Eurasian Journal of Business and Economics 2009, 2 (3), 15-34.

Centralization and Decentralization of Public Policy in a Complex Framework

Maria ROSARIA ALFANO*

Abstract

The public economic literature of the past century is characterized by a traditional paradigm that ascribes little attention to the spatial dimension. However, contemporary globalization requires that researchers and economists expand their perspectives to consider space conceptualization. What is required in the 21st century is a richer and more realistic framework that broadens existing concepts of socio-economic analysis while overcoming narrow national borders. Although national governments will remain prominent performers in the global market, regional and local governments cannot be ignored because citizens worldwide are exerting greater self-determination in influencing governmental decisions.

This paper is focused on the opportunity to analyze the governance of decentralization by the new optimizing procedures provided by complex system theory. The first section of the paper explores the positive and normative issues related to centralization and decentralization in a globalized framework as well as the increased interdependence in power sharing among different jurisdictional level. In the second section, Kauffman's (1993) contributions are examined as a means of determining if the fitness landscape allows combining the institutional evolution. Finally, this paper concludes highlighting that complex system theory is one of the possible tools useful to redesign the map of institutional sharing power in an era of globalization, considering that it allows catching Pareto improving in the level of welfare.

Keywords: *Centralization, Decentralization, Coordination, Complex systems*

JEL Classification Codes*:* H 77, P00, P51

* Researcher of Public Economics and Finance, Faculty of Economics, Seconda Università di Napoli, Dipartimento di Diritto ed Economia, Italy, mariarosaria.alfano@unina2.it

1. Introduction

The public economic literature of the past century is characterized by a traditional paradigm that ascribes little attention to the spatial dimension. This limitation is reflective of the difficulty arising from the integration of territory-specific factors into a higher level of abstraction required by marginal calculus. However, contemporary globalization requires that researchers and economists expand their perspectives to consider space conceptualization. What is required in the 21st century is a richer and more realistic framework that broadens existing concepts of socio-economic analysis while overcoming narrow national borders. Although national governments will remain prominent performers in the global market, regional and local governments cannot be ignored because citizens worldwide are exerting greater self-determination in influencing government decisions. Most democracies today have sub-national governments, and countries worldwide are providing political, fiscal, and administrative powers to sub-national tiers of government. Unfortunately, sometimes decentralization is implemented haphazardly, resulting in central decision makers losing control of the decentralization process. In particular, local frameworks are often ignored when models of decentralization from other countries are adopted without any modification.

Theoretically speaking, globalization can enhance diversity of local policy preferences[1] while simultaneously reducing the benefits of being part of a larger political union. In other words, on one hand we should expect demands for decentralization to increase while on the other hand opposition to decentralization is also likely to increase. This theory is supported by market literature that examines international investors' preferences for more political decentralization as horizontal competition among regions[2] increases. Salmon (1998) addressed the unrealistic descriptions of competition models in economics and pointed out that "This by no means excludes, at a different level of abstraction or generality, the detailed examination of an almost infinite variety of interactions, not all of them competitive. For Breton, it is clear that the same approach or strategy should be adopted to study government" (p. 125).

A large part of literature focuses on the positive effects of both vertical and horizontal competition among governments while some experts consider the decline in government power which results from increasingly footloose tax base.

[1] For a detailed analysis on how global economic integration increases regional diversity, see Deeg (2001), p. 51.

[2] Deeg (2001) clearly highlights that "Investors would then expect higher levels of subsidies for their investment, whether through direct cash transfers, lower taxes, wage suppression, or other market friendly policies".

The expected[3] results have spread across countries along different spectrums and with varying levels of development. Some empirical evidence underscores the need to create appropriate conditions for achieving the objectives of fiscal decentralization.

Conversely, Garrett and Rodden (2000) emphasized the fact that many regions increase their demand for fiscal centralization in order to obtain a stronger central government that can protect them against sudden economic downturns and cover their needs through fiscal transfers. Therefore, market integration seemingly generates incentives for both centralization and decentralization within the same socio-economic systems. Yet a country's particular political institutions must be considered when fiscal centralization is being implemented in response to trade integration (Garret and Rodden as cited in Deeg, 2001).

This dichotomous generation of incentives for both centralization and decentralization within the same system indicates that even if resource allocation and linked benefits of a decentralized government are unquestioned (Tanzi 1996), the multiplicity of government functions raises substantial problems for macroeconomic control at the national level. Therefore, it seems "that the actions of decision-makers in the real economic world should be studied … in the light of the capacity of the human mind to frame problems, and to represent reality in innovative ways, in an endeavor to reduce their uncertainty and ignorance" (Egidi and Marengo, 2002: 11). In this scenario, new disciplines could help to investigate "the classic yet still unresolved questions of human creativity … and their relationship with the evolution of institutions" ensuring the migration from the conventional systems to adaptive complex systems (Egidi and Marengo, 2002: 11).

