to represent the financial system would be a generalized *NK* model at the level of single elements and functions. Figure 2 shows the financial system in three equivalent representations at different levels of aggregation. Panel (a) displays the financial system as *NK* model in terms of the subsystems described above. According to our definition, at the subsystem level each fitness component is identified with one element. Upper-case and lower-case X indicate that there is higher interdependency within the subsystems

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Figure 2. (a) The financial system as NK model on the level of subsystems with (N = 4 K = 3); the upper case letter indicate strong complementarity, the lower case letter indicate lower interaction. Grey boxes indicate subsystems. (b) The financial system as generalized NK model with $N = \Sigma n$ elements of all subsystems as elements and F = 4 components at the subsystem level and intermediate complexity ($0 < K < N - 1$). (c) The financial system in an generalized NK representation at the level of elements, with $N = \Sigma_i\, n(s_i)$ elements and $F = \Sigma_i\, m(s_i)$ functions.

	S_1	S_2	S_3	S_4
C_1	X	x	x	x
C_2	x	X	x	x
C_3	x	x	X	x
C_4	x	x	x	X

(a) NK at subsystem level

	S_1						S_2				S_3			S_4	
	E_1 s_1	E_2 s_1	E_3 s_1	E_4 s_1	…	$E_{n(s_1)}$ s_1	E_1 s_2	E_2 s_2	…	$E_{n(s_2)}$ s_2	E_1 s_3	…	$E_{n(s_3)}$ s_3	…	$E_{n(s_4)}$ s_4
C_1	X	X	X	X	…	X		X	…			…		…	X
C_2				X	…		X	X	…	X		…		…	
C_3					…				…	X	X	…	X	…	
C_4			X		…	X		X	…			…		…	X

(b) generalized NK with F components

		S_1						…	S_4
		E_1 s_1	E_2 s_1	E_3 s_1	E_4 s_1	…	$E_{n(s_1)}$ s_1	…	$E_{n(s_4)}$ s_4
C_1	c_1,s_1	X	X	X		…	X	…	
	c_2,s_1		X		X	…	X	…	
	c_3,s_1	X		X		…	X	…	X
	c_4,s_1				X	…		…	
	…	…	…	…	…	…	…	…	…
	$c_{m(S_1)},s_1$	X			X	…	X	…	
…	…	…	…	…	…	…	…	…	…
C_4	$c_{m(S_4)}s_4$			X		…		…	X

(c) generalized NK representation

than across subsystems. There is maximum complexity ($K = N - 1$) as each of the subsystems to some degree influences all performance components. The grey cells display the subsystems. Panel (b) presents a generalized *NK* representation of the financial system, where the elements making up the subsystems are disaggregated, while the performance of the financial system is still measured at the subsystem level (C_1–C_4). The identification of each fitness component with exactly one element is removed. We have four fitness components, and $N = \Sigma_i\, n(s_i)$ elements. Again the subsystems are displayed as grey cells. Each element of a subsystem influences the performance of the subsystem to which it belongs, but there are also interdependencies across subsystems. Finally, panel (c) of Figure 2 displays the same system at the maximum level of disaggregation. Here, both the single

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elements and functions of the subsystems are considered. More precisely, we consider now a generalized *NK* model with $N = \Sigma_i\ n(s_i)$ elements influencing the performance of $F = \Sigma_i\ m(s_i)$ functions. Due to space limitations, panel (c) displays only a small part of the system. As is easily seen, the generalized *NK* has intermediate complexity, as not each of the elements influences all components. The interaction is higher within subsystems than between subsystems. This representation captures the idea that there is high interdependency, but not each element influences all functions the financial system provides.

