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The transition process in Russia and China and the Ising Model

A Monte Carlo simulation based on the statistical mechanics Ising model

by

Gian Paolo Caselli*
Tommaso Minerva**

January 2000

Università degli Studi di Modena e Reggio Emilia
Dipartimento di Economia Politica
Via Berengario, 51
41100 Modena (Italia)
* e-mail: pcaselli@unimo.it
** e-mail: minerva@unimo.it

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Abstract

In this paper we propose a rereading of the events that have characterized the transition from plan to market in the centralized economies of Russia and China according to the language of phase transitions and tracing an analogy between economic and dynamical physical systems. Using dynamical Monte Carlo simulations of a two-dimensional Ising model, we show that mutual play between microscopic local interactions and microsistemic factors is essential for the development of a stable aggregate of active economic agents.

1. Introduction

The language of phase transitions originally developed in the field of the physics of matter has been, recently, employed as a useful key for interpreting very diverse events, in biology (Peng 1992) and physiology (Suky 1994), to the point where it can describe complex situation like the growth of conurbations (Makse, Havlin, Stanley 1996) and the evolution of prices in the financial markets (Mantegna, Stanley 1995). Applying physical models, or evolutionary, to economics entails the reduction of an economic system to a "dynamical system" in which the mutual interactions among the constituents coexist with macro-systemic effects (Durlauf 1996). The behaviour of the macro-economic system can be obtained from an evolutionary simulation in which the local interactions among economic agents are fully kept into account (Minerva, Poli, Brusco, 1999). The choice of a simple physical model (simple by the nature of the constituents and interactions) does not rule out the onset of very complex phenomena such phase transitions and critical phenomena. The evolution of a simple dynamic system, characterised e.g. by effective mutual interactions solely among contiguous elements, in normal conditions exhibits local fluctuations – that is, changes in one part of the aggregate that exert weak effects on the neighbouring parts and do not appreciably affects the state of the system as a whole. However, there are some situations in which these local fluctuations may propagate to the point where they cause instability on a macroscopic scale. In this case it is said that the system has reached a critical state in which local modifications anyway exert overall effects on the entire system. This seems to conjure up the ideal model inspiring the choices of systemic transformation in the planned economies according to which, once private economic agents are left free to produce and exchange goods, the transition from planned to market economy should occur spontaneously.

In this work we shall show that by tracing an analogy between dynamical physical systems and economic systems, and between physical and economic quantities responsible for the phase transition, conclusions can be drawn regarding the real transformation process. In particular, we shall use the simplest physical system featuring critical phenomena and phase transitions,

i.e. a two dimensional Ising lattice, to describe the different outcomes of the Russian and Chinese transition.
In section 2 and 3 we describe the main features and differences of the transition from plan to market economy in Russia and China. In section 4 we introduce the Ising Model as a model for microscopic magnetic phase transition and we discuss the relevance of such a model with the economic transition in Russia and China. In section 5 we show the results obtained by a Monte Carlo simulation of the transition in Russia and China based on the Ising Model. Differences and analogies are also discussed in this section. In the final section we draw the conclusion of our simulation study.

2. Two different transitions: Russia and China

It may be interesting to compare the reform process of the russian and chinese planned economies for two main reasons: they both were quite big economies in geographical and demografic terms, they were similar from an historical point of view insofar as they had a spontaneous revolutionary process. For these two common features it's a task of different magnitude to reform China and Russia or to reform Slovenia, the Baltic countries or even the larger Poland.
Planned economies have been described as systems where the activity of private agents is structurally impeded by central planning institutions issued by the party-state. For ideological reasons, the latter obstructs private economic activity (Kornai 1992) by creating a system that may be negatively defined as "destroyed capitalism" (Balcerowicz 1995).
Gosplan and the Politburo were the macro-institutions that centrally determined the institutional and economic policy decisions in the planned economy, compelling economic relations to be fulfilled in a hierarchic vertical way, against the horizontal mode of a market capitalist system.
In Recent history, the economic events of countries with a planned economy have shown the following: once the institutions of a planned economy are abolished, the birth and development of a market economy – that is, the development of an aggregate of economic microagents and their mutual relationships – cannot be left solely to spontaneous private economic activity but demand intervention of macrosystemic type, centrally decided and aimed at changing and setting up a network of horizontal economic relations.
The Russian economy transformation's initial stage can indeed be described as a long process of enfeeblement of the planning apparatus, beginning in the post–Stalin era, speeded up during the mid-1980s , and turning, from 1991 onwards, into a conscious dismantling by the Russian governing class of the central planning mechanism, together with the attempt to first engender a socialist market economy and, subsequently, an outright capitalist economy. The institutions and salient features of a centrally planned economy were represented by: 1) the centralized planning mechanism (Gosplan, Gosbank, Gosnab, etc.); 2) a several levels hierarchical organization system hindering competition among goods and services suppliers; 3) the centralization of the right to create, restructure and liquidate industrial enterprises; and 4) a redistribution of funds among enterprises through the state budget and the mono bank financing system .
The dwindling ability of such a complex mechanism to control the economic system was manifested in the high tide of the USRR post Stalin era, with the growth and spread of transactions occurring outside the planned system --- illegal economic activities that, paradoxally, represented a necessary condition for the planned system as a whole work, by reducing its rigidity (Andreff 1993). With the appointment of Gorbachev as Secretary General in 1985, alongside the ever-increasing expansion of the unofficial economy, the first legislative steps were taken towards allowing private activity (law on individual activity, law on

cooperatives, law on firm lease); central planning powers were weakened, in the attempt to create a system in which private economic activity could coexist with a less rigid, less all-embracing planning system. However opaque, this was a move in the direction of market socialism, somewhat recalling the Chinese experience, though in a much more industrialized country. Therefore, this period witnessed the growth of economic activities not subjected to planning, whether illegal or allowed by the new laws. The advent of Yeltsin as President of the Russian Republic and the dissolution of the Soviet Union in December 1991 initiated a period of deliberate dismantling of the centrally planned economy in order to replace it with an overwhelmingly economy characterised by private property and regulated by market forces. The symbolic moment of this transformation was represented by the mass privatisation in early 1992 under the Gaidar government, which simultaneously set in motion a drastic manoeuvre for macroeconomic stabilisation (Aslund 1995).

According to the dominant view, if the transition from a planned to a capitalist economic system is to be successful and increase the economic efficiency of the system, the plan of transformation must be very radical and the number of provisions must attain a critical threshold, otherwise the transition will fail into three parts: 1) macroeconomic stabilisation; 2) liberalisation (liberalisation of prices, elimination of bureaucratic controls over economic activity, liberalisation of foreign trade); and 3) fundamental restructuring of institutions (privatisation of enterprises, establishment of a stock exchange and a watchdog of the stock market, reordering of the banking sector, total reform of the tax system). The second and third elements constitute the real transformation of the system. Therefore, in this process, the activity of the government bodies has a double function: to do away with the previous economic and institutional apparatus and, at the same time, to set up a market economy with all the institutional apparatus needed to function. The other important feature of the transition process is that the change must come about in a very short lapse of time (Balcerowitz 1995).

All the three parts of the transformation plan were launched almost simultaneously by the Russian reformers and the results were not the expected ones: up to now the Russian GNP halved, there has been a tremendous process of deindustrialization and the living conditions of the Russian citizens worsened in a considerable way.

3. China's different path of reform.

The Chinese approach has been totally different from the one followed by Russia in the last ten years (Nolan 1995, Stiglitz 1999); this approach has been characterised by economic gradualism (groping stones to touch the river) and parallel institution building accompanied by limited political reform that nonetheless has been able to accomodate drastic socio-economic changes, without falling into a situation of political and economic chaos that has affected other transition countries (Yongnian Zheng 1999) .

Economic reforms started without a blueprint, but were a sequence of not predetermined reforms, a sequence of experiments that allowed the market forces to start to increase their role, and at the same time decreasing the role of the plan in a process of growing out of the plan (Naughton 1995). In the very beginning this approach has been criticised within the Chinese territory and abroad, as it was deemed not enough radical and insufficient. For the Chinese reformers the efficacy of the reforms had to be demonstrated by their capacity to improve the living standards of the Chinese people and not by the formal consistency of formal economic models; a rapid and radical reform entailed risks and the Chinese ruling class did not want to run, remembering the terrible sufferings of the Chinese people in this century. The post-Maoist leaders were determined to go slowly, leaving great space to local experimentation, but at the same time keeping under control the whole process. The chinese transition experiment may be conceived as a path-dependent evolutionary process in which "reform strategy matters,