This paper focuses on investigating the possibility of implementing a new methodology for analyzing the evolution of fiscal processes and evaluating the usefulness of new optimizing procedures for the governance of decentralization. The first section of this paper explores positive and normative issues related to centralization and decentralization in a globalized framework as well as the fundamental role of increased interdependence in power sharing among jurisdictions. In the second section, Kauffman's (1993) contributions are examined as a means of determining if the topography of the landscape ought to be considered when combining conflicting centralization and decentralization processes. Finally, this paper concludes with an exploration of how a form of intermediate coordination between fully centralized and fully decentralized systems could provide the best outcome. Such an intermediate form of coordination applied to a framework with several agents (each of which has exclusive control over more than one but less than all elements), seems to be the

[3] Such as to enable efficient allocation of resources, improve governance, accelerate economic growth, reduce poverty, achieve a gender balance and empower weaker sections of society.

best solution for fully decentralized decision processes that are a hindrance in cases of congruent jurisdictions or cases involving strong interdependencies (e.g., globalized systems).

2. Centralization and Decentralization in a Globalized Framework

The issues related to centralized and decentralized systems in economic production have long been debated in economics literature. First, Coase pointed out how economic agents incur an unseen cost when they rely on decentralized markets; Hayek then argued that "decentralized systems have information processing advantages since economic agents acting on local information could process more information than a central coordinator" (as cited in Williams, 2000: 1).

2.1. Decentralization

The traditional framework for fiscal decentralization is drawn from the contributions of Stigler, Musgrave, Buchanan and Oates. The classic argument in favor of decentralization is that local governments are more efficient and responsive to the needs of citizens as well as being held to a higher level of accountability than national government structures. In spatial considerations, sub-national governments become a necessary conduit for setting up an efficient solution for equating benefits and cost. Yet new perspectives on economic integration and the vertical distribution of governmental authority reveal a basic trade-off between the benefits of large jurisdictions and the costs of heterogeneity in large populations (Alesina and Sporaore, 1997; Alesina and Wacziarg, 1998). Benefits seem to be derived from the availability of more efficient forms of taxation, common defense, free trade within the country, economies of scale, and the decreasing per capita costs of non-rival public goods; however, these benefits must be compared to the costs of satisfying people with heterogeneous preferences and income levels across regions. The costs and benefits of maintaining a large jurisdiction thus affect the demands for secession, in accordance with the number and size of nations. As in the Musgrave-Oates formulation, sufficiently high levels of heterogeneity generate demands for decentralization or even secession. Many countries stopped this secede demand, opting instead for a fiscal decentralization scheme (Alesina and Sporaore 1997). In fact, "any benefits of decentralization that might be obtained in a world with several nations may also be achieved within a unified nation by replicating the administrative structure of the world with several nations and implementing a suitable degree of decentralization of authority among the regions" (Bolton and Roland, 1997: 1057-58).

The Leviathan monolithic government hypothesis (Brennan and Buchanan, 1977, 1978, 1980) asserts that massive migration would be the result in the case a particular jurisdiction attempt to exploit citizens in a Tiebout situation, "any

attempt on the part of one jurisdiction to exploit its citizens would cause massive out-migration to an alternative, non-exploiting jurisdiction (intergovernmental competition)". Goodspeed (1998) underlined that "the horizontal tax competition can result in an efficient allocation of resources if the taxes used are benefit taxes. …. If taxes do not reflect benefits, however, Oates (1972) suggests that externalities are created so that tax prices diverge from social marginal cost". Therefore, this decentralization hypothesis assumes implicitly that fiscal decentralization (and fragmentation) automatically implies increased levels of horizontal competition among jurisdictions (Atkinson 2006) thereby decreasing the ability of Leviathan to extract resources from the private sector[4]. Therefore, an increase in fiscal decentralization will lead to less total government spending and restrict government intrusion into the economy, ceteris paribus, and will extend taxes and expenditures of decentralized institutions. However, it is possible that as decentralization occurs, the component governments in a federal system may collude to organize a cartel-like arrangement in order to circumvent the competitive influences of fiscal federalism. Brennan and Buchanan (1980) explained, "within a constitutionally designed federal structure, one would predict that there would be constant pressure by competitive lower-level governments to secure institutional rearrangements that would moderate competitive pressures" (Shadbegian, 1999: 262 - s).

2.2. Centralization

Economic integration seems to increase the credibility of secession threats in countries with high levels of income inequality between regions. In this case, it may well be possible to forestall secession by instituting a decentralization program, which allows local governments' greater freedom over local schools and cultural institutions. Such devolution need not translate, however, into a shift of fiscal resources into the hands of local governments. Therefore, even if fiscal federalism could increases economic competition among regions and it is likely to justify smaller governments, the more integrated economies are exacerbating the demands for governmental redistribution of wealth and powerful regions pushing across centralized systems of taxing and spending, rather than decentralized ones.

Following the economic logic of fiscal decentralization and with the political logic of centralization, Garrett and Rodden (2000) empirically showed that globalization increases demand for fiscal centralization. In their study of 60 countries from 1978-1997, Garret and Rodden concluded:

Globalization may have made [centralization] possible for smaller political units to break away from larger extant nations. But it has also empowered regions that

[4] For an interesting and deep discussion about the empirical relationship evidence that supports both Brennan and Buchanan hypotheses, see Shadbegian (1999).

choose to stay within countries to push for fiscal arrangements that better mitigate market risk for citizens within their borders. And it is centralized systems that achieve this objective. Finally, these authors show that the vertical organization of the public sector is much more than an efficient institutional response to shifting demands of voters and investors (2000: 21). In fact, this agents perceive that globalization strictly increases the volatility and aggregate economic risk therefore they look for a national insurance schemes which can only be handled by central government that, having tax authority and power for geographical distribution of expenditures, ensures that this scheme should work through pro-cyclical subnational spending.