2.4. Implications

Models like Kauffman's *NK* model or Altenberg's generalized *NK* model focus on systems' statistical properties to achieve tractability for analyzing complex systems. They cannot provide definitive answers, but they can provide guidance for questions on why only particular financial systems are observed, and how and why financial systems change over time. At the present stage of research the most important contribution is the answer to the question, *what are the implications of complementarity for financial systems?*

We can start our answer with the help of the representation of the financial system as an *NK* system at the subsystem's level. Let us consider two instances of a financial system consisting of the four subsystems outlined (a, b, c, d). Let each of the four different elements take two values B and M for the bank-based system and the market-based system and define the two systems $FS_M = (a_M, b_M, c_M, d_M)$ and $FS_B = (a_B, b_B, c_B, d_B)$, which consist only of elements with values M and B respectively. We further assume that the system has maximum complexity, and that only one-characteristic changes are possible,[3] then there are on average $2^N/(N+1)$ local equilibria (Kauffman, 1993: 47). In the case of the $N = 4$, $K = 3$ model, there are usually three equilibria. We call the local optima the bank-based system, market-based system, and network-based system, $FS_N = (a_B, b_M, c_B, d_M)$. These three types are consistent configurations. The other 13 intermediate financial systems are not local optima. Their performance can be improved by changing one of the four elements.

The property of the *NK* model, that the number of local equilibria increases with the number of elements N and the interdependence parameter K, suggests that, if financial systems are complex systems with a number of institutions that exhibit institutional complementarity, we should be able to observe more than one stable constellation.[4] The finding that there are three local equilibria is an

3 While the one-bit mutation is a plausible assumption for biological systems, in social systems the depth of search may be higher. Note that allowing for several changes at the same time would permit an escape from inefficient local equilibria. However, the more elements are allowed to change, the more costs are incurred, as the number of possible moves increases exponentially with the number of elements that are allowed to change (Frenken *et al.*, 1999; Kauffman *et al.*, 2000).

4 The fact that there are three equilibria follows from the assumption of an ($N = 4$, $K = N - 1 = 3$) model. Systems with size $N = 3$ and maximum complexity, or systems with $N = 4$ and $K = 2$ would

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interesting result in its own right, as it points out that one need not go beyond the dichotomy at the level of elements to obtain at the system level the result that there are more than two equilibria. It mirrors the claims of some observers that the dichotomy of bank- and market-based systems has important limitations for the comparison of financial systems. A number of financial systems neither fit the bank-based nor the market-based ideal type. In their study of the French financial system, Cobham and Serres (2000) find that the differences between the French financial system and the market-oriented or bank-oriented ideal types are significant and relatively stable over time. They argue that France was never a truly bank-based system, and that the French financial system did not converge towards the market-based system. Cobham *et al.* (1999) and Barca and Trento (1997) reach similar conclusions for Italy. Cobham and Serres (2000) argue that the financial systems of most developed and developing countries may be closer to the French and Italian examples than to the German or the US financial system.[5] The advantage of going beyond the dichotomy of market-based and bank-based systems is that countries which were classified as disequilibrium phenomena can be classified as specific types.

Let us now consider some simple adaptive dynamics of the model. We define two other systems $FS_{M'} = (a_M, b_M, c_M, d_B)$ and $FS_{B'} = (a_B, b_B, c_B, d_M)$, which differ from FS_M and FS_B insofar that one element has been changed. Then, if the system is one of full complementarity, it must hold that

$$FS_M \text{ is better than } FS_{M'}$$

$$FS_B \text{ is better than } FS_{B'},$$

even if it is common knowledge that c_M is better than c_B, and irrespective of whether FS_M is better or worse than FS_B or FS_N. In terms of convergence, note that $FS_{B'}$ is between the bank-based system and the network-based system and it is therefore equally likely to turn into one of these two systems. If d_M is changed into d_B, $FS_{B'}$ will turn into FS_B; if c_B is changed into c_M, it turns into FS_N. $FS_{M'}$ will turn into FS_M, if d_B is changed into d_M. This is the predicted outcome with one bit-search. However, if by some chance event another element of $FS_{M'}$ is changed into a 'bank-based' element, we would need to know the form of the basins of attraction of the three equilibria in order to be able to predict which

exhibit a lower number of equilibra, usually two. The $N = 4$, $K = 3$ formulation of the financial system is used as shorthand for a generalized representation of a two-stage hierarchical *NK* model with a large number of elements and intermediate complexity.

