Institute of mathematics & its applications

IS THERE ANY CONNECTION BETWEEN THE NETWORK MORPHOLOGY AND THE FLUCTUATIONS OF THE STOCK MARKET INDEX?

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Contents

INTRODUCTION

Behavioral aspects of the investors have become an important field of study in Finance and Econophysics. In this work we have considered an agent based model which is able to reproduce most of the actual characteristics of the stock market. We proposed an extension of this model to analyze different network morphologies for the investors trust network (Regular, Random and Complex), different initial conditions for the state of the investors (buying, holding selling) and three scenarios for behavioral profiles (imitator, anti-imitator, indifferent) and then to analyze their influence in the stock market fluctuations. Employing tools from statistical mechanics as cellular automata, infinite size analysis, Monte Carlo and fractal analysis, we obtained and characterized the stationary limit for each scenario tested, focusing on the changes introduced when complex lattices were used.

- An extension of the model to take into account different network morphologies.
- To analyze how psycological tendencies influence the investors' decision, leading to a stock index oscillations.
- The index was initially set to 100 and then was updated at each time step considering the balance between the number of investors buying and selling stocks.

AIM

To test different conditions for the state of the investors and different scenarios for their behavioral profiles in order to extract informations, considering how the network morphology influence – if it does – the evolution of the stock market index in a behavioral model of the investors.

Specifics Points

- To Characterize different network morphologies.
- To test different initial conditions.
- To test four scenarios for the behavioral profiles.
- To analyze how the stock market index behaves under each conditions proposed.

METHODOLOGY

REGULAR AND RANDOM NETWORKS

Networks are very important for the spreading of information, and play a central role on the social relations.

- **Regular Network**

The Moore neighborhood (8 neighbors), Figure 1, was implemented for the square lattice. For all regular lattices, all the investors have the same number of neighbors and there is no preferential attachment.

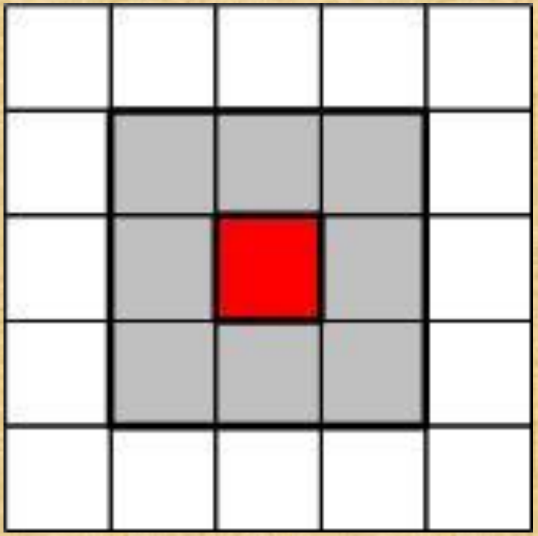

Figura 1. Moore Neighborhood. Grey cells are the neighbors of the red cell.

METHODOLOGY

- **Random Network**

By taking random lattices case, we considered two different algorithms:

1. Conservative case - we started out building a square regular lattice with N sites and then perform N random permutations on the regular connections, in such way that, at the end, all sites will have the same number of neighbors, but with a complete random ordering;

2. Non-conservative case - we take a square lattice with N sites and, then, we sort randomly N connections among the sites in such way that, at the end, each site will have a number of neighbors which may vary between 0 and N, randomly sorted.

METHODOLOGY

Complex Network

Small World Network (SWN)

The code considers a preferential attachment of the links in such way that as greater the number of links of a node (investor), higher is the probability of a new node to be connected to it. “The rich get richer!”

We generate a SWN up to N nodes whose links distribution by node follows a power law Figure 3. The distribution of links lengths is also shown. It is worth to note that the value of the exponent $\gamma \approx -2.5$ agrees with the value predicted by Barabsi-Albert model.