More, the globalization process increases also the aggregate social utility of automatic interregional tax-transfer insurance schemes. An additional consequence of economic integration, as suggested by Krugman (1991), is the regional specialization that increases the vulnerable export-oriented jurisdictions, referred to as "export clusters," with relatively undiversified economies. Obviously this fiscal centralization logic holds in countries where regional business cycles are not highly correlated; therefore, these issues seem most plausible in large and diverse nation-states.

These contrasts suggest that important issues linking globalization and the movement of authority between different levels of government remain not only unresolved but are also increased by the cross-border activities which give rise to struggles among different jurisdictions at the lower level. These struggles lead to strong interdependence and cause crises of the traditional modes of operation.

2.3. Interdependence

Interdependence is the main consequence of increased integration among economic and political institutions. In this scenario, physical space, proximity, and power sharing among jurisdictions play a fundamental role. Theory and evidence[5] indicate that decisions relating to decentralization are influenced by a number of exogenous factors. The interdependencies among jurisdictions vary along a continuum; so revenue functions of each may be dependent or they may have joint supply and cost functions.

A large part of economic literature examines fiscal interdependence among governments and the externalities created by such dependencies, which directly influence the central public decision maker to delegate decision rights and also implies that there are benefits by coordinating the activities at the lower-level jurisdictions. The local public decision maker is delegated decision rights that will optimize the welfare of his own jurisdiction rather than consider the impact of his decisions on other jurisdictions. Hence, the cost associated with decentralization

[5] See Abernethy et al. (2001) for the analysis of firm organization.

will increase as operating dependencies increase; therefore, centralization will be the least cost option when interdependencies are high.

Current globalization trends suggest that the interdependencies are progressively increasing. Therefore, fiscal fragmentation, in the case where taxes do not reflect benefits, indicates that levels of destructive downward competition among jurisdictions is increasing, which leads to distortion in the allocation of factors and a lower level of public services than what would be optimal.

There is a rich literature[6] describing (a) the computationally intractable heterogeneous individual elements, (b) endogenously determined individual responses to changes in state, and (c) inter-element spillover effects of substantial magnitude. Rust defines "computationally intractable" problems as those "for which the lower bound on the computation cost increases exponentially with the problem dimension". Therefore, in the worst case complexity bounds, “many intractable problems become tractable when we consider alternative measures of complexity which account for different amounts of prior information about a problem and allow for different ways of assessing the accuracy or quality of an approximate solution”(Rust, 1997: 3).

3. Conflicting Constraints Interdependencies as Complex Systems

A better analysis to control interactions requires the investigation of evolutionary concepts throughout the history of economic thought. For example, Alchian (1950) interpreted the static concept of equilibrium in perfectly competitive markets of neoclassical economics as the outcome of a dynamic selection process between competing firms. Although Alchian focused only on profit maximization, he was clear about the application to consumers. This implies, as Simon (1969) defined, that systems containing elements that are interrelated within a particular structure can be defined as complex systems. Hence, “the dependencies between elements imply that the choice of an element cannot be made independently from the choice of other elements due to interaction effects. The set of optimal choices for the elements with regard to element-specific output variables may prove suboptimal when the effects of dependencies between elements are taken into account” (Frenken, 2001a: 4)[7].

Kauffman (1993) contributes to our understanding of search processes by relating the topography of the landscape to the underlying interdependence of the components being combined. His simulations include two parameters: the number of components and the degree of interdependence between those components.

[6] See Rust (1997) that provides an excellent overview of the development of impossibility theorems in these various disciplines.
[7] For further details see Frenken et al. (1999).

A socio-economic system is a complex system consisting of a multitude of agents, households, firms and different level of governments, which interact under the broad umbrella of cooperation and competition developing several economic and political activities that often span several hierarchical levels of functional interdependence. In this scenario, the socio-economic analysis of decentralization could be characterized by conflicting constraint due to interdependencies between its constituting elements that requires analysis of dynamic efficiency in which the central point is to consider what should be the organization of a socio-economics model and in what ways a fitness landscape can be searched. Waldrop (1992) and Kauffman (1995) adopted Wright's idea (1932) to study evolution, by visualizing the distribution of fitness values, as a kind of landscape.

3.1. NK Fitness Landscapes to Analyze the Evolution of Interdependence among Jurisdictions

Kauffman's representation of a fitness landscape is a simple but powerful framework for considering questions of adaptive learning (Levinthal, 1997). The evolutionary properties of complex systems have been subjects of research in theoretical biology (Kauffman and Levin, 1987; Kauffman, 1993). Frenken (2001a) discussed the various levels of activity between genotype and phenotype and provided an explanation for complexity.

Complexity means here that a gene does not simply translate into a particular trait, but operates in conjunction with other genes…Due to dependencies among genes, a mutation in a single gene may have both positive effects on some traits and negative effects on other traits, which jointly determine an organism's fitness[8].

Later in evolutionary economics, these models have been used to simulate economic agents randomly searching for new technological systems containing interdependent elements by trial-and-error and running the risk of ending up in suboptimal solutions. In this scenario the issue of interdependence among policy variables has been indicated in recent empirical work in the human resource literature (Ichniowski, Shaw, and Prennushi, 1997).