5 A number of taxonomies that go beyond the basic dichotomy have been proposed. For example, Zysman (1983) proposed a classification based on three ideal types by considering as an additional dimension the patterns of state intervention (see also Boyer, 1997; Grabel, 1997; Schmidt, 2003). Zysman identifies a third ideal type as a credit system with an interventionist state, exemplified by France. Weimer and Pape (2000) distinguish between the market-oriented system, and the Germanic, the Latin, and the Japanese types of network-oriented systems of corporate governance.

local equilibrium will be reached. The adaptive walk on a *NK* landscape provides an intuitive metaphor for the dynamics of financial systems.

As there is higher interdependency within subsystems than across subsystems, there is a close relationship between the concept of the financial system we outlined and the concept of near decomposable systems (Simon, 1996, 2002). Near decomposable systems are systems that are not completely decomposable into separable subsystems but have a structure of interrelations such that the majority of interrelations are located within subsystems and there is low interdependency across subsystems. It can be argued that the financial system itself is nearly decomposable, as most interrelations are within the financial system. Panel (c) in Figure 2 suggests also the subsystems of the financial systems are to some degree near-decomposable. Full near-decomposable systems have the advantage that they can be improved by changes within subsystems without much need to coordinate between subsystems (Simon, 1996, 2002). The simulation results obtained by Frenken *et al.* (1999) show that, in complex *NK* landscapes, exhaustive, optimizing strategies which aim to find the global optimum (exhaustive search) are inferior to 'satisficing' strategies based on decomposition schemes (more-bit searches). The latter take into account only a subset of improvement possibilities and generally do not permit the attainment of the global optimum. In other words, there is a trade-off between the time of finding the optimum and the average performance during the search process. In a similar vein, Frenken *et al.* (1999) devised landscapes that have the properties of nearly full decomposable systems. Their simulation results show that on such landscapes search strategies which come closest to the degree of true decomposability of the landscape outperform all other search strategies in terms of converging to a high optimum in reasonable time.

These results have important implications for the management of changes in the system: On the one hand, as efficiency needs to be evaluated in the context of the system, some degree of centralized and concentrated decision making is necessary to increase the efficiency of complex systems. Changes pursued by agents which only have an influence on one of the elements in a subsystem and which can only induce small changes will most likely fail to converge to optimal results. This is related to the fact that with one-bit mutations, one always ends up in the nearest local equilibrium. On the other hand, the results of Frenken *et al.* (1999) show that too centralized and coordinated decision making may be misplaced when the cost of coordinating changes is high.

If we consider the generalized *NK* representations of the financial system in panels (b) and (c) of Figure 2, these implications become more intuitive. In the generalized *NK* model, interrelationships need not be symmetric, and some elements influence a number of fitness components, others only one. Elements which influence only one fitness component can be optimized within subsystems, while elements that influence a number of fitness components need to be evaluated at a higher level. The set of highly interdependent elements is the 'core' of the system. The existence of highly interrelated elements has two implications for the modification of existing financial systems. First, for core elements, the risk that improvements in performance in one component are offset by reductions in performance in other components is high. The more complex the system is, the higher is the likelihood that a change in one element may conflict with overall performance. This implies that elements in the core are less likely to be changed, and that changes in the system are primarily made by substituting, adding, or changing peripheral elements. The second implication is that the core reduces uncertainty, as it represents a stable and working institutional set-up. Thus, there is an incentive to keep core elements as they are. In financial systems the 'core' is the set of institutions, rules, and routines that guarantee consistent reciprocal expectations.