but depends on history" (Yingyi Qian 1999) and whose social and economic effects were carefully checked by the chinese central institutional apparatus. This reform process was at the same time centrally directed and spontaneous in its local effects. To set an example, the households responsibility system and its dual track system arose spontaneously in Anhui Province at the end of the seventies, and the party endorsed it only at the end of 1982 then extended after checking for its success to other agricultural areas of the country. Given the success of the dual track system in agriculture, this method of agricultural output division was applied to the industrial sector by the Chinese government in 1984.
The incremental features of the Chinese reform process may be followed looking at the decisions taken by the highest organs of the Chinese communist party.
The reform process begun in December of 1978 when the Third Plenum of the Eleventh Congress of the Chinese Communist Party decided "to reform and open up". The main measures were taken in the area of regional decentralization of government functions, of opening up the economy with the establishment of special economic zones, fiscal decentralization and the household responsibility system in agriculture.
In 1984 The Third Plenum of the Twelfth Party Congress adopted a resolution in order to extend the reform to urban areas in which the role of market forces was recognized alongside the main role of the plan. Following this resolution the dual track approach was extended to the industrial sector , a reform of the monobank banking sector started, the establishment of town and village enterprises outside the plan was permitted; at the end of the eighties, this sector became the most important sector of the Chinese economy.
A burst of inflation in 1988 and the Tienanmen square massacre put a brake on the process of economic reform. But a new wave of reforms began in 1992 whose goal was the establishment of a Chinese socialist market economy; this goal was announced at the Fourteenth Party Congress in September 1992 and the details of the economic policies necessary to achieve this goal were set down at the Third Plenum of the Fourteenth Party Congress in November 1993. The following step was represented by the declaration taken at the Fifteenth Party Congress, which stated that State ownership was simply a "pillar of the economy " and private property was regarded as " an important part of the economy".
This principle was written in the Chinese constitution in the amended Article 11 which stated that "the non public sector, including individual and private business, is an important component of the socialist market economy ".
Between 1994 and 1998 the main part of reforms have been made in the area of foreign reserves (where central plan allocation of foreign exchanges was abolished), in the banking sector (where the central bank, according to the central bank law of 1995, was given the task of conducting an independent monetary policy), in the government sector (where many industrial ministers were abolished and the number of civil servants was cut by half down to four million employees). In the area of state owned enterprises a process of privatisation took place under the slogan "grasping the large and letting go the small", meanwhile, state owened enterprises began to fire their employees, breaking for the first time an ideological taboo.
The striking side of the Chinese Reform Process was that the institutions of the old planning apparatus were not abolished until the new ones were ready to function without the creation of an institutional vacuum in such a way that the new market agents had plenty of time to learn the different economic behaviour requested by a market environment. No such a time was given to the Russian if the reform process is conceived not only as a process of changing prices and institutions, but also as a mind changing process.
The Chinese reformers had two different tasks: to assure a rapid economic development of a very poor country and at the same time to reform the planning mechanism avoiding the danger of hindering the Chinese economic development with a too quick reform of the planning apparatus. In the last twenty years they were successful: the Chinese economy had an outstanding growth performance and at the same time even at a cursory glimpse the economic

machinery underwent a radical change. The co-presence of spontaneous microeconomic phenomena and macrosystemic changes directed from the centre is essential for understanding the nature of the transition from plan to market of the Chinese and Russian economies, and many of the differences among the Russian and Chinese results can be referred to the different dynamics by which these factors have influenced one another.
A dynamical Monte Carlo simulation based on the Ising model of the spin magnetism can be used to explore the differences and the analogies in the Russian and the Chinese transitions from plan to market. In the next section we illustrate the main features of the Ising model and we establish the analogies with the economic system under investigation.

4. The Ising Model

Let us now describe the features of a generic aggregate of micro agents subjected to exceptionally simple mutual interactions, that will make up the model with which we shall simulate the events leading to the transition from planned to market economy.

The dynamic system employed is shown in figure 1. This is a two-dimensional lattice in which each lattice point represents an *'agent'*; each agent, e.g. the *i-th* agent, is characterised by a quantity σ_i (the *spin* of the *i-th* agent) that may assume only two values +1/-1 (activated / non-activated, represented in the figure 1 as black dot or white dot, respectively). It is then supposed that each agent may interact only with its nearest neighbours and that this interaction tends to force the variable σ_i, associated with each agent, to assume the same value: an activated agent (site marked by a black dot, i.e. $\sigma_i=+1$) will tend to compel activation of the nearest agents, just as a non-activated agent (white dot, $\sigma_i=-1$) will tend to compel non-activation of the neighbouring agents. By analogy with magnetic systems, for which the Ising model was originally formulated, the variable defining the state of each agent will be called *'spin variable'*, and the microscopic interaction will be said to be such as to favour a local alignment of the spins.

The analogy between this dynamic abstract system and the economic system under study consists in identifying each private economic agent with a point in the two dimensional lattice; the spin variable ascribed to each node/agent corresponds to the ability of that agent to be 'economically active': thus $\sigma_i=+1$ means that the agent is active on the economic stage, producing goods and services and wishing to exchange them, whereas $\sigma_i=-1$ means that the agent is not active. In the first case we have an agent following the market economic rules while in the second one we have an agent following the plan economic rules. The presence of an agent active on the market, i.e. ready to exchange goods, will favour the activation on the market of the contiguous agents and, conversely, the presence of non-active agents will favour the deactivation in the neighbourhood. In this sense, the mutual interaction among contiguous agents tends locally to favour the alignments of the spins on different nodes.

Besides microscopic interaction, the physical model contains three important macroscopic parameters: the quantity T (*Temperature*), that defines the degree of disorder of the system, a quantity that we shall call H (*External Field*) and that, on the contrary, tends to favour a global spin alignment and another quantity, we call it J (*Exchange Term*), that measures the strength of the local interactions. A high value of T is associated to a high tendency of the system to exhibit a disordered phase, i.e. the tendency to break the local spin alignment. A low value of T, on the contrary, will favour the establishing of an ordered phase with a high level of spin alignment. A phase transition, order/disorder, behaves on passing through a critical state. The temperature parameter, *T*, plays an essential role in the attainment of the critical state and the achievement of the phase transition: by diminishing the value of T, a critical situation in which the tendency to spin alignment will no longer be hindered can be reached, and the microscopic interaction among the neighbour agents can extend to the point where it defines an order on macroscopic scale.

Also the quantity H is a macroscopic parameter that tends to favour a collective orientation of the spins and it is, this way, an element of order that influences the attainment of the critical state. In the physical system the two values of spin (+1 / -1) are equivalent. The system can exhibit an ordered phase with *down* alignment or, equivalently, an ordered phase with *up* alignment. In absence of external field ($H=0$) the two alignments are equally probable while in presence of a non-negligible external field the sign of H indicates the preferred alignment.

The system evolves towards an equilibrium state depending on the value of the parameters T, H and J and characterised by the minimum value of an objective function (*the energy,* in the physical system) associated to the statistical equilibrium configuration. The equilibrium is dynamical. To each node corresponds a spin flip transition probability and spin transitions continuously behave in the lattice. The transition probability depends on the entity of the energy variation induced by the spin flip and by the value of the temperature, T. The higher the energy variation is, induced by the spin flip, the lower the transition probability rate will be, while a higher T means a higher transition probability. A high value of T will favour the change of the spin states and a low value of T will depress the spin transitions. In this sense T is an order parameter.

The dynamic evolution of a two-dimensional Ising lattice can be simulated by techniques of statistical mechanics. For all the simulations we referred to a 2D-50x50 Ising lattice corresponding to a sample of 2500 interacting agents. Let us assume then, that the system is in a given configuration, characterised by a random distribution of spins (for example, the one shown in figure 1), and let us ask whether the system, if subjected to the forces we have described, will tend to modify this configuration, and if so, which stable configuration it will tend to assume. In qualitative terms the answer is very simple: in a regime of high order (low T) the configuration of figure 1 is certainly not the stable one and the system will evolve towards a configuration of perfect spin ordering. To make this argument more quantitative and to obtain definite answers also in the regime of intermediate order it is useful to follow the general principia of systems dynamical evolution and equilibrium. For each dynamical system, known the mutual interaction among the components, we can define a quantity, the Hamiltonian, (Goldstein 1965) depending on the microscopic variables of the system. The minimum in the Hamiltonian corresponds to the equilibrium configuration of the system. The system, under the action of the forces acting on the micro-components, evolves toward the configuration corresponding to the minimum of the objective function represented by the Hamiltonian. For an Ising lattice this objective function, E, depends by the microscopic variables, σ_i, and can be written as (Parisi 1988):

$$E(\sigma_1,\sigma_2,\dots,\sigma_{n1}) = -J\sum_{ij}\sigma_i\sigma_j - H\sum_i\sigma_i \tag{1}$$

where the summation is extended to the first neighbours (this means that we include in the model only first neighbours interactions) and J is a positive constant that describes the coupling intensity between contiguous spins, while H is a constant that may be positive or negative: given that the first addendum in (1) is negative when all the spins are parallel (or all + or all -), this term will favour an equilibrium configuration (minimum objective function) characterised by the local alignment of the spins. The second term is not associated with a mutual interaction among the individual agents, but with the interaction among the agents as a whole with an 'external field' H which will favour a collective orientation of the spins in a direction opposite to H. In the dynamic systems with which the physics of matter is concerned, this objective function is the total energy of the system. In order to include the effects of macroscopic order/disorder associated with parameters T and H, one may proceed by using simulative techniques based on the Monte Carlo approach (Novotny 1995). These techniques are founded on the fundamental assumption of statistical mechanics according to which the probability of a given configuration follows the canonical distribution:

$$p(E) \propto \exp(-\frac{E}{K_b T}) \tag{2}$$

where E is the value of the objective function (the Hamiltonian) in that configuration and T represents a measure of the degree of disorder of the system (K_b is merely a constant of proportionality and often the term $\beta = 1/K_b T$ is used as an equivalent of the temperature). The configuration, for which the value of E is minimum, will be the configuration with maximum probability, i.e. the equilibrium configuration; the larger T is, the smaller will be the differences between the different configurations in terms of probability (Kornay 92) and more favoured will be the spin transitions.