The degree of interrelationship among policies has a counterintuitive implication for the topography of a fitness landscape. Therefore, similarly to biology studies, the competitive decentralization could be described as a complex system that is composed of a set of parts of the system, which jointly determine the national welfare. Only if some combinations of system parts are complementary can the result be a high national welfare. Conversely, if the combinations of system parts are incoherent, the result is a lower level of national welfare. Searching for a good fit between policy parts of the system is difficult as a mutation in one policy, even if

[8] For further details on complexity in biology, see Frenken (2001a).

it yields improvements in some functions, may well turn out to be detrimental for the overall performance of the political socio-economics system as a whole.

Obviously the interdependencies between policy jurisdictions indicate that the choice of one strategy cannot be made independently from the choice of others. The existence of interdependencies thus provides a rationale for coordination of search activity at a centralized level. More of these independent actions of system elements can be handled using genetic algorithms to approach search problems[9]. In this way the algorithm tries to find a single solution to a complex problem by mutating and selecting strings that represent individual solutions to the problem. In fact, the main idea is that if the best solutions are selected in many iterations, the algorithm would converge to a single very powerful solution in the end. However, algorithms often get trapped on a poor solution and several runs often generate different solutions. This outcome has striking similarities to natural evolution whereby the ultimate complex problem is self replication, which results in greater diversity of species.

The framework for this search problem is the NK-model (Kauffman, 1993), which was originally developed as a model of biological evolution even though its formal structure allows for many other applications[10] because it allows for handling interdependent systems using only two parameters: N stands for the number of parts[11] of the system and the factor K determines how many other parts[12] are influenced by every other part,[13] evaluating consequently the dependencies or the so-called "epistatic relations" that imply a mutation in one element can affect the functioning of many other elements[14].

Starting from these assumptions, we will consider the possibility of borrowing from the NK model for the purpose of solving the complex and fully conflicting constraints of competitive decentralization among jurisdictions while looking at the original ones and identifying the policies and payoff value in the following terms:

[9] A detailed explanation about the algorithms operation is in Post and Johnson (1999).

[10] Egidi (2001), provides a highly developed discussion of the features of the evolutionary properties of biological systems and the features of the evolutionary nature of human artifacts, institutions, and organizations, showing that "in human organizations evolution involves a process of collective learning that is driven by human conscious will, in which, during a rational, … activity of planning, despite the effort … to be fully rational, nevertheless errors are unintentionally created. Even though by mutations it is possible to introduce improvements into the organizations, and get closer to an optimal configuration, the evolution of an organization based only on mutations should require an enormous amount of time. The evolution of organizational structures is, on the contrary, relatively speed and discontinuous, because is based on the human ability to represent, design and revise their settings".

[11] Called by Kauffman "genes or loci".

[12] Called "loci".

[13] Called "locus".

[14] See also Frenken (2001a).

N jurisdictions (1,…,N) for each jurisdiction n (like players in a game), there exists a number of states (like strategy in a game), which are coded by integers (0, 1,…..n). The number of states of a jurisdiction n is described as An . Each string s is described by the chosen states s1,s2...sN and is part of a possibility set S, for which holds:

$$s \in S \; ; \; s = s_1 s_2 ... s_N \; ; \; s_n \in \{0, 1, ..., A_n - 1\}$$

The N-dimensional space S, called space design, includes all possible combinations between the strategies, assuming that all the jurisdictions have the same number of strategies A. The size of the design space S is given by:

$$S = A^N$$

The combinatorial nature of the design space of a system requires that elements are orthogonal to one another; therefore, one element of a system cannot correspond with an allele of another element in the same system.

Kauffman (1993) restricted his analysis of complex systems to particular types of architectures expressed by one parameter K, which stands for the number of elements. This parameter can be considered as an indicator of a system's complexity, with K=0 being the least complex and K=N-1 the most complex architecture.

In our case, a low value of K highlights little interaction among policy choices of different jurisdictions, so the fitness landscape is smooth or highly correlated; therefore, a change in one policy has little impact on the fitness contribution of other jurisdictional choices. In contrast, a high value of K implies that a change in one jurisdiction policy has a large impact on the fitness contribution of other jurisdictional choices. Therefore, given an initial setting of incremental change in the vector of N, policy jurisdictions may substantially change the overall payoff level. As a result, the fitness landscape becomes less correlated, or equivalently, more rugged, with a higher K value. When there are significant interaction effects among policy variables, there may be a number of local peaks.

The existence of local optima like peaks in the N-dimensional landscape of fitness values are given by strings for which there exists no neighboring string with higher fitness. This implies that each neighboring string cannot reach the local optima even if there will be mutation in one element. A peak in a fitness landscape implies that a well-known search algorithm by "trial-and-error generates a new string (trial) by randomly changing the allele of one element" (Frenken 2001a: 8-9). This process proceeds by evaluating how system fitness W is affected by a mutation. The existence of multiple peaks characterizes a "rugged landscape."

3.2. NK Model Properties

To understand the relationship between the complexity of an architecture and the properties of its fitness landscape, Kauffman (1993) simulated a large number of fitness landscapes having different values of K and N. Therefore, setting the parameter K from lowest to highest value and comparing the properties of the fitness landscapes, they found the following:

(a) The number of local optima increases exponentially with K and the probability to end up in a sub-optimal solution increases with K;
(b) the "mean fitness of local optima is highest for systems with a positive low complexity (around K=3 for N around 8);
(c) the higher the complexity of a system, the more randomly spread the local optima"[15] are in design space;
and (d) the probability of finding a local optimum with a high fitness value is higher than the probability of finding a local optimum with a low fitness values.