If we think about institutional systems as systems whose dimensionality grows over time, it may well be that some core elements become very rigid due to their interlocking relationships. This rigidity provides a notion of *lock-in*, which captures the phenomenon that changes within a system are implemented within the context given by the structure of the system. Not all avenues are open once a starting configuration is determined, and the rugged structure of the fitness landscape limits the number of local optima attainable from the starting point (Kauffman, 1993: 51). The implication is that a certain systemic selection bias is at work when individual mechanisms and arrangements are chosen. This raises the question as to whether there is a hierarchical relationship between institutions (Amable, 2003: 66). The notion of a hierarchy of institutions captures whether one or a few elements are of fundamental importance to the structure of the system. In the context of the generalized *NK* model, the 'core' of the system is similar to the concept of institutional hierarchy. The core elements exhibit a tight coupling, which does not allow piecemeal changes, as these changes require a reorganization of the system. Piecemeal changes are possible for peripheral elements. An example for the importance of hierarchy of institutions in financial systems is provided by the failed attempts by the US military governments to reform corporate and finance law in Germany and Japan after World War II in order to weaken the powers of banks and industrial groups (e.g. Hoshi and Kashyap, 2001; Kindleberger, 1993). These changes in law failed to change the trajectories of both the Japanese and the German financial systems and were revoked later on. This suggests that the changes initiated did not penetrate the respective cores of the two financial systems. On the other hand, the story told by Roe (1994) about the transformation of the US financial system in the 1930s shows that legal change is able to transform financial systems when it disrupts the core of the system.

Complementarity leads to path dependence as a dynamic attribute of complex systems. This notion is similar to the path dependence and lock-in theories of Arthur (1989) or David (1985) who consider the diffusion of technologies where adoption choices lead to feedbacks upon the incentives of next adopter via imitation, network externality, or learning effects. Nothing in the *NK* metaphor suggests that the complementarity of institutions is something that was intended *ex ante* by institutional design. The institutional complementarities are best conceptualized as carriers of history (David, 1994). The different institutions, organizations, rules, and conventions of the financial systems constitute a grown set of ordering principles. This is especially true when one considers the fact that many of the characteristics are not predetermined rules of the game (law or formal conventions) but ones which can be selected by the agents (discrete decisions, informal conventions, routines). The latter can be interpreted as 'ways playing the game' (Nelson, 2002). Therefore, we should consider real world financial systems as *evolutionary configurations* that are relatively stable, but undergo permanent changes caused by the changes in external contingencies, internal conflicts and tensions, and innovative actions by economic agents.

3. The convergence of financial systems

The discussion on the convergence of financial systems is closely related to the idea of a best financial system. According to a naive (evolutionary) view of convergence based on the principle of the 'survival of the fittest', one should not worry about institutional reforms, as in the long run international competition would force firms to minimize costs. Cost minimization requires firms to adopt rules to raise external capital at the lowest cost. Competition is assumed to ensure that all financial systems would converge to the most efficient system. Countries that fail to adopt the right system would inflict costs to their firms, which would be less able to raise capital, and as a result might migrate away from that country, if not appropriate corporate rules are adopted.[6] It is often argued that the pressure to converge is increased by the internationalization of trade and finance and the unraveling of the coalitions who supported the previous financial architecture. Some commentators argue that the market-based system occupies a higher evolutionary plateau and is intrinsically superior to bank-based systems (Hansmann and Kraakman, 2002). This perspective is closely related to the Chicago School of law and economics (Bratton and McCahery, 2002). Financial systems are seen as systems with low complexity and few structural interdependencies.

However, the message from the empirical finance and growth literature is that there is no overall 'best' system. Overall financial development and the efficiency of the legal system are more important for growth than the specificity of the financial structure (e.g. Levine, 1997). The ability of a country's financial system to provide external finance to industries with high growth potential is important.

6 However, note that a number of researchers have pointed out that in market-based systems, fund-raising may be very costly for firms facing strong informational asymmetries (Fazzari *et al.*, 1988; Nooteboom, 1999).

The channel through which this external finance is provided does not appear to make a difference (Beck and Levine, 2002).