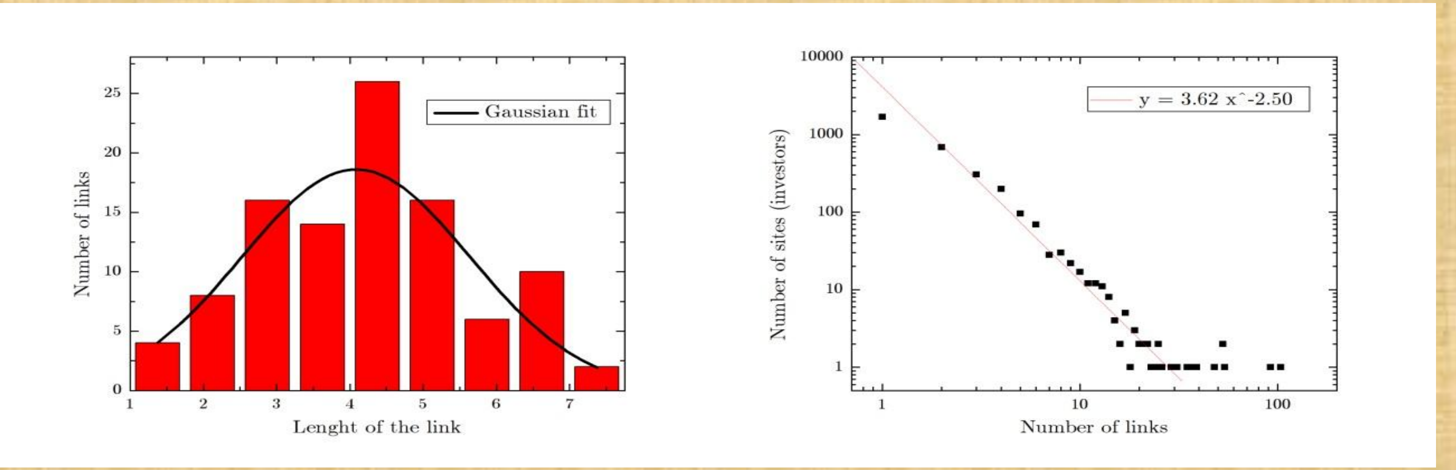

FIG. 2. Statistics of some parameters of interest for the small world network. Left: length distribution of links. Right: link distribution by node. The straight lines correspond to the best curves obtained in each case.

METHODOLOGY

- **Random Network**

Figure 3, we show some examples of the networks studied in this paper. The results for the regular cases are trivial, since these lattices are completely homogeneous. The distribution of length only has a nontrivial result for the case of the random networks, where we note the predominance of Gaussian distributions, as expected.

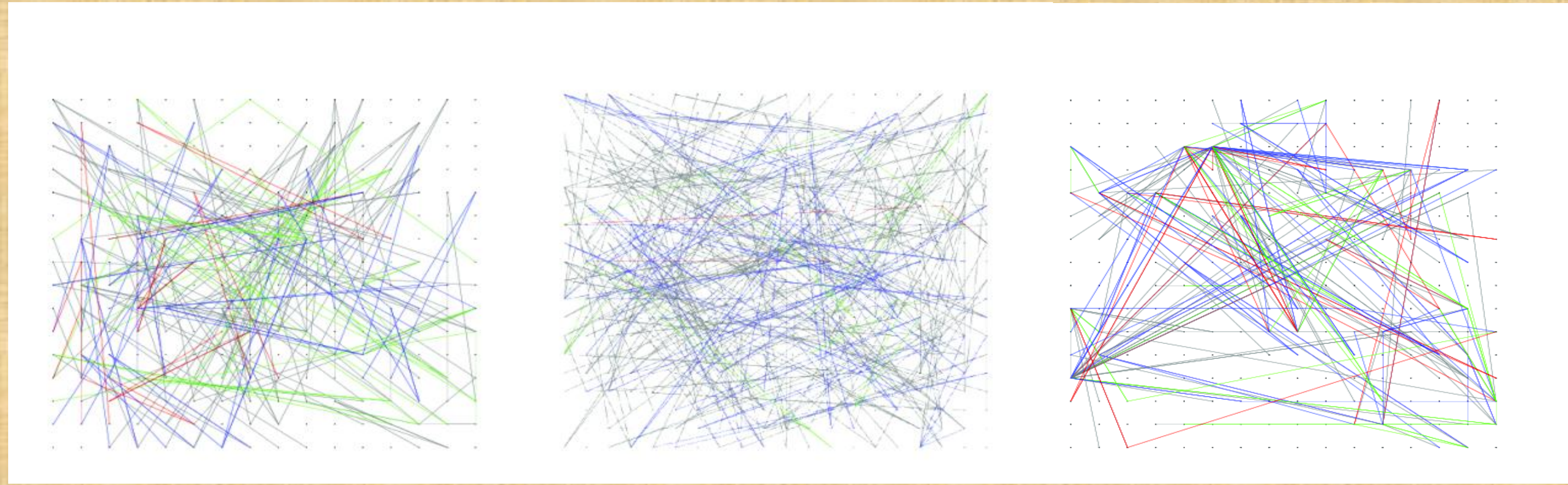

Figura 3: Examples of networks. Left: random network, conservative case (N/2 links were removed and were shown). Center: random network, non-conservative case. Right: small world network. In all cases, N/2 links were considered into the lattices with N sites.