A possible evolving algorithm based on the Metropolis-Hastings schema can be summarized as follows: starting from a random initial configuration of spins in the 50x50 cells lattice we randomly select a cell and extimate the difference:

$$\Delta E = E_1 - E_0 \tag{3}$$

where E_1 represents the value assumed by the hamiltonian function if the spin of the selected cell change its value respect to the initial state and E_0 is the corresponding value in the initial configuration. Then randomly select a sample, r, from the continous uniform distribution $U(0,1)$. If $\exp(-\beta\Delta E) > r$ we accept the move (spin flip) obtaining a new spin configuration else we refuse the move leaving unchanged the spin map.

We repeat these steps until the hamiltonian reaches a stable configuration, a dynamical equilibrium state, depending by the macroscopic quantities T, J and H. In such a way we obtain a simulation of the dynamical evolution of the system toward the highest probability configuration.

As recalled, in physical systems the phase transition corresponds to the passage from a state of disorder to one of collective order or viceversa. This passage occurs at determinate values of the macroscopic parameters. In the case under investigation the macroscopic parameter driving the transition is T, and the value where the transition happens is appropriately called 'critical temperature', indicated by T_c: if we introduce a parameter, the disorder parameter $R = T/T_c$, then for values of $R > 1$ (corresponding to $T > T_c$) the local order favoured by the microscopic interactions is contrasted by the high effect of disorder while for $R < 1$ (this corresponds to the case $T < T_c$) the tendency to local ordering extends to involve the system as a whole. This behaviour is depicted in figure 2 where the evolution of the dynamic system we have described is shown in successive steps of the simulation and for different values of parameter R (or equivalently different values of temperature T). It can be noted how, starting from the same initial configuration, the evolution of the system depends on the value of the disorder parameter R, and how only for $R < 1$ ($T < T_c$) does the local tendency to order manage to propagate until it becomes a global feature of the system. Thus we observe that for values of $R>1$ ($T>T_c$), starting from an initial configuration in which the proportion between active (black dots in figure) and inactive agents (white dots in figure) is slightly slanted in favour of the latter, a situation is attained in which this unbalance is cancelled owing to the relatively high value of the disorder parameter in such a way that the final configuration involves an equal percentage of active and inactive agents.

In the two cases where the value of T is lower than the critical value ($R<1$), the interaction among contiguous agents that favours alignment of spins on different sites is no longer hindered and the system evolves towards a state in which the initially preponderant spin extends to all the sites. In the case depicted in figure 2, the final configurations at $R < 1$ ($T < T_c$) are therefore characterised by a global order where the agents are almost all inactive. Quite different is the case in which the initial configuration features a preponderance (even minimal) of active agents: in this case, the dynamic evolution of the system will, in the case $R<1$ ($T<T_c$), once again attain a situation of complete order, but with nearly all its agents active. Thus if the initial configuration shows a difference between active and inactive agents, resulting from the effect of the mutual forces that tend to favour a global spin alignment, it will evolve towards a configuration in which the initially preponderant spins will overwhelmingly prevail. While the role of the macroscopic variable T is to define whether the situation will be one of the two ordered phases or a disordered one, the role of the initial configuration is to define whether the active or the inactive agents will prevail in the situation of order. Thus figure 3 shows the evolution of the Ising lattice for different values of T (R), starting from an initial configuration in which the active agents preponderate.

Calculating the percentage of active agents out of the total can follow the attainment of the critical state and the phase transition; this quantity is reported in figure 4 for various cases. Note that only for $R<1$ ($T<Tc$) the number of active or inactive agents is around 100% (maximum order) at the end of the simulation, whereas for values of $R>1$ (T greater than T_c) the number of active agents oscillates round 50% representing the absence of a preferential orientation (maximum disorder).

Lastly, in order to clarify the role of the macroscopic parameter H, figures 5a and 5b shows the dynamic evolution of an Ising lattice in presence of a positive external field H that tends to impose a generalised activation of the agents: different values of H, even in presence of a high disorder ($R>1$ or $T>T_c$), determine a stable configuration in which the number of active agents is markedly greater than the 50% proportion than would be the case with $H=0$. The same will happen for a negative external field in which the preferred order imposes a deactivation of the agents. The role of H is then to indicate to the system (out of the possible two states) the preferred alignment of the spins or, in other words, the preferred order. If the temperature is below the critical point then the system will evolve toward the ordered state indicated by H with a rate depending from the strength of the external field.

In the analogy between the Ising model and the economic system that we propose to draw, the parameters T and H were associated, in a previous work (Caselli, Manghi 1999) with the macro systemic parameters linked to the existence of centralised intervention in the economy and structures of planning. In this paper we redefine the association between physical parameters and socio-economical behaviours obtaining a finer tuning of the role of T and H but preserving all the results reported in the above cited reference.

We have emphasized how the presence of an active private agent in the economic arena tends in itself to favour the activation of neighbouring agents. On the contrary, the presence of non-active agents tends to depress the activation of further agents. The presence of economic plan activities opposites to the agent activation while the prevalence of market rules tends to favour the activation of the agents. In the first case an active agent may exchange goods only with the centralised enterprises instead of with contiguous agents, thus weakening the effect of mutual activation. The interventions centrally determined in order to obstruct or stimulate private entrepreneurship are described by an external macroscopic parameter that favours the generalised activation or deactivation of private agents; in accord with the language previously used, this macroscopic magnitude is the *'external field H'*, which, as we shall see, does indeed indicate a *'preferred'* collective spin orientation - that is, an activation or a deactivation of the economic agents that cannot be referred to 'microscopic' mutual interactions but is associated with an overall effect decided from above.

In a social system the indication of *'a preferred'* state (plan or market) is not enough to determine the collective behaviour. The system must have the force to impose the rules. In other words the system has to be able to stabilize its state and to opposite to the transitions. In a planned economy this means that in some way the activation (transition to market) has to be strongly hindered and the same happens in a market environment where transitions to a planned behaviour cannot be considered. In the first case the transitions are neglected by social and political rules while in the second case it is the intrinsic structure of the market economy that hinders the transition. In the Ising system the temperature plays a similar role. So we associated the temperature to the ability of the system to enforce the rules, to the ability to hinder the agent transitions from a state to the opposite one. A low value of T (less than the critical value) means a capability to discourage the spontaneous transitions: an ordered state. A high value of T (greater than the critical value) means that the system is not able to keep the control of the collective behaviours: a disordered state.

5. Monte Carlo simulation for Russian and Chinese transitions from plan to market

We are now in a position to use the phase transition in a two-dimensional Ising model as a metaphor of the transition from planned economy to market economy. We describe two kinds of transitions. The first corresponds to Russia, a case of uncontrolled transition, and the second corresponds to China, a step-by-step controlled transition. Let us then consider an initially planned economic system, in which not only the economic activity entirely governed by the planning apparatus but also private economic activities are deliberately hindered for ideological reasons the economic activity are entirely governed by the planning apparatus and the private inititives are deliberately hindered for ideological reasons. Talking about Russia, this situation corresponds generically to the Stalinist phase. Translated into the terms of the model we have adopted, this corresponds to a lattice in which almost all the agents are inactive, parameter T has a low value, $R < 1$ or $T < T_c$, (strong political control) and the parameter H is different from zero but of a sign such as to impose a preferential tendency to deactivation.

The first phase of the simulation considers a period in which the political control on the economy has been weakened by the events (or deliberately kept weak) but the model still is a planned economic system. In such a situation a not negligible amount of agents are active on the economic stage but they are playing against the plan and the political apparatus is not able to control (or tolerate) them. In terms of our Ising model this phase corresponds to a disordered phase with T>>Tc (weak control) and H<0 (preferred alignment indicated by the external field corresponding to strong presence of a planned economy structures). This last choice is necessary in order to describe a situation in which a strong planned economic activity, which would produce by itself a configuration in which the agents are active and inactive in equal proportion, is not however sufficient to bring out an appreciable activation of private economic agents.