The insights from academia have also changed during the past two decades. In the 1980s and 1990s, the idea that bank-based systems are more conducive to economic growth was a common view (e.g. Porter, 1992). In recent years it has been argued that a market-based system is better for economic growth (e.g. Holmström and Kaplan, 2001). A market-based system is better at funding high risk projects, which arise when there is rapid change in technology or market environments, while bank-based systems perform better in a more 'static' environment characterized by gradual and incremental change and innovation. The basis for this perspective is the flexibility of market-based systems and the trust-based interaction in bank-based systems. Market-based systems have advantages when radical structural changes that are fueled by deregulation and radical technological change emerge. These changes are well mediated by markets. Bank-based systems with their corporatist structure are less prone to facilitate fast changes in firm strategies. Dosi (1990) concluded that one should observe different technological specialization patterns for countries within different financial systems. Bank-based systems favor insiders and incumbents and should therefore be comparatively specialized in mature industries exhibiting incremental technological change. In contrast, market-based systems favor new ideas with high profit opportunities, and should therefore be comparatively specialized in new industries with disruptive technological change. And, indeed, when industries are ranked by the intensity of patent registrations (relative to a 12 country average), the patent intensity in Germany is almost inversely related to that of the US, with Germany specialized in fields with predominately incremental technology and the US predominantly specialized in fields with radical technology (Hall and Soskice, 2001: 42). The findings of Carlin and Mayer (2003) confirm that institutional structures of financial systems do affect the types of activities in which the different countries are engaged and the level of R&D. In a more direct test, Block (2002) confirmed that market-dominated financial systems are relatively better at promoting innovation activities characterized by high technological opportunity and a focus on product innovation, while systems with low market-based finance are better at promoting innovation activities characterized by high levels of cumulative knowledge.

If today's patterns of industrial specialization has an impact on tomorrow's growth potentials, as argued by Peneder (2003), then Dosi's proposition has important policy implications. Policy makers in countries with bank-based financial systems should try to introduce at least some elements of market-based finance into their financial systems in order to aid the establishment and growth of innovative industries. However, further evidence is needed, not only with respect to the relationship between financial structure and innovation, but also with respect to the diffusion of new technology into other, more established sectors of the economy and, last but not least, the trade-offs between the functions of the financial system. If we recall the definition of the financial system in terms of four components in Section 2.3, there is a strong indication that, for example, the function of the financial system to provide stability may stand in conflict with the ability to provide finance to new firms. The presence of institutional complementarity implies that, even if we are able to identify a system with 'best components', this is not necessarily a 'best' system.

3.1. System dynamics and processes of change

The transformation of financial systems is no easy task. The complexity of the assignment suggests a sequential change of the characteristics of the single elements. However, with complex interdependent systems, this is likely to lead to inconsistencies and to temporary reductions of efficiency. The latter creates a pressure to return to the old system (Bebchuk and Roe, 1999; Hackethal and Schmidt, 2000). Hackethal and Schmidt (2000) use the complementarity argument in their discussion on the convergence of market- and bank-based financial systems. They base their distinction on an underlying system logic and emphasize internal consistency. A similar emphasis on institutional persistence is also present in much of the varieties of capitalism literature (e.g. Berger and Dore, 1996; Hollingsworth and Boyer, 1997; Whitley, 1999; Hall and Soskice, 2001). This stands in contrast to our discussion of the implications of institutional complementarity in the context of complex *NK* systems, where we argue that financial systems should be considered *evolutionary configurations* that are only relatively stable. As long as the core of a financial system is not changed, stabilizing tendencies are dominant. Peripheral elements which do not exhibit complementarity relationships can be adapted quite easily, while changes in core elements require an adjustment process which might lead to more radical changes in the financial system. Changes in peripheral elements can be thought of as *institutional adaptation*s, which do not compromise the overall functioning and fit of the system. Therefore, we concentrate on changes in core elements. We can distinguish three potential scenarios of system dynamics.