Summing up with rank order statistics, Kauffman highlights the following properties in Table 1.

Table 1

Cases	A[16]	B[17]
Constructional Contraints	K=0	K=N-1
Local Optima	1	2N/ N+1
Length of adaptive walk	N/2	Log2N

In the case of intermediate values of K (0<K< N-1), the highest peaks of the fitness landscape can be found in the same region of the landscape, and the longest distance from the highest peak that still contains information about the highest region is called the correlation length of the landscape.

From the above we can conclude that adaptive walk is quite efficient at finding the highest point on the fitness landscape in systems with K = 1, where an element's fitness contribution is a function only of its own state. On average, it will take no

[15] For further details about the optima of less complex systems, see Frenken (2001a), p. 10.
[16] In absence of interaction among the parts there exists a single optimum therefore it can be reached from every starting point: i) adaptive walks in this landscape are relatively long (N/2); ii) neighbouring points of the landscape are correlated therefore one point can give information about the neighbouring points. Further details are on the webpage, Evolution on rugged fitness landscapes, June 2000, Colloquium of Berngruber.
[17] In presence of maximum interaction (K=N-1) there exists an enormous number of local optima with low to intermediate fitness: i) adaptive walks in this landscape are likely to get trapped in a local optimum with low fitness**;** the length of the adaptive walk is shorter than on a smooth landscape (log2N); ii) the landscape is uncorrelated (random) therefore a point gives all kinds of information on its neighbor. In a rugged K=N-1 landscape adaptive walks would end sooner (length $\log_2 N$) than in a smooth landscape (length N/2). Further details are on the webpage, Evolution on rugged fitness landscapes, June 2000, Colloquium of Berngruber.

more than N/2 steps of the adaptive walk to find the optimal configuration of simple systems with K=1. In systems with substantial interconnections, the algorithm performs progressively less and less effectively. In fact, an increase of spillovers induces a ruggedness into the fitness landscape based on the element dimension N and the state dimension S. This ruggedness looks like a landscape with many points of various heights of which one is the highest. This peak is called the "global fitness peak" (global optimum).

Figure 1 depicts an example of fitness landscape. The two horizontal axes represent the elements N and the states S. The vertical axis represents the fitness. This landscape is not particularly rugged; so the adaptive walk algorithm may lead to two local optima.

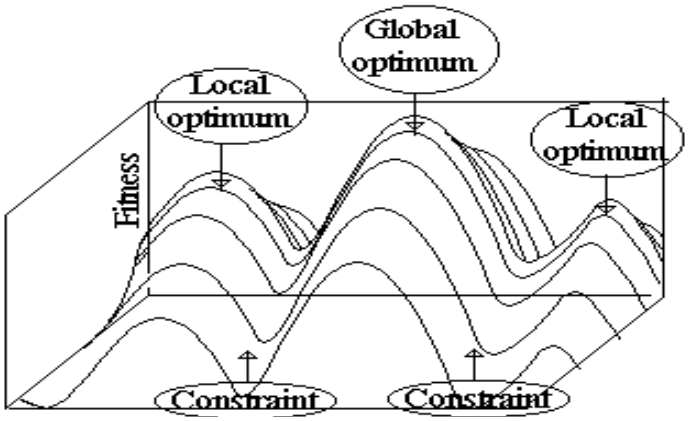

Figure 1

In economic situations the fitness is really rugged, so activity of search is not necessarily local. In fact, human search can mutate any number of elements at the same time, avoiding getting trapped in strings of purely optima local (Lissack, 1996), so the application of a sufficient long-search distance will enable an agent to find the global optimum because only one string will count as an optimum. The number of local optima in a fitness landscape is thus not a given one, but dependent on the applied search choice (Frenken, et al. 1999).

The simulations done by Kauffman and Macready (1995) showed that decentralized control usually does not optimize a complex system. It might be that the optima strings in the case of centralized search does not correspond to the optima in the case that the search is decentralized. Hence, it seems that fewer optima exist for fully decentralized search compared to fully centralized search and in addition, for

strings corresponding to optima in centralized search, there is at least one agent that can improve its fitness. For the above reasons decentralized search risks to find no optimum at all; therefore, Kauffman and Macready (1995) argued that both fully centralized and fully decentralized searches suffer serious deficiencies when optimizing complex systems.

4. Patching

The above deficiencies pushed Kauffman and Macready (1995) to study a form of coordination that is intermediate between fully centralized and fully decentralized coordination. This intermediate form of coordination is applied in the case where there are several agents, each of which has exclusive control over more than one but less than all elements. Therefore, Kauffman partitioned the elements, and each block of elements that is controlled by a single agent is called a "patch". Many authors (Post and Johnson, 1999; Eisenhardt and Brown, 1999; Sussman, 2000) explain that difficult problems with many linked variables and conflicting constraints can be solved by breaking the entire problem into non-overlapping domains called patches (see Figure 2).