The second phase, the one corresponding to Gorbachev's reforms, corresponds to a decrease of the value of the parameter T to indicate the attempt to take the control of the economic activities but gradually eliminating explicit impediments to the activity of private agents even in presence of planned economy activities ($H \cong 0$). This is ***still*** a phase ***in which*** the political power shows the lack of control on the economic activities ($R>1$, $T>T_c$, a disordered phase) but an economic model (plan or market) is not deliberately indicated. In the last phase the entire plan's structures are removed and a control has been enforced (but within a different set of rule,

the market rules) it therefore shows a reduction in parameter T below the critical value while the 'external field' suggest a market behaviour (H>0). The second phase, immediately preceding the one in which the transition occurs, is actually the most important for defining the positive or not positive outcome of the transition itself in economic terms: for in this passage the starting configuration for the last step in the dynamic evolution is determined. As previously said, the fall of parameter T below the critical value has the effect of causing all the spin variables to move to the value prevailing at the moment when T is lowered. At the end of the transition if the starting configuration had the active agents in a majority, even only a small one, all the agents are active. On the contrary, all agents will be inactive if the strarting configuration had a majority of inactive agents. This can be clearly seen from the results of the dynamic simulations shown in figure 6, where the dynamic evolution of the two-dimensional Ising lattice is shown for the three phases described above. The role of parameter H in the second phase – i.e. of the incentives (legislative, economic, etc.) towards private activity - is crucial to determining the nature of the final configuration of the whole process of transition. This is shown in figure 6 by choosing two different values of H able to determine an unbalance, even if slight, in favour of the inactive agents (case a) or the active ones (case b). This is the economic point that can be deduced from our model, independently of the deliberately drastic simplifications we have adopted. Therefore, from the outcomes sharply counter posed and represented by the simulations reported in figure 6, two different scenarios are possible; what differentiates the two cases is the configuration reached by the system in the period immediately preceding the abolition of the planning apparatus when the political system was not able to give a government to the economy.
In the Russian simulation an intermediate disordered phase ($T > T_c$), corresponding to a lack of political control on the economy, can have a relevant influence on the final state. The situation is quite different for the Chinese one. In this case a controlled step-by-step collective transition has been activated on a long period. The transition from plan to market economy follows several phases. In each phase a sector of the economic activities has been left free to move toward a market behaviour. The agents involved in that sector were slightly stimulated to assume an active state but the central government kept the rules under control, although two different set of rules coexist: market rules in the liberalized sectors and plan rules in the centralized sectors. In term of our model this means that in the Chinese case the temperature is always below the critical point, $R<1$ or $T<T_c$, (ordered state) while the 'external field' assumes a different sign and intensity in different zones of the lattice. In the liberalized sector the sign of the field is compatible with an activation of the agents while in the planned zones the sign of the field inhibits the agent activation. In this case we have the presence of 'local activating fields' corresponding to economic sectors or geographical zones were the transition from plan to market is favoured. The local stimulation process can induce economic activation on agents contiguous to the active zones even if they are not directly involved in the transition but they feel the influences through the local interactions with activated agents.
The dynamical simulation, within the Ising model and the Monte Carlo approach, follows these guidelines. We started with a lattice where the majority of the agents are inactive, resulting by $T < T_c$ ($R < 1$) and $H < 0$. This means that the preferred alignment of the spins is negative ($\sigma_i=-1$) and the transitions to positive states are statistically unfavoured. In other terms, the system indicates a preferred state (plan economy, i.e. non active agents) and has the capability to impose it ($T < T_c$). The simulation proceed through 5 different intermediate phases where we kept constant the value of $T < T_c$ ($R = 0.8$ *or equivalently* $T = 0.8 * T_c$) but greater then the corresponding value in the initial and final state ($R=0.5$ *or equivalently* $T = 0.5 * T_c$). This indicates that during the transition the state flips are less hindered than in the extreme phases. In each phase, we simulated the step-by-step activation by introducing a *'local activating field'* positive and able to stimulate the agents activation. In other words each phase is characterized by the turning on of a positive field in a well-defined region of the Ising lattice while outside

the background negative field still acts. This corresponds, in our simulation, to different phases of the controlled Chinese transition from the plan economy to the market economy. Each *'local activating field'* has to be interpreted as an action undertaken by the Chinese government in order to introduce market economy in a well-defined sector of the economical activities. The final phase correspond to a complete transition where the plan constrains has been removed and a non-negative external field will be present on the whole lattice. The goal of the simulation is to study the dynamical evolution of such a system respect to the percentage of activated agents at the end of each phase (mainly related to the extent of the 'activating field'), to the contamination effects on regions contiguous to the activated ones and to the ability to obtain a transition to a full market economy.
In Table I we show the parameters we used to characterize the different phases of the dynamical simulation for China. In this table the value of H_0 corresponds to the initial negative external field and to the background field for all the intermediate phases (intermediate phase 1 – intermediate phase 5) while the value of H_i, $i=1,..5$, represents the value of the positive activating field defined on localized regions. The final phase, characterized by H_f, corresponds to the situation where the active state is indicated as favoured on the whole lattice. In the same Table we also show the extent of the activated regions (S_a) as well as the percentage of active agents (n_a) at the end of each phase. For each phase (except for the initial and final state) we considered a simulation running on 50 time steps.
The information on the localization of the activated zones and on the steps of the dynamical evolution of the lattice is shown in Figures 7a and 7b where we present, respectively, the maps of the activated regions (*white=background field, black dot=positive local field*) to be compared with the corresponding maps of the agent states (*black dot=active, white dot=inactive*). In Figure 8 we show the percentage of active agents through the dynamical simulation. The dotted and dashed curves in figure 8 represent the evolution of the system if the final condition ($H_f=0.1$ and $R=0.5$) were imposed at the end of the intermediate phase 3 and the intermediate phase 4, respectively. These cases correspond to liberalization before the active agents reach the 50% of the total.
The results seems indicate that such controlled step-by-step transitions can induce activation effects also in regions contiguous to that with an activating external field. This is evident in figure 7a and 7b and in Table I. In fact, we can find active agents also in the neighbourhood of the activated zones. The rate of number of active agents in connection with the extent of activated zones is close to two, indicating that for each agent directly activated we can observe another agent indirectly activated.
In terms of our Ising lattice, a complete transition from plan to market can be activated only if the active agents are more than 50%. In this case if we keep the temperature below the critical point and impose a null (or slightly activating field) the system will evolve toward a complete (or almost complete) agents activation on the contrary if the active agents are less than 50% of the total the system can evolve toward a stable configuration where the agents are not totally activated and the transition plan to market is not fully performed.

Conclusions

The outcome of the economic transformation process of the former planned economies in market economies is not at all clear and moreover there are non negligible differences among countries: if we take into account the GNP growth it is quite evident that only the transition process in Poland may be considered as a successful experience, while until 1999 the Russian one is an example of a complete failure (Stiglitz 99, Kolodko 99, Aslund 99). On the contrary the Chinese transition process which is occurring in an historical and institutional setting is quite different from the Russian and the Polish one, and it is characterized by a strong growth which began in 1978 and it is still going on. It may seem strange to put together the Chinese and Polish transition, but what the Chinese and polish transition have in common is the long period of time, all the eighties, during which the Polish government of general Jaruselski and the Chinese one of premier Den Tsiao Ping, favoured, for quite different reasons, the birth of market agents, weakening the planning institutions and creating an economic situation which has been defined in Poland as creeping capitalism (Poznansky 96) and in China as dual track system (Nolan 95). This long period of time has been necessary for the economic agents to learn market economic behaviour, which cannot be learnt immediately after the quick dismantling of planning institutions. In our opinion the transition process entails not only a macro stabilization package, a liberalization process, and a building institution; what is usually forgotten in the transition literature is the learning process that must accompany the creation of a market economy, a process which necessary takes time and must be accomplished in a quasi-stable environment. This time has been given to Chinese and Polish people. In Soviet Union and in Russia afterwards, for historical and political reasons, this long time period of time has not been given to the economic system and when the planning mechanism was dismantled there were few and not enough strong economic agents in the economic scenario. The horizontal market relationships were underdeveloped and tweak and the behaviour routines used for seventy years in a planned economy could not be abandoned quickly and the new behaviour routines of a market economy could not be learnt in one night.

The model we used, in spite of great simplifications, enabled us to emphasize a crucial economic point, i.e. the importance, in the model as in the reality, of the macro-systemic interventions, which have the function of preparing the system to the transition. These macro-systemic interventions must guarantee that the configuration of the economic system, in the phase before the abolition of the planning mechanism, is able to activate a number of active agents that may give rise to a generalized activation of micro-economic agents.

The phase transition necessarily occurs when the planning mechanism is weakened above (below) a critical value, as our dynamic simulations have shown. What is not determined is the success of the transition: in fact, if the weakening of the planning apparatus is not accompanied by an effective central intervention which favours the birth of market active agents, the transition will evolve towards a generalized state of deactivation. The mutual play of micro-local interactions and macro systemic interventions is therefore essential in order to reach the critical phase, but also for the successful outcome of the whole process of transition.

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Table I					
Phase	**Field (*H*)**	$R=T/T_c$	$S_a(\%)$	$n_a(\%)$	n_a/S_a
Initial (plan)	$H_0=-0.2$	0.5	0.0	1.8	---
Intermediate 1	$H_1=+0.8$	0.8	4.2	8.6	2.1
Intermediate 2	$H_2=+0.3$	0.8	10.3	18.8	1.8
Intermediate 3	$H_3=+0.6$	0.8	11.7	25.9	2.2
Intermediate 4	$H_4=+0.5$	0.8	16.8	43.2	2.6
Intermediate 5	$H_5=+0.3$	0.8	22.1	51.3	2.3
Final (Market)	$H_f=+0.1$	0.5	100.0	85.3	---