METHODOLOGY

BEHAVIORAL MODEL OF INVESTORS

- The algorythm was developed and implemented with four different networks: Regular, Random Conservative, Random Non-Conservative and Complex (SWN).
- The scenarios are chosen from four different behavior implemented and tested . A – All Imitators; B – All Anti-Imitators; C – All Indifferent; D – Mixing (probability is given by: 1/3 of A, 1/3 de B e 1/3 de C).
- Initial conditions: random, where the sites are filled in randomly with the states: buy, hold and sell with probability of 1/3 for each one of them; and alternate, where the columns of the lattice are filled in alternating the states buy, hold and sell successively.
- The effect of limiting the investors action to buy and sell by setting a finite quantity of money and stocks.
- Tools from statistical mechanics as cellular automata, finite size analysis, Monte Carlo and fractal analysis have been applied.

BEHAVIORAL MODEL OF INVESTORS

Buy

Sell

Hold

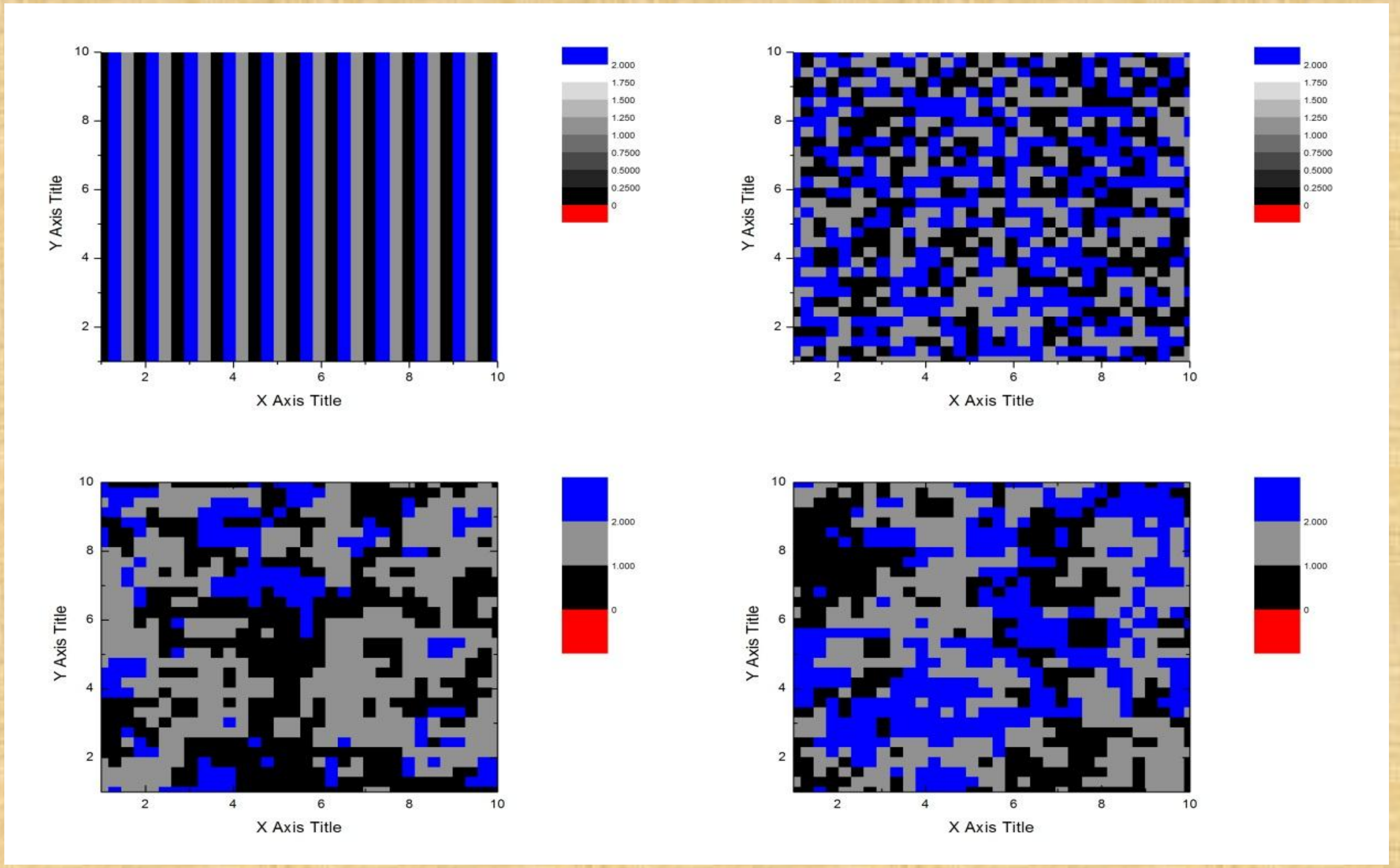