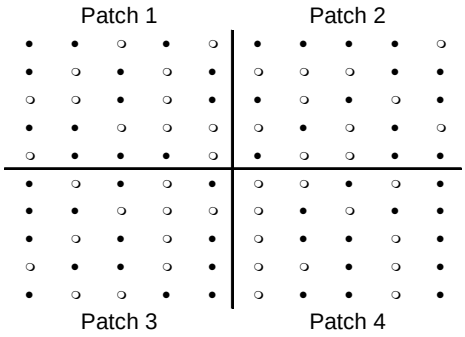

Figure 2

The logic of patches may suggest new powerful tools in the design and handling of problems in complex organizations and in the evolution of complex institutions. In this way, systems having various kinds of local autonomy may represent a fundamental mechanism underlying adaptive evolution in economic and social systems.

Eisenhardt and Brown (1999) refer to patching as the association of a number of interdependent elements to a higher-level construct like to a core element. The patching process involves the notion of decomposing a given set of elements into smaller subsets to better exploit opportunities, a process related to the patching procedure for solving highly interdependent decision problems, as described by Kauffman (1995).

The analysis of institutional decentralization could be captured in a system of patches in which each group of jurisdictions (patch) selfishly optimizes rather than seeking a global optimum,[18] having a mindset that views any structure as temporary because the action of each patch deforms the landscapes of other patches. Essentially, when a patch finds a good solution, it changes the problem faced by neighboring patches. This intermediate-level structure seems like a compromise among the varying interests of the patches, so that even though they might do things that are contrary to the interests of the whole, the whole learns more than it would if central control were in place, therefore, the whole system is more efficient. When the interjurisdictional system maps a patching structure, it will create a continually shifting mix of highly focused and tightly aligned policies that could respond to changing global market opportunities. In fact, patching is less critical when the status is relatively unchanging, but when the situations are turbulent, like in globalization, patching becomes crucial. They balance on the edge of chaos between equity and efficiency. Hence in the case of competitive decentralization, finding a good solution that ensures the maximum welfare for one jurisdiction will change the problem to be solved by the parts in the adjacent patches.

If the system is divided into a few large patches, we have large jurisdictions that rapidly immobilize poor local optima. If instead the system is fragmented into many patches (small jurisdictions), the system remains in a chaotic regime. “The optimum behavior is found near the transition phase between order and chaos. Here, as if by an invisible hand, the system of selfishly optimizing (hence coevolving) patches, optimizes the optimum obtained”[19]. This seems to summarize a good compromise between centralized and decentralized authority structure, which should keep constant pressure of separatism linked to the heterogeneity coming from lower-levels of government and the increasing cost linked to the existence of high interdependencies.

Patch size is P, and it refers to the number of jurisdictions contained in each patch; each jurisdiction pertains only to one patch, so patch size ranges from P=1, representing a completely decentralized system to P=N, representing a completely centralized system. The number of patches is thus given by N/P, within each patch, and a search takes place using a local search by mutation in a single unit. Each mutation in a patch is assessed with reference to its effect on the average fitness of jurisdictions pertaining to its patch and independently of its effect on fitness values of jurisdictions related to other patches (Kauffman and Macready, 1995).

The number of local optima is linked to the levels of decentralization, and generally higher fitness, W, can be achieved when the number of local optima is smaller. A

[18] See Studying Strategic Landscapes on Lissack’s Web page.

[19] Kauffman, Lecture 1, Coevolutionarily constructable communities of adaptive entities … to a self-organized critical state, http://www.santafe.edu/sfi/People/kauffman/ Lecture-1.html.

lower number of local optima in a fitness landscape computation indicates costs, in term of time, to reach a local optimum. Conversely, a higher level of centralization indicates costs of evaluation of a mutation in one jurisdiction, hence, higher coordination costs.

According to Kauffman and Macready (1995), the optimal fitness values by local search were indeed reached for patch size levels between 1 and N, with the exact optimal value depending on N. Of course, emerge that "intermediate levels of centralization are to be preferred to balance the number of local optima and coordination costs at the one hand and the time-efficiency of search on the other hand" (Frenken, 2001b: 16).

4.1 Congruence among Jurisdictions

The effectiveness of patching as a tool for handling these complex problems is dependent upon the relationship between patch boundaries and spillover effects between individual elements and those inter-element effects that are internalized within patches and those that are not. Central and local governments have to solve problems defined over complex systems so a main goal for the institutions is the formation of congruent, independently optimized decision-making sublevels[20]. Dividing into "patches the institution allows or prohibits "changes of state" at the "patch members" on the basis of the aggregate within and overall effects. Decentralized rule-making systems in which individuals are members of non-overlapping[21] groups function according to the perceived welfare of the individuals within the sublevels of governments and tend to define their patch boundaries geographically. Obviously decision-making patches aligned in geographic terms allow for the activation of a mechanism for finding the highest peak for any system where spillovers are geographically distributed and decision-making units within the patches are largely congruent.

The implications of this work for institutional innovation may come as a small surprise to those familiar with theories of competitive federalism. Dividing up a complex system into independent self-optimizing decision-making patches can increase the efficiency of the search for optimal system-wide configurations. These theories reflect a broad consensus regarding the benefits of a decentralized system that can work as an efficient sorting mechanism. In fact, dividing a decision-making policy into subunits may be subject to fewer inefficiencies of information transfer; therefore, local governments and consumers will be more likely to make better (welfare-maximizing) decisions.

[20] For a traditional point of view about the optimal structure of local governments, see Hochman, Pines and Thisse (1995).
[21] For more information on the overlapping concept in a federal framework, see Casella and Frey (1992).