2D-(50x50) Ising Lattice

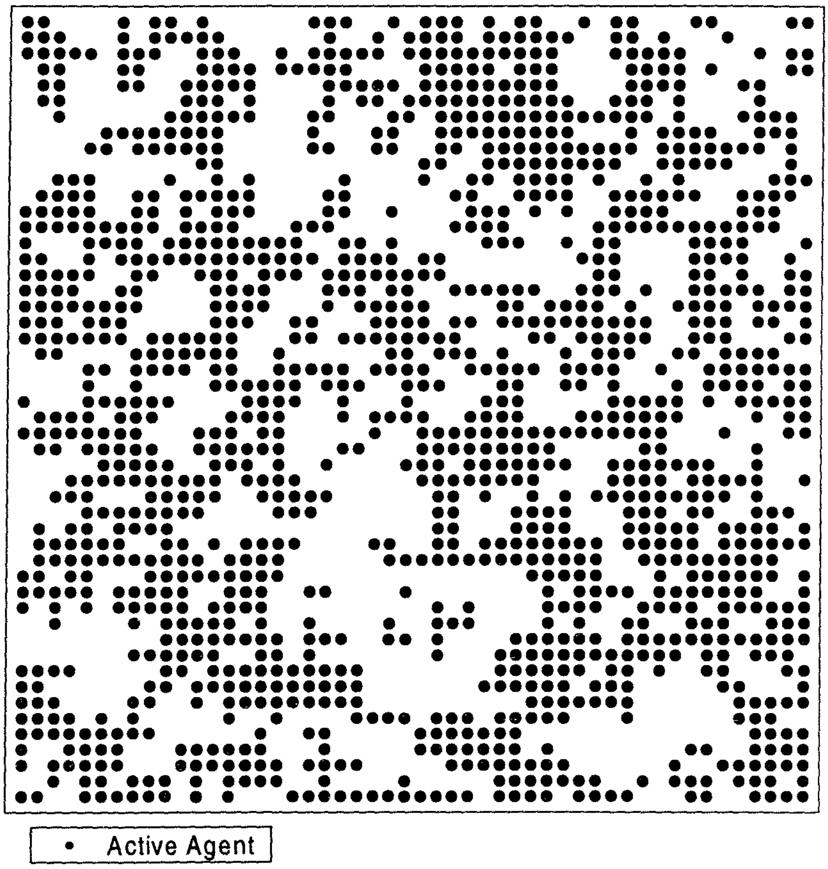
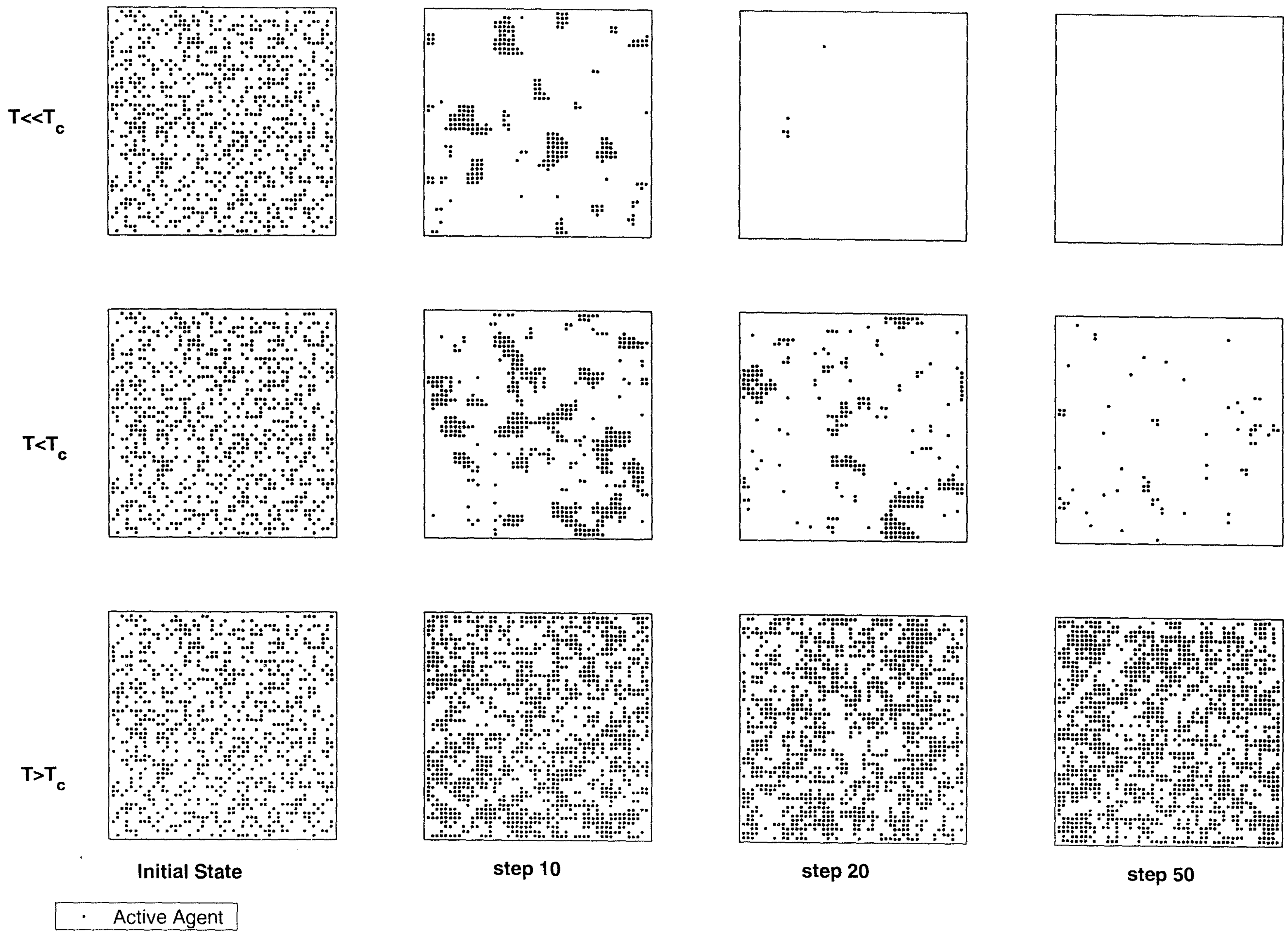
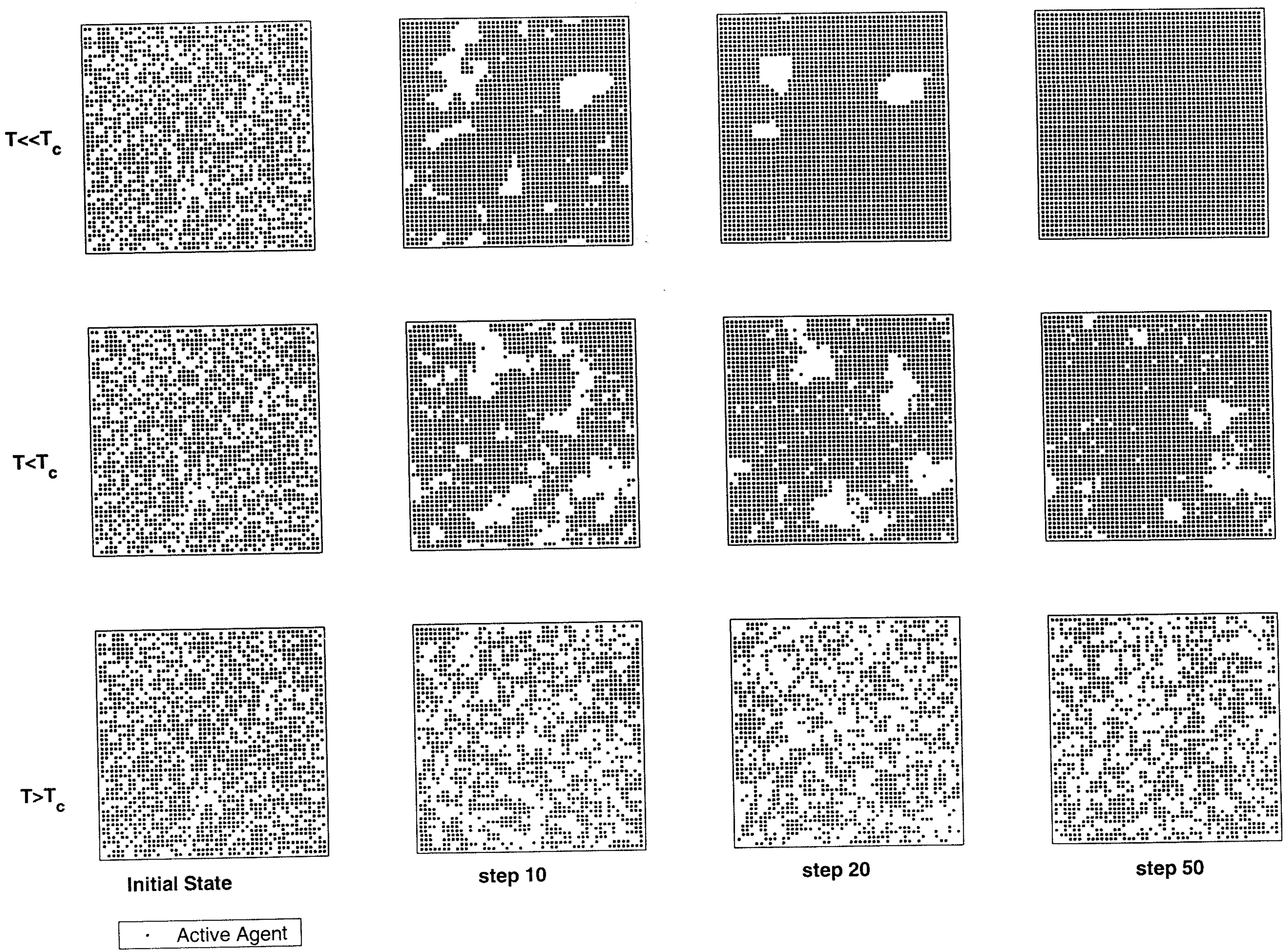