The first scenario is *institutional ossification*. It emphasizes the stabilizing tendencies in systems that exhibit institutional complementarity. The stabilizing tendencies derive from the structural interdependencies of the system and are reinforced by the expectations mediated by the behavioral and institutional context of the financial system. These endogenous dynamics force the system back to the original configuration. An example is the unsuccessful redrafting of Japanese commercial laws by the US occupying forces after World War II. The aim was to weaken the power of Zaibatsus. These laws were undermined and replaced by the institutions of stable cross-holdings and cross-directorships (e.g. Hoshi and Kashyap, 2001). An implication of the institutional ossification perspective is that relatively inefficient systems may be able to survive for a long time, at least until the social costs of the change of the configuration are lower than the short-term efficiency gains. This scenario is related to the thesis of institutional sclerosis emphasized by Mancur Olson (1965), where rent-seeking special interest group behavior becomes an accepted institution in society. And, indeed, one central element in Bebchuk and Roe's (1999) theory of path dependence in financial systems is the rent-seeking by controlling owners, managers, and labor. In a similar vein, Rajan and Zingales (2003) propose an interest group theory of financial development, where incumbents oppose financial development because it breeds competition.

The second scenario is the *institutional crisis*. In this scenario, the inconsistencies within the system become so large, that the stability of expectations is undermined. Expectations are no longer congruent. Fundamental uncertainty overrides stabilizing tendencies. This scenario is associated with the thesis that extreme external shocks are necessary for a transformation of financial systems. These external shocks can be related to the internationalization of finance, which would imply a coevolution between the financial systems of different countries, or dramatic changes in neighboring systems (e.g production, law) which disrupt the fit of the financial system. Both cases can be captured in an NK framework that accounts for coevolution (Kauffman, 1993: chapter 6). Coevolution links the fitness landscapes of various groups so that the actions in one group alter both the fitness value in their own landscape and the fitness landscape of the other groups. In the thus modified NK system, called $N(K+C)$ model by Westhoff *et al.* (1996), the fitness contribution of each element depends not only on K other intra-group characteristics but also on C characteristics for other groups. There are two possible outcomes. In the first, the groups continually evolve as the landscapes are deformed in response to another's action. In the second, the groups reach a steady state, which is similar to a Nash equilibrium in game theory (Kauffman, 1993: 245, Westhoff *et al.*, 1996), as in such state no party can improve its fitness by altering a single characteristic. The scenario of institutional crisis only fits the second outcome. In the first case there is ongoing change, so that there would be permanent 'crisis' and no specific system could be identified as ideal type. An example for institutional crisis is the reshaping of the US financial system. Roe (1994) explains the development of the market system with the specific political climate in the US, which stood in opposition to anyone getting too powerful in the financial sector. According to Roe, the US financial system was on a similar trajectory as the German financial system, characterized by dominant universal banks. The political thrust of the Glass Steagall Act, the Securities Act of 1933, and other measures were what fundamentally changed the shape of the US financial system.

Institutional ossification and institutional crisis are closely related. Both scenarios rely on strong interdependency requirements that lead to path dependence. Therefore, the only possible process of change is a radical transformation of the system. The adoption of these two scenarios together with the dichotomy of financial systems leads to a static understanding of the change of financial systems, which cannot account for the variegated changes in financial systems that are observed. The scenario of *institutional transformation* accounts for the evolvability of institutional systems. The theoretical rationale for this scenario is that our representation of the financial system in a generalized *NK* framework does not require that all elements making up the core of the system be tightly connected with each other. Institutional transformation accounts for the possibility that core elements can change independently of each other. Local changes can be made without compromising the overall workability of the system. This need not be related to the idea that financial systems exhibit low complexity. On the contrary, the idea behind the scenario of institutional transformation is that existing complementarities may be changed into new complementarities. Transformation is not the copying of all details of one model, but the integration and transformation of some aspects of the core of the system in a manner which is congruent with other elements of the prevailing core.

Take for example the reforms of corporate governance. Many of the reforms are related to the concept of shareholder value. This concept is an essential element of market-based and not bank-based finance. It is closely associated with the short time horizon of economic relationships in the Anglo-American financial system. If this concept is adapted into the German financial system with a long time horizon and the relaxation of the negative distributional consequences for labor, this need not conflict with the institution of labor co-determination (Streeck, 2001). If this scenario can be realized, the resulting German system will be different, as the reform of corporate governance will remove the strong role of banks in its insider system of corporate governance. However, it would be difficult to classify the resulting system as either bank based or market based.