Figura 4: Evolution of the state of the investors in function of the initial conditions, having a Regular Network. The scenario considered was 100% of anti-imitators and we showed on the upper panels the initial conditions: alternate at left and random at right. The bottom panels show the stationary state corresponding to each initial condition. It is clear that for this scenario the initial condition does not play any role.

RESULTS

The effect of limiting resources in the system. Figure 5, we compare the same scenario in two different situations: with and without limitation of resources. It is clear that the limitation of resources imposes a dynamic for the system which attains a stationary state after a transient.

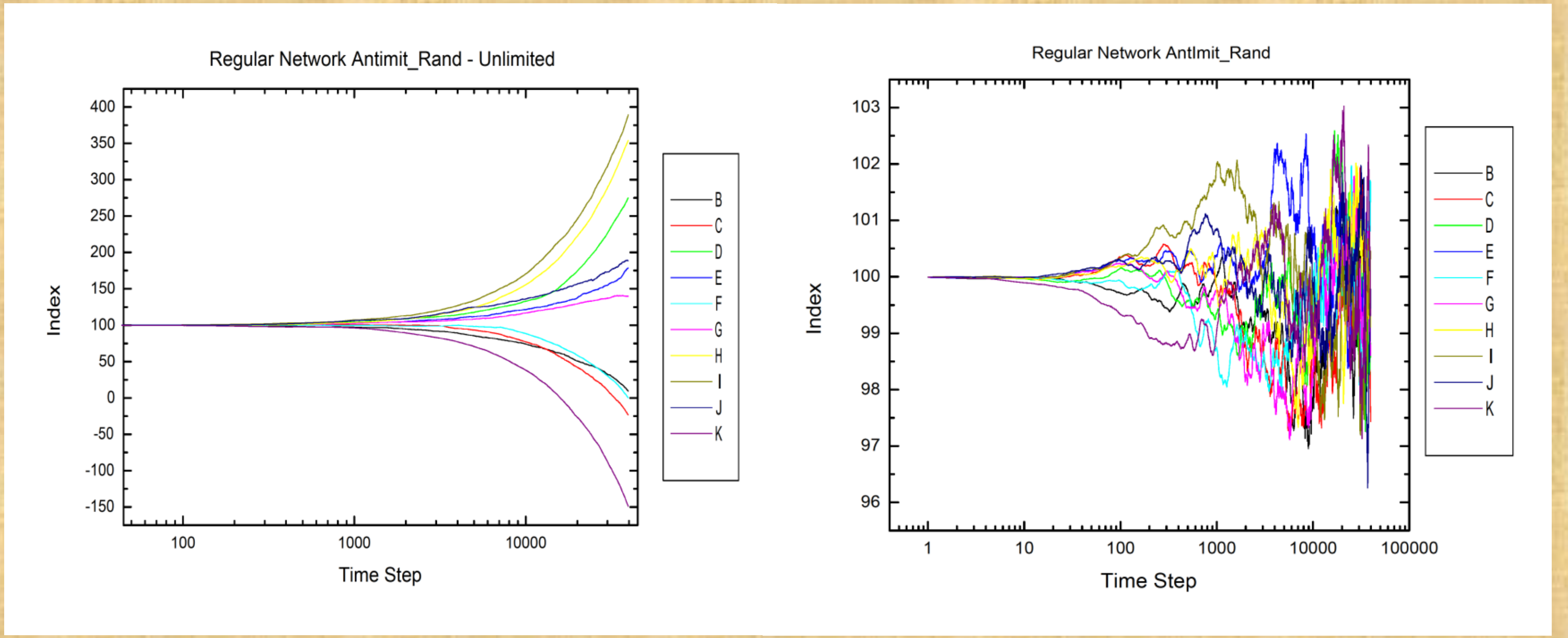

FIG. 5. Effect of limiting resources. Left: unlimited resources case. Right: limited resources case. A scenario of all anti-imitators was considered. Note the behavior of the index for the unlimited case, reflecting the random initial conditions. In the limited case, the index evolves to a stationary state due to the limitation of resources.