Figure 1



T<<T$_c$
T<T$_c$
T>T$_c$
Initial State
step 10
step 20
step 50
Active Agent

Figure 2



T<<T$_c$
T<T$_c$
T>T$_c$
Initial State
step 10
step 20
step 50
Active Agent

Figure 3

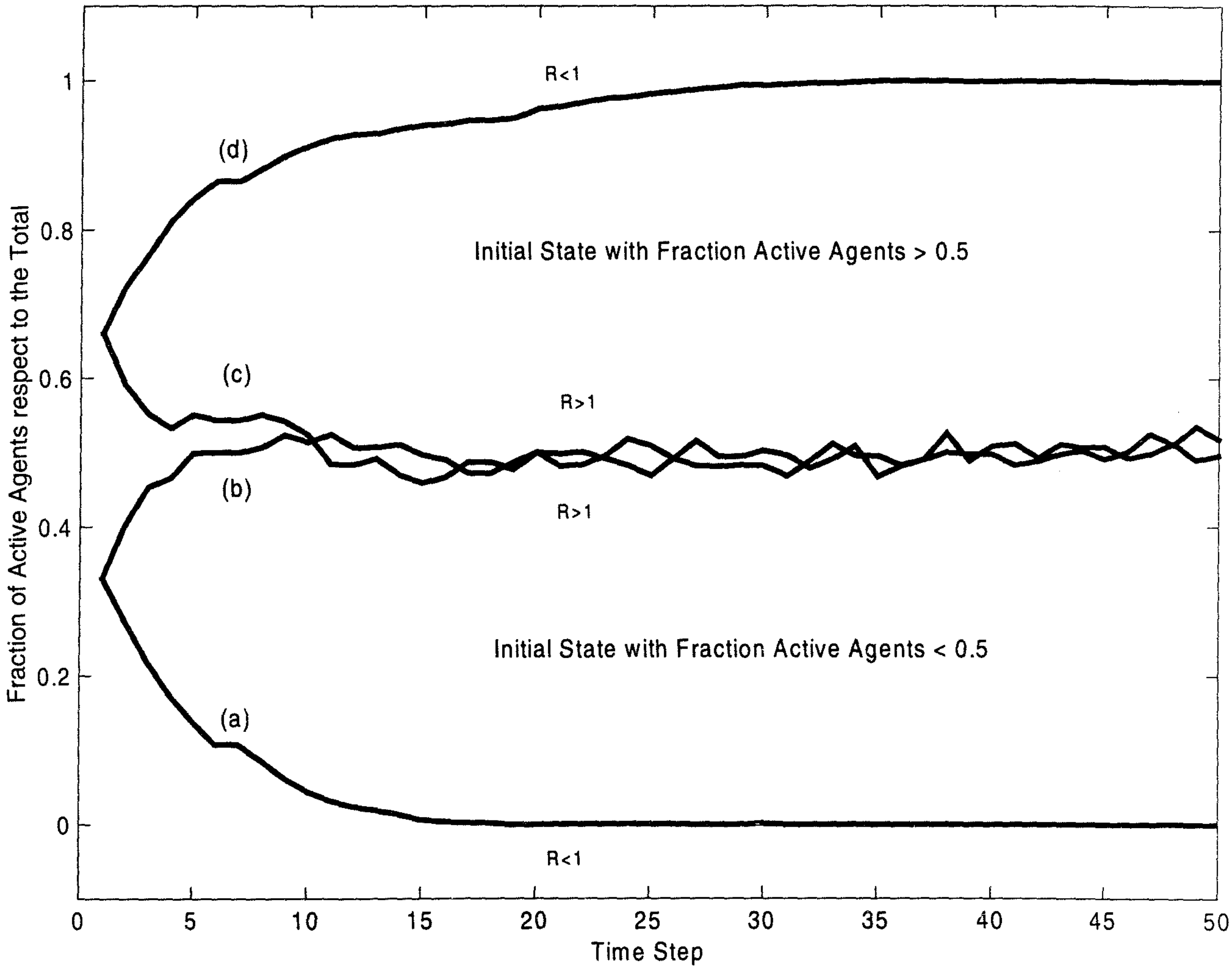

R<1
(d)
Initial State with Fraction Active Agents > 0.5
(c)
R>1
(b)
R>1
Initial State with Fraction Active Agents < 0.5
(a)
R<1
Fraction of Active Agents respect to the Total
Time Step
0
0.2
0.4
0.6
0.8
1
0
5
10
15
20
25
30
35
40
45
50