This example shows that there are limits to the scenario of *institutional transformation*. Institutional changes induce uncertainty, as institutions creating mutually consistent expectations are called into question. Existing routines need to be changed and new routines and rules found. The competition among beliefs is characteristic for transition processes. If the uncertainty is too strong this might lead to changes in core elements, which would disrupt the fit of the system fundamentally, and lead to an *institutional crisis*. In the example used this would imply the transformation of the German system into a market-based financial system with no codetermination. The question as to what extent the hybridization of systems is possible cannot be answered on the basis of available knowledge on complementarities. The *NK* metaphor suggests that the hybridization of systems is possible, as there are multiple optima, but that there are limits to hybridization, as there is not an infinite number of equilibria. That hybridization could be a possible scenario is shown by the fact that small firm

Table 1. Stock market growth 1990–2001

	Growth of the number of listed domestic companies		Stock market capitalization to GDP			
	1993–2000	1993–2002	1980	1990	1999	2001
USA NYSE	35.8%	5.9%	44.2%	57.0%	150.3%	122.9%
USA Nasdaq	–1.4%	–24.8%				
UK	–0.1%	–1.9%	33.3%	85.2%	167.5%	144.1%
Japan	23.3%	27.1%	29.9%	121.2%	71.9%	55.9%
Gemany	12.0%	7.7%	8.2%	21.5%	55.2%	54.3%
Italy	20.2%	19.0.%	4.2%	14.6%	50.6%	51.0%
France	11.3%	–[a]	8.1%	28.2%	78.5%	85.7%
Belgium	15.7.%	–[a]	9.8%	35.8%	79.2%	64.9%
Netherlands	27.2%	–[a]	16.7%	47.6%	150.1%	123.8%

Notes: [a]these stock exchanges merged into the EURONEXT stock exchange system.
Sources: Number of listed companies: FIBV (World Federation of Exchanges) statistics (www.fibv.com); stock market capitalization to GDP: Financial Structure Database, World Bank (http://www.worldbank.org/research/projects/finstructure/database.htm).

finance is largely bank based and even relationship oriented in market-based countries (Petersen and Rajan, 1994; Berger and Udell, 1998).

3.2. *Hybridization or convergence towards global shareholder capitalism?*

There has been a shift toward market-based financial systems, as many countries rewrite their corporate laws and review the requirements for firms to be listed on exchanges. The privatization of state enterprises in Europe has created thick financial markets in many countries where there previously were none. Table 1 shows that the aggregated market capitalization in real terms has increased for all countries since 1980. The maximum is reported for most countries in 1999, with the exceptions of Italy and France, where the peak is in 2001, and Japan, where the highest value was at the beginning of the 1990s. The growth of the aggregate stock market capitalization was not confined to market-based countries and is not a recent phenomenon. As early as the decade between 1980 and 1990, stock market capitalization increased remarkably in most European countries.

Columns 2 and 3 in Table 1 show that the number of domestic companies listed on the stock markets increased from 1993 to 2000 for all, usually as bank-based or network-oriented classified countries. Aside from privatization, the set up of 'new markets' in the late 1990s contributed to the increased importance of stock markets in the European economies. Stock markets like the *Neuer Markt* (Frankfurt) or the *Nouveau Marché* (Paris) were set up based on the model of the Nasdaq in order to create opportunities for entrepreneurial companies with high growth potential to go public, raise equity, and mature. The new markets opened during a worldwide period of rising valuation of technology firms, which was followed by a decline starting in mid 2000. These markets helped establish venture capital industries in these countries. Venture capital provides an explicit connection between the stock market and the productive and innovative sectors of the economy, which is often neglected in the political economy literature (O'Sullivan, 2003). The growth of the importance of stock markets indicates that a perspective based on stabilizing tendencies alone cannot account for these changes in financial systems. From our theoretical perspective, the identification of the core of the financial system is central to an assessment of the likelihood of the scenarios proposed.