RESULTS

Another effect that we have verified was the influence of the initial conditions in the stationary state of the system. Figure 6 shows the stationary state for the same scenario and two different initial conditions.

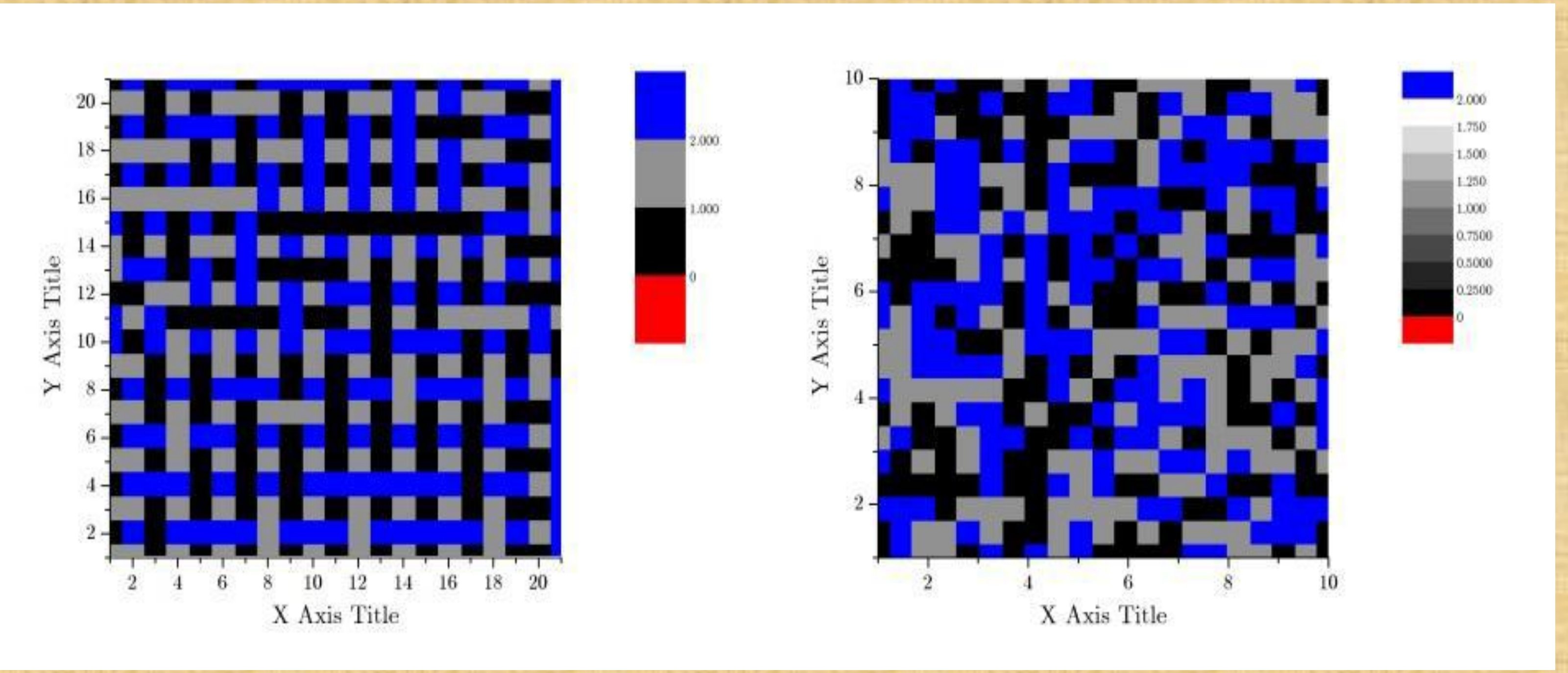

FIG. 6. Eect of the initial condition in the evolution of the state of the investors. Here we show the stationary state for the scenario of 100% of imitators, under the same initial conditions considered in the Figure 4, alternate and random, respectively. It is worth to note that for the all imitators scenario, the stationary state exhibits a strong dependence with the initial congurations.