On the other hand, there are costs associated with decentralization where jurisdictions are not congruent. But nowadays the assumption of geographically clustered spillovers no longer holds; in fact, there is a strong increase in the magnitude of between-patch spillovers, so the relationship between patch membership and spillovers has been perturbed in a substantial way. Therefore, we must find ways to re-establish the congruence[22] of jurisdiction groups as efficient problem-solving mechanisms. Globalization might reduce the congruence founded on the geographical aspect and give rise to jurisdiction groups with low congruence, and the independent decisions of such patches will be increasingly unlikely to find high peaks on the global welfare landscape.

Patching may be more than merely a metaphor for decentralized systems; those structures may, in a sense, be instantiations of the patching algorithm in the political realm. The underlying mechanics of the patching algorithm appears to be effective precisely because it is destabilizing. This destabilization allows local configurations to change in ways that may be suboptimal in the short term from the standpoint of the system as a whole, driving the system down from suboptimal foothills in fitness space, but these moves alter the environment of other local units, generating reactions and adjustments by these adversely affected neighbors and creating a pull and tug among conflicting rule sets that ultimately allows the overall matrix to achieve a better solution over the course of a large number of moves.

Summarizing the effectiveness of patching as a tool to handle these complex problems depends on the relationship between the borders of the patch and the spillover effects among the single elements. In this context, as highlighted by Post and Johnson (1999), patching seems to work better in a system having the right equilibrium between internalization and non-internalization of the effect for other elements within a patch, like a congruence between 0 and 1.

Implications arise from such discussions at an institutional level, in particular in designing the dimension and the level of government power. Therefore, the central point is to design congruent subgroups that optimize independently. In this way, the local governments that are members of subgroups that do not overlap each other decide on evaluating the effects of behavior on the under-group geographically defined as a patch. This division in independent decisional patch self-optimizing can increase the efficiency and indicate that decentralized decisions are disadvantageous when jurisdictions are congruent or the interdependences are strong. In other words, the institutional federalism seems to work better in systems having an intermediary level of congruence rather than in the cases of spillovers that are weakly internalized inside the patch (low congruence).

[22] Further details about the congruence are in Post and Johnson (1999).

5. Conclusions

This approach points out that dividing up a complex system into independent self-optimizing decision-making patches increases the efficiency of research for optimal welfare because each subunit of the decision is subject to fewer inefficiencies of information transfer. On the other hand, there are costs of decentralization where the jurisdictions are not congruent.

Innovation in institutional design seemingly can be handled by patching, the size of which depends on the relationship between the borders of the patch and the spillover effects among the single elements. This suggests that decentralized decision-making systems like competitive federalism need one efficient method of finding optimal configurations of a problem-solving algorithm which seems to crucially depend on the relationship between spillover effects within-jurisdiction and between-jurisdiction. Hence, the above described methodology seems one of the possible tools useful to redesign the map of institutional sharing power in an era of globalization, considering that it allows to catch Pareto improving in the level of welfare. In particular, as Frenken (2001b) suggests, "intermediate levels of centralization are to be preferred to balance the number of local optima and coordination costs at the one hand and the time-efficiency of search on the other hand" (16).

In this scenario, a form of intermediate coordination between fully centralized and fully decentralized will provide the best outcome; because an intermediate form of coordination applied to a framework with several jurisdictions solves the problem of fully decentralized decision process that are disadvantageous where jurisdictions are congruent or where the interdependences are strong like in the case of globalized world.

References

Alesina A., & Spolaore E. (1997), On the Number and Size of Nations, in Quarterly Journal of Economics 112 (4): 1027-56.

Alesina A., & Wacziarg R. (1998), Openness, Country Size and Government, in Journal of Public Economics 69 (3): 305-21

Atkinson A. B. (2004), New Sources of Development Finance, Oxford University Press, Oxford.

Atkinson T. (2006), Global public finance, Oxonomics 1, pag 2-4, by The Oxonomics Society, Published by Blackwell Publishing Ltd

Berger J.B. (2001), Fitness for Survival & Prosperity, article published on Suite101.com From Peak to Peak: The Quantum Leap, Traveling the Fitness Landscape, articles published on Suite101.com, http://www.bergerconsultant.com/ articles.htm

Bolton P. & Roland G. (1997), The Breakup of Nations: A Political Economy Analysis, in Quarterly Journal of Economics 112 (4): 1057-1090.

Brennan G., and Buchanan J.M. (1980), The Power to Tax: Analytical Foundations of a Fiscal Constitution, Cambridge University Press.

Breton A. (1987), Towards a Theory of Competitive Federalism, European Journal of Political Economy (3): 263-329.

Buchanan J. M, (1996), Federalism and individual sovereignty, in CATO Journal, Fall 95/Winter 96, 15 (2/3): 259-268.

Buchanan J. M. (1995), Federalism as an Ideal Political Order and an Objective for Constitutional Reform, in The Journal of Federalism 25(2): 1-9

Buchanan, J. M. (1978), Markets, States, and the Extent of Morals, American Economic Review 68: 364-68

Casella A., & Frey B. S. (1992), Federalism and clubs: towards an economic theory of overlapping political jurisdictions, European Economic Review (36): 639-646.

David I. (2004), From dialectics to political theology: rethinking complexity in federalism, www.inter-disciplinary.net/AUD/David%20paper.pdf

Deeg R. (2001), Contemporary challenges to German federalism: From the European union to the global economy, Law and Policy in International Business, 33 (1): 51-75.