In important contributions, LaPorta *et al.* (1997, 1998) suggested that law is a primary determinant of the architecture of financial systems. The lesson from their work is that the protection of outside investors in interaction with agency problems determines ownership structures. Their results suggest the policy recommendation to strengthen the rights of minority shareholders and creditors in order to foster economic growth. As Berglöf (1997) and Bratton and McCahery (2002) indicate, this would involve the need to change the basic legal system. Given the path-dependent nature of the law (e.g. Teubner, 1989), this is a complex task. The experiences of Germany and Japan after World War II mentioned earlier suggest that formal reform of company law will not be enough to transform bank-based systems into market-based systems. Both Germany and Japan resisted the introduction of US-style Corporate Governance by the US military governments. It was only in the last decade that the resistance in both countries diminished. However, the initiatives to harmonize the structure and control of corporations on a European Union level were largely unsuccessful for a long time. In the last years corporate and capital market laws have seen some convergence, while financial and legal systems are still heterogeneous (e.g. Hopt, 2002). Moreover, as Rossi (2003) and Cools (2004) note, while the company laws of different countries are not too dissimilar in structure, the results are very different, which suggests important limitations for formal legal reform.

Another important element is the reform of pension systems. In many European countries, pay-as-you-go systems are under pressure to be reformed into more market-based systems. The pension system is complementary to the financial system as (i) it channels a large amount of savings, (ii) its institutions play a central role in the corporate governance (especially pension funds that are shareholder value oriented), and (iii) it provides incentives to employees on whether to invest in firm-specific human capital or to invest in more general human capital. The convergence process within Europe towards a more market-based system may not primarily be a result of concentrated actions by the European countries in order to introduce a 'best' corporate governance system to foster industrial success, but the result of the privatization of the pension system. However, a definitive assessment of what forms the core of financial systems is not possible on the basis of available knowledge. Further research is needed to go beyond speculation.

4. Conclusions

This paper provided a discussion of recent developments in the literature on financial systems and proposed an evolutionary perspective on financial systems based on complex systems theory. We argued that such a perspective based on the generalized NK model has a number of advantages as formalization of institutional complementarity:

1. The generalized NK model provides a formal representation of a complex decision space with high uncertainty about interdependencies between elements at an institutional macro level. It thereby provides an appropriate metaphor of the problem faced by economic actors within the system and by policy makers confronted with the problem of institutional design.
2. The model shows that the presence of complementarity relations leads to path-dependence and the possibility of lock-in. Thus the model provides a theoretical rationale for the non-convergence hypothesis based on institutional complementarity.
3. The concept of the core in the generalized NK model provides an interpretation of institutional hierarchy. It allows a different perspective on the question of 'tight fit' versus 'loose coupling' of elements in the institutional fabric.
4. Last but not least, the *NK* model provides a framework to guide empirical research.[7]

The complementarity of elements provides a framework for the reconstruction of past financial systems and reflection on changes in financial systems. The close relationship between financial systems, legal systems, and political traditions, as well as the number of organized interests, suggests that stabilizing tendencies are quite strong. In short, path dependence makes fast and full structural convergence a highly unlikely prospect. Institutional path dependence is an interesting phenomenon, as it explains institutional inertia as a result of past decisions. Placing a high weight on path dependence allows us to make clear predictions. However, these predictions may be incorrect, because institutions develop over long time periods and the set of complementarities is more likely akin to a complex bundle than to a single, simple logic (e.g. Ebbinhaus and Manow, 2001). The application of the NK framework showed the limitations of the bipolar dichotomy of national financial systems used in much of the literature. While this dichotomy is useful for guiding theoretical research at the micro level, and to explore relationships between the financial system and other aspects of the economic system (e.g. Dosi's, 1990, attempt to endogenize technology), the assumption that national systems are characterized by an overall internal congruence has only limited value when one attempts to dig deeper into the comparison of financial systems, especially into what concerns the dynamics of

7 Frenken (2001a), Flemming and Sorenson (2001) apply the NK model empirically to phenomena from the economics of innovation.

financial systems. The exclusion of the possibility of hybridization of financial systems eliminates the possibility of institutional innovation in the sense of a reconfiguration of institutional complementarities.

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