Fig. 4

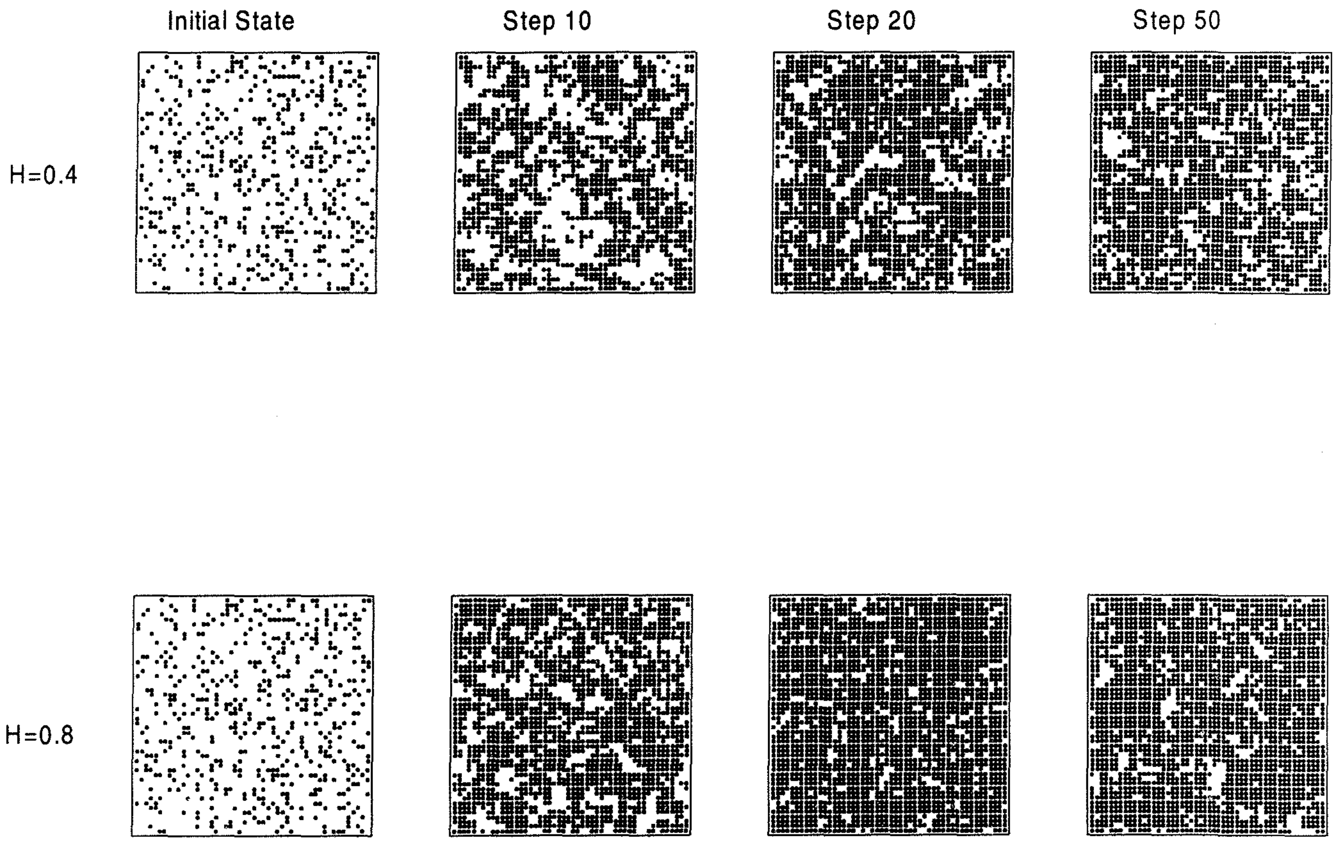


Figure 5A

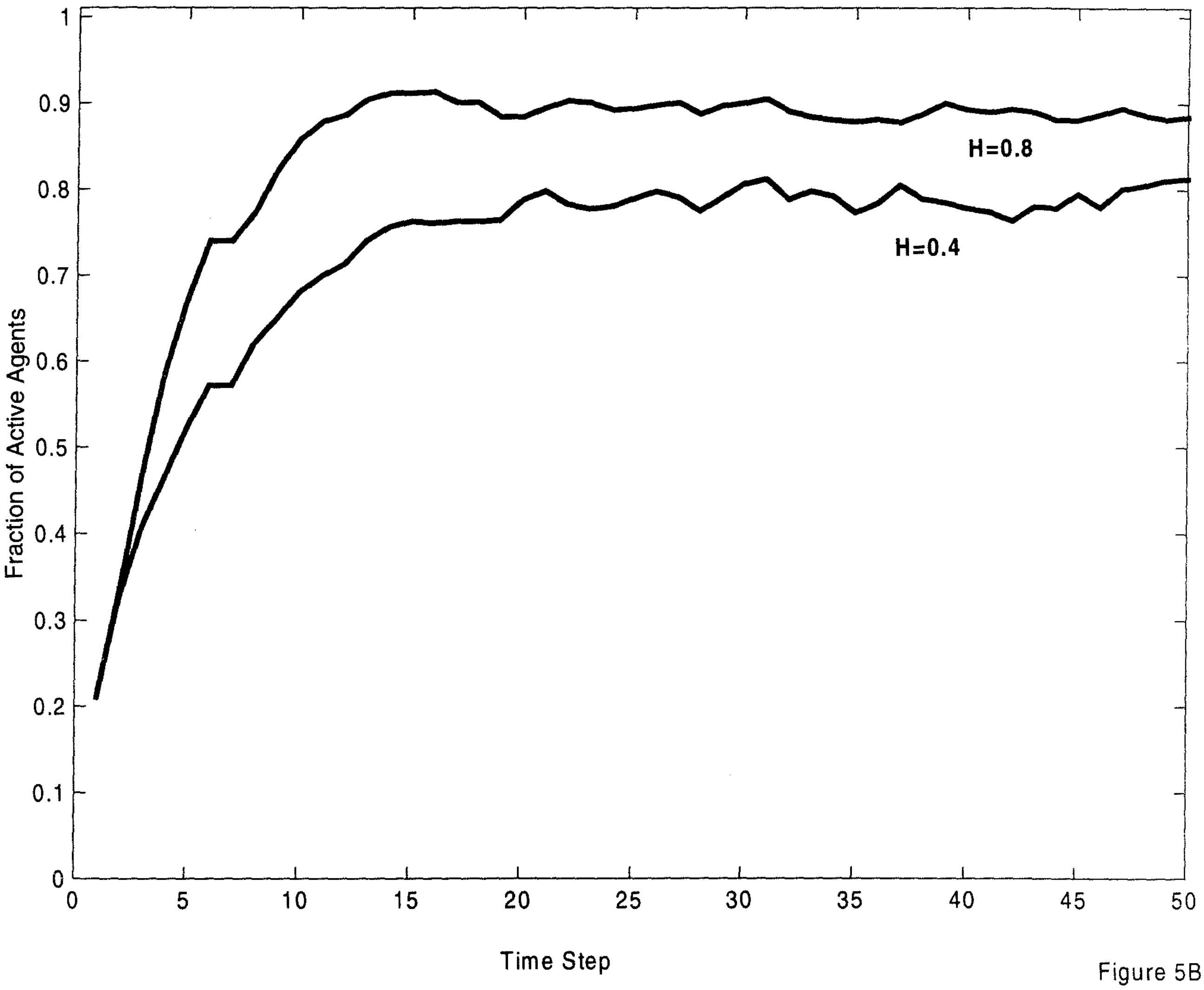

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Fraction of Active Agents
H=0.8
H=0.4
0
5
10
15
20
25
30
35
40
45
50
Time Step

Figure 5B

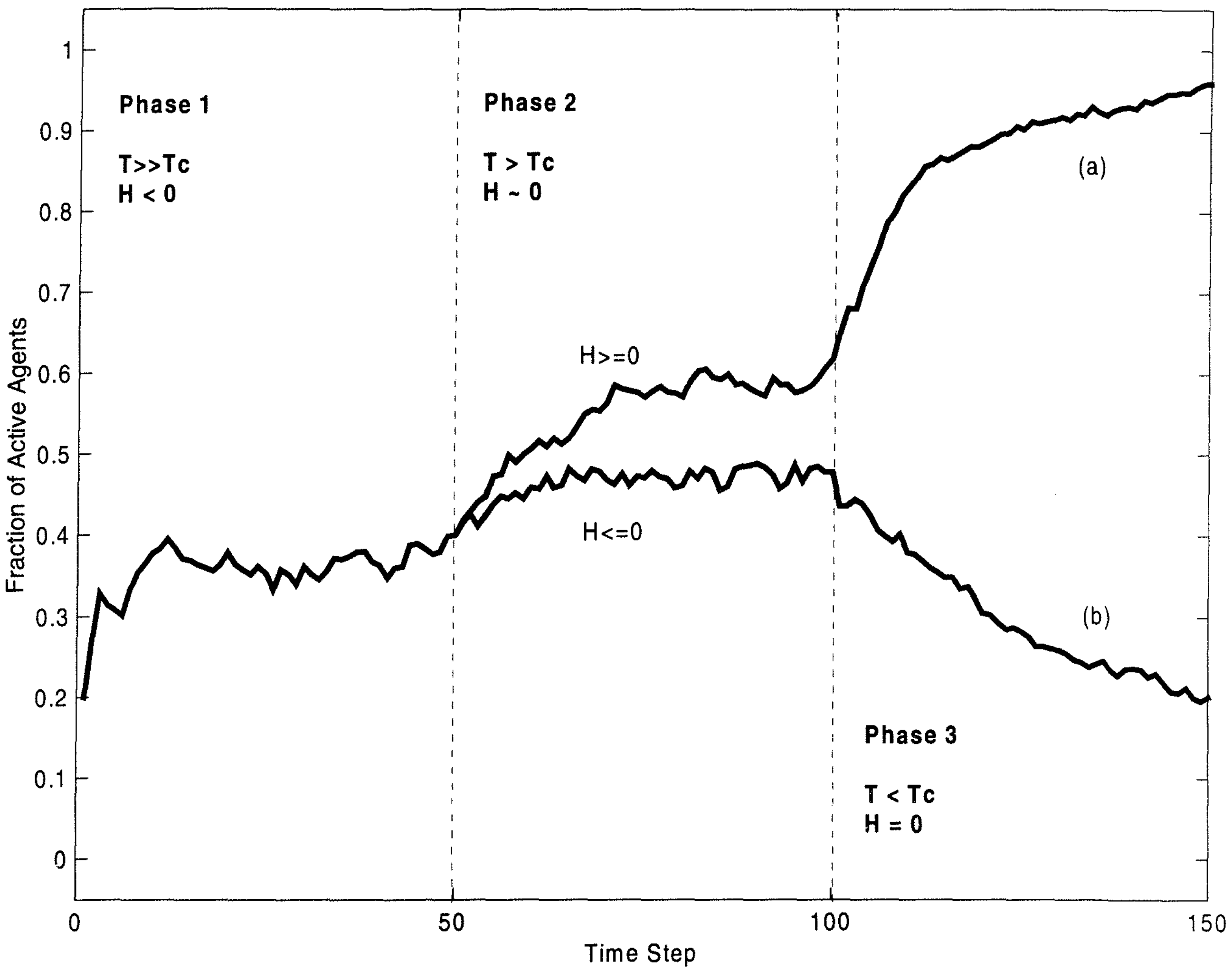

Phase 1
T>>Tc
H < 0
Phase 2
T > Tc
H ~ 0
Phase 3
T < Tc
H = 0
H>=0
H<=0
(a)
(b)
Fraction of Active Agents
Time Step
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150