Egidi M. & Marengo L. (2002), Cognition, institutions, near decomposability: rethinking Herbert Simon's contribution, CEEL, Working Paper, 6-02.

Egidi M. (2001), Biases in organizational behavior, in The Economics of Choice, Change and Organization: Essays in Memory of Richard M. Cyert, Edited by Mie Augier and James J. March, Forthcoming in Edward Elgar

Eisenhardt K. M. & Brown S L. (1999), Patching.(adapting organization structures), Harvard Business Review 77 (3): 72(1).

Elazar D. J. (1991), Exploring Federalism, University of Alabama Press, Tuscaloosa.

Essletzbichler J., & Rigby D.L. (2007), Exploring evolutionary economic geographies, Journal of Economic Geography Advance Access published online on June 27, 2007

Frenken K. (2001a), Modelling the organization of innovative activity using NK-model, paper presented to Nelson and Winter Conference, Aalborg, 12-16 June

Frenken K. (2001b), The organisation of search activity in random fitness landscapes, paper submitted to the volume, Firm Organization and Routines (eds. N. Foss, T. Knudsen, S.G. Winter).

Frenken K., Marengo L. & Valente M. (1999), Interdependencies, near-decomposability and adaptation, pag. 145-165 in Brenner T., Computational Techniques for Modelling Learning in Economics, Kluwer Academic Press

Garrett G., & Rodden J. (2000), Globalization and Decentralization, paper prepared for the Annual Meeting of the Midwest Political Science Association, April 27-30, 2000, Chicago, http://www.yale.edu/leitner/pdf/2000-03.pdf

Garrett G., and Rodden J. (2001), Globalization and Decentralization, paper prepared for the Prepared for the Conference on Globalization and Governance, The Grande Colonial Hotel, La Jolla, CA, March 30-31, 2001

Goodspeed T.J. (1998), Tax Competition, Benefit taxes and Fiscal federalism, in National Tax Journal 51(3): 579-86.

Hayek F.A., (1979), The Political Order of a Free People, vol. 3 of Law, Legislation, and Liberty, Chicago University Press

Hochman O., Pines D. and Thisse J.F. (1995), On the Optimal Structure of Local Governments in, The American Economic Review 85 (5): 1224-40.

Kauffman S. A. (1995), At Home in the Universe, London

Kauffman S.A., & Macready W.G. (1995), Technological Evolution and Adaptive Organizations, Complexity 1: 26-43

Kauffman, S.A., & Levin, S. (1987), Towards a general theory of adaptive walks on rugged landscapes, Journal of Theoretical Biology, 128: 11-45

Krugman P. (1991), Geography and Trade, Cambridge, MIT Press

Lachlan A.A. (1950), Uncertainty, evolution, and economic theory, Journal of Political Economy 58: 211-221.

Ledyard J. O. (2007), The Economics of Informational Decentralization: Complexity, Efficiency and Stability, Essays in Honor of Stanley Reiter, Springer-Verlag

Levinthal D.A. (1997), Adaptation on rugged landscapes, Management Science, 43 (7): 934-950.

Lissack M. R. (1996), Chaos and Complexity - What does that have to do with management? A look at Practical Applications, webpage, http://www.onepine.info/ mcreat.htm

Martin R. & Sunley P. (2007), Complexity thinking and evolutionary economic geography, Journal of Economic Geography 7(5): 573-601

Oates W.E. (2001), Fiscal competition and European Union: contrasting perspectives, in Regional Science and Urban Economics 31: 133–145

Oates W.E., & Schawb R.M. (1988), Economic competition among Jurisdiction: efficiency enhancing or distortion inducing?, Journal of Public Economics 35: 333- 354.

Post D.G., & Johnson D. R. (1999), Chaos prevailing on every continent: Towards a new theory of decentralized decision-making in complex systems, Forthcoming, Chicago-Kent Law Review

Rust J. (1997), Dealing with the Complexity of Economic Calculations, October, invited paper for workshop on, Fundamental Limits to Knowledge in Economics, Santa Fe Institute, July 31-August 3, 1996; http://econwpa.wustl.edu:8089 /eps/comp/papers/ 9610/9610002.pdf

Salmon P. (1998), Competitive Governments: An Economic Theory of Politics and Public Finance in Eastern Economic Journal, Winter 24 (1): 124-126, Book reviews, by Breton A. Competitive Governments: An Economic Theory of Politics and Public Finance, Cambridge University Press, 1996

Shadbegian R. J. (1999), Fiscal federalism, collusion, and government size: Evidence from the states in Public Finance Review; Thousand Oaks 27 (3): 262-281

Simon H.A. (1969), The Sciences of the Artificial, Cambridge MA. & London: MIT Press, 3rd edition, 1996.

Sussman J. M. (2000), Ideas on the complexity in systems –twenty views, February, http://web.mit.edu/esd.83/www/notebook/20ViewsComplexity.PDF

Tiebout C. M. (1956), A Pure Theory of Local Government Expenditures, Journal of Political Economy (64): 416-424.

Waldrop M. M. (1994), Complexity: the emerging science at the edge of order and chaos, London

Williams C. (2000), Coordination in an agent-based division of labor model, www.casos.ece.cmu.edu/conference2000/ pdf/Charles-Williams.pdf