RESULTS

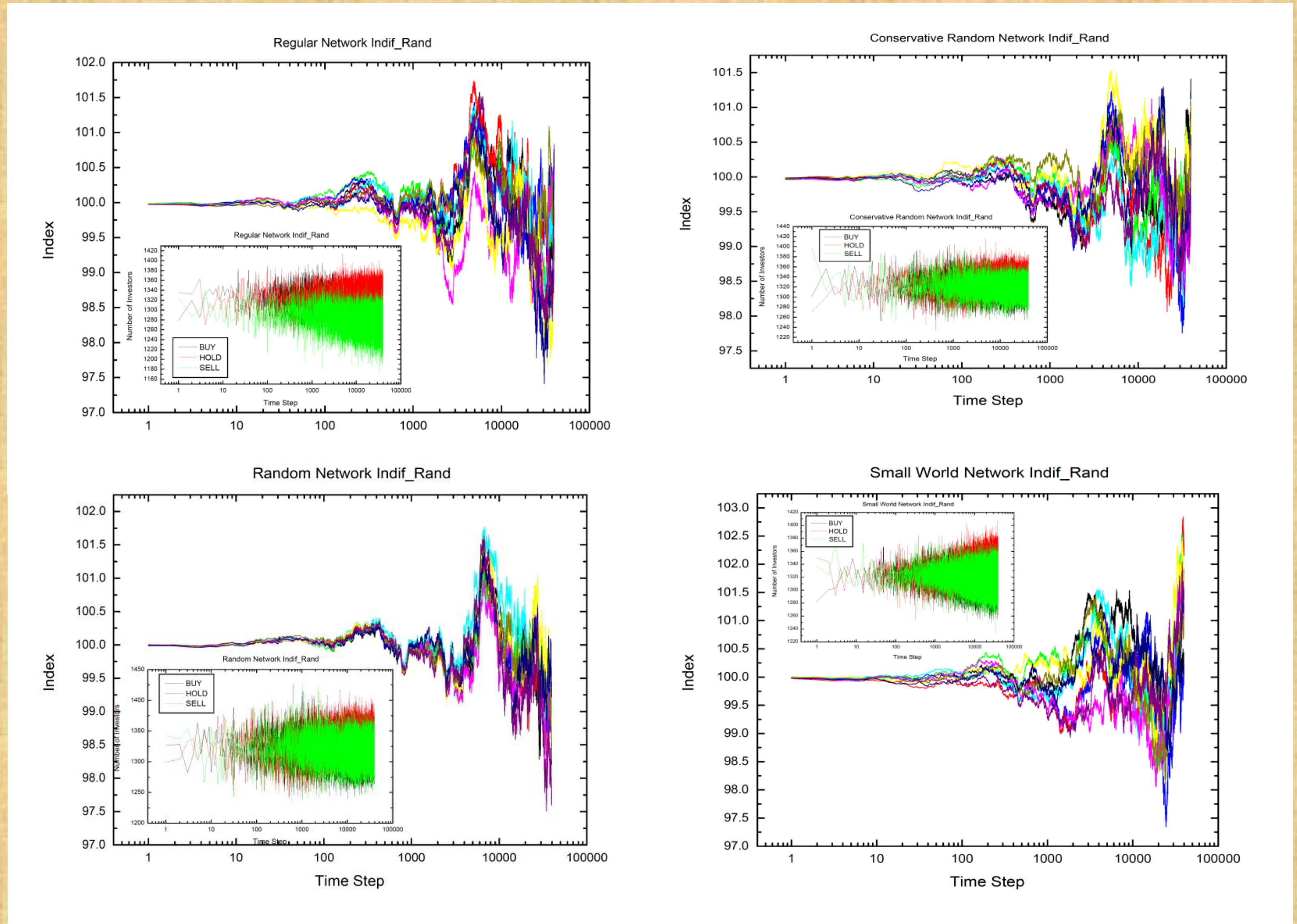

FIG. 7. The scenario of all Indifferent having the same initial condition doesn't influence the stock index. Upper panels: left - Regular Network; right - Conservative Network. Bottom panels: left - Random Network; right - Small World Network.

RESULTS