Fig. 6

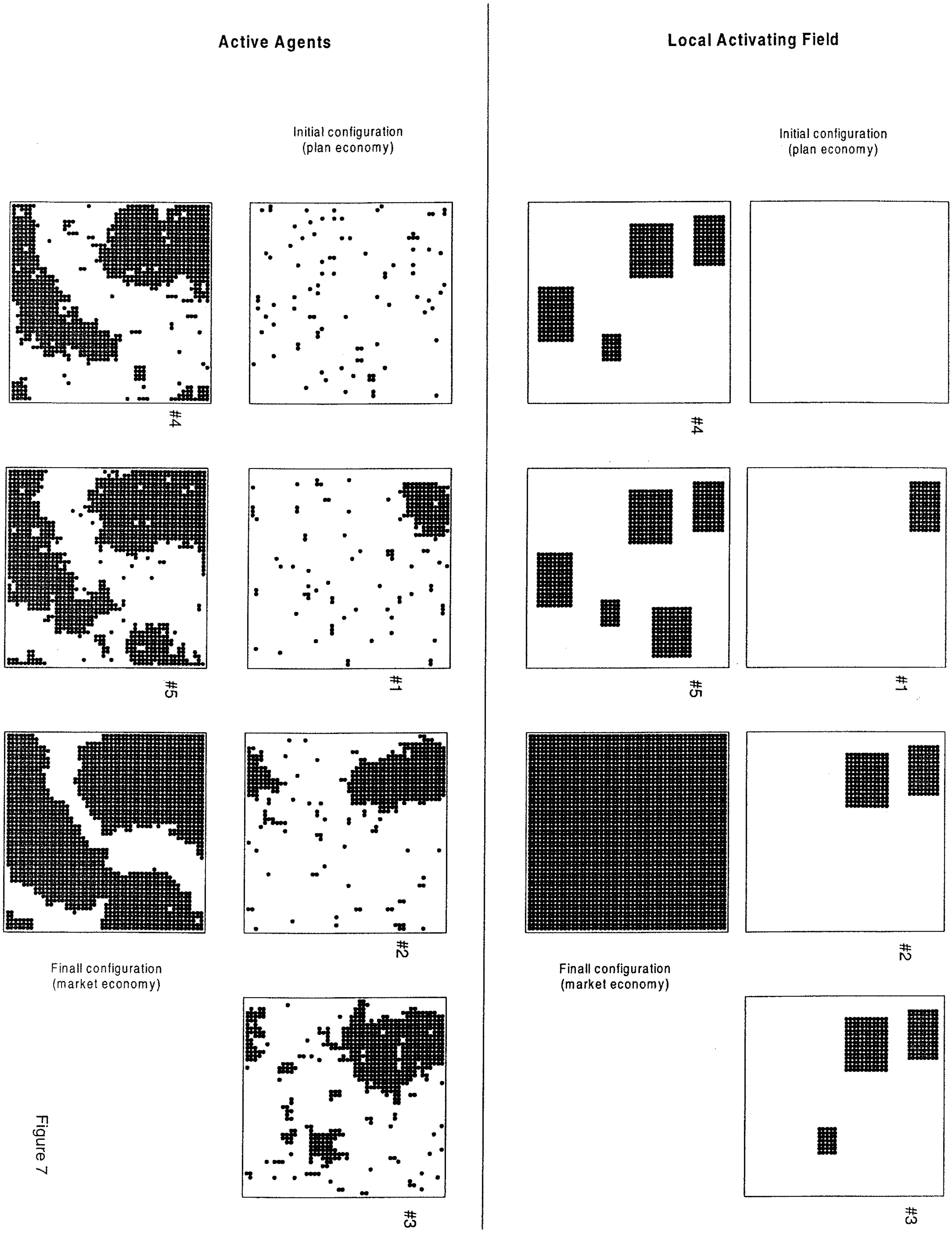

Active Agents
Local Activating Field
Initial configuration
(plan economy)
Initial configuration
(plan economy)
#4
#5
#1
#2
#3
#4
#5
#1
#2
#3
Finall configuration
(market economy)
Finall configuration
(market economy)

Figure 7

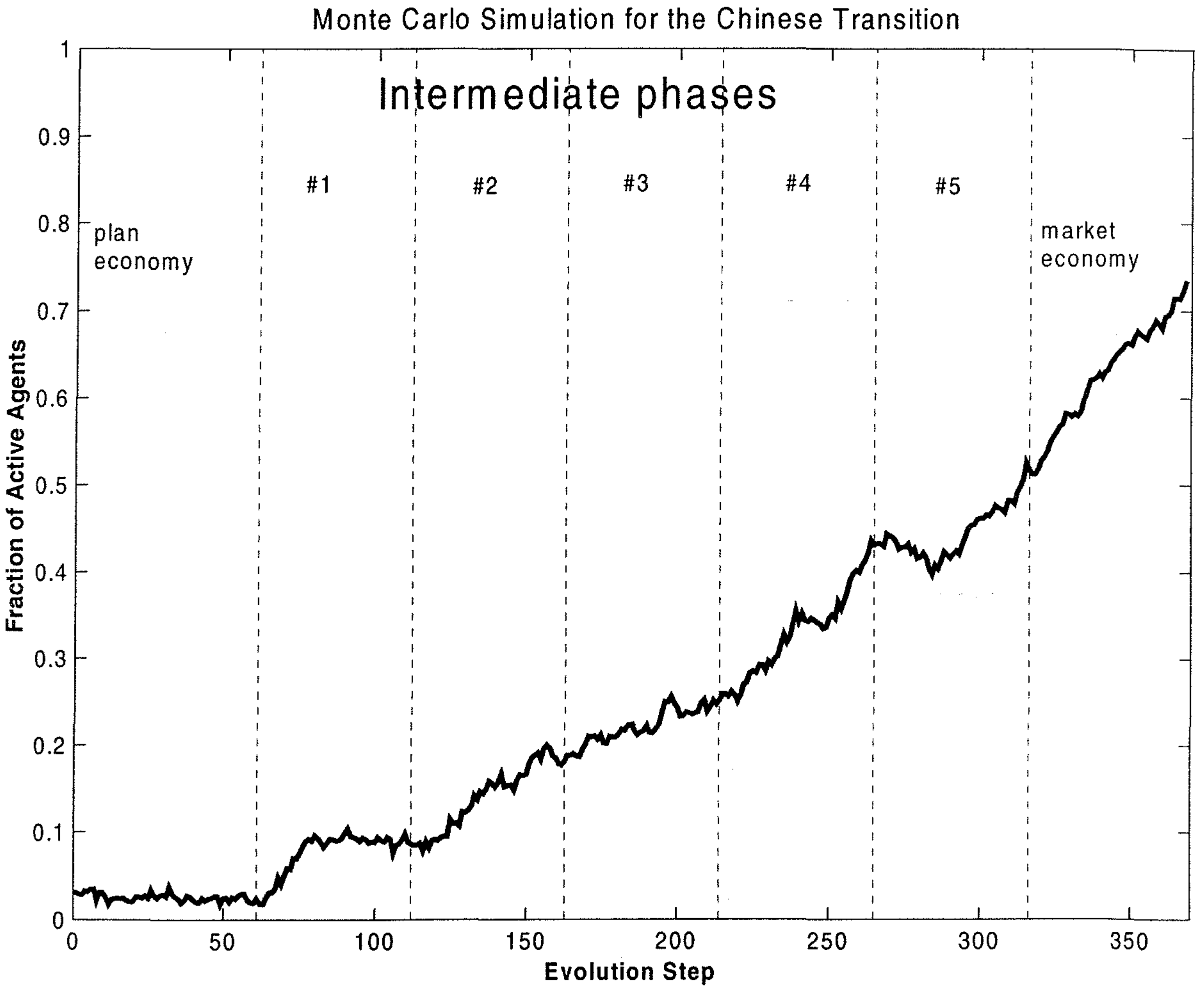

Monte Carlo Simulation for the Chinese Transition
Intermediate phases
#1
#2
#3
#4
#5
plan economy
market economy
Fraction of Active Agents
Evolution Step
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350

Figure 8

Captions

Table I
The parameters used to characterize the different phases of the dynamical simulation for China. The value of H_0 corresponds to the initial negative external field and to the background field for all the intermediate phases (from intermediate phase 1 to intermediate phase 5) while the value of H_i, $i=1,..5$, represents the value of the positive activating field defined on localized regions. The final phase, characterized by H_f, corresponds to the situation where the active state is indicated as favoured on the whole lattice. S_a represents the extent of the activated regions while n_a is the percentage of activated agents at the end of each phase. R is the temperature parameter ($R=0.5$ means half of the critical temperature and $R=0.8$ means 80% of the critical temperature) and n_a/S_a is the multiplier activation factor indicating the ratio of activated agents respect to the active surface extent.

Figure 1
The random 2D-50x50 Ising Lattice. The black dots represent spin-up sites or, in our picture, economic active agents.

Figure 2
Monte Carlo simulation phases at different steps for three different temperatures and starting from a minority configuration. The three simulations refer to the same minority starting configuration (active agents less than 50% out of the total) but at different temperature (below, nearly and above the critical temperature). The black dots represent the active agents and the external field is null.

Figure 3
Monte Carlo simulation phases at different steps for three different temperature and starting from a majority configuration. The three simulations refer to the same majority starting configuration (active agents more than 50% out of the total) but at different temperature (below, nearly and above the critical temperature). The black dots represent the active agents and the external field is null.

Figure 4
Percentage of active agent during the Monte Carlo evolution for different starting configurations and temperatures ($R=T/T_c$). Curves (a) and (b) refer to an Ising lattice evolving from a minority configuration while curves (c) and (d) refer to a lattice evolving from a majority configuration. In curves (a) and (d) R<1 (temperature below the critical point) while in curves (b) and (c) R>1 (temperature above the critical point).

Figure 5
Monte Carlo simulation phases at different steps with different values of the external field (5a). The two simulations refer to the same minority starting configuration (active agents more than 50% out of the total) but with different values of the external field (H=0.8 and H=0.4). The black dots represent active agents and the temperature is kept above the critical point. In figure 5b are represented the fractions of active agents corresponding to the simulation shown in figure 5a.

Figure 6
Monte Carlo simulation for the Russian transition from plan to market. The dynamical evolution has been divided in three phases. Starting from a state where the majority of agents were not active, the first phase corresponds to a situation where R>>1 ($T>>T_c$) and H<0. This phase indicates a disordered phase (low political control, T>>Tc) within a planned scenario (H<0). The second phase exhibits a higher political control (but non enough to endorse a full control, T>Tc) and no indication about the economic model ($H \cong 0$). In this phase the value of H can be slightly negative or slightly positive. The curve (a) represents the case in which H is positive and the active agents at the end of the evolving dynamics are slightly more than 50%. The curve (b) represents the case in which H is negative and the active agents at the end of the evolving dynamics are slightly

less than 50%. In the third phase T<Tc and H=0. The evolution of the system during this phase depends from the final configuration of the second phase.

Figure 7

Monte Carlo simulation for the Chinese transition from plan to market. The upper pictures, (7a), show the external field while the lower pictures, (7b), show the corresponding configuration of active agents. The initial phase corresponds to a planned economy with a negative external field. In this case the number of active agent is very low (less than 2%). The different intermediate phases (#1 to #5) correspond to positive 'local' activating fields (black dots in the upper pictures) acting on a slightly negative background (white dots). In the final phase the background has been switched to be slightly positive indicating the active as preferred alignment (market economy). The temperature has been always maintained lower than the critical point indicating a full control of the political power.

Figure 8

Fraction of active agent in the Monte Carlo simulation for the Chinese evolving path. The dotted and dashed curves represent the evolution of the system if the final condition ($H_f=0.1$ and $R=0.5$) were imposed at the end of the intermediate phase 3 and the intermediate phase 4, respectively. (see also Table I).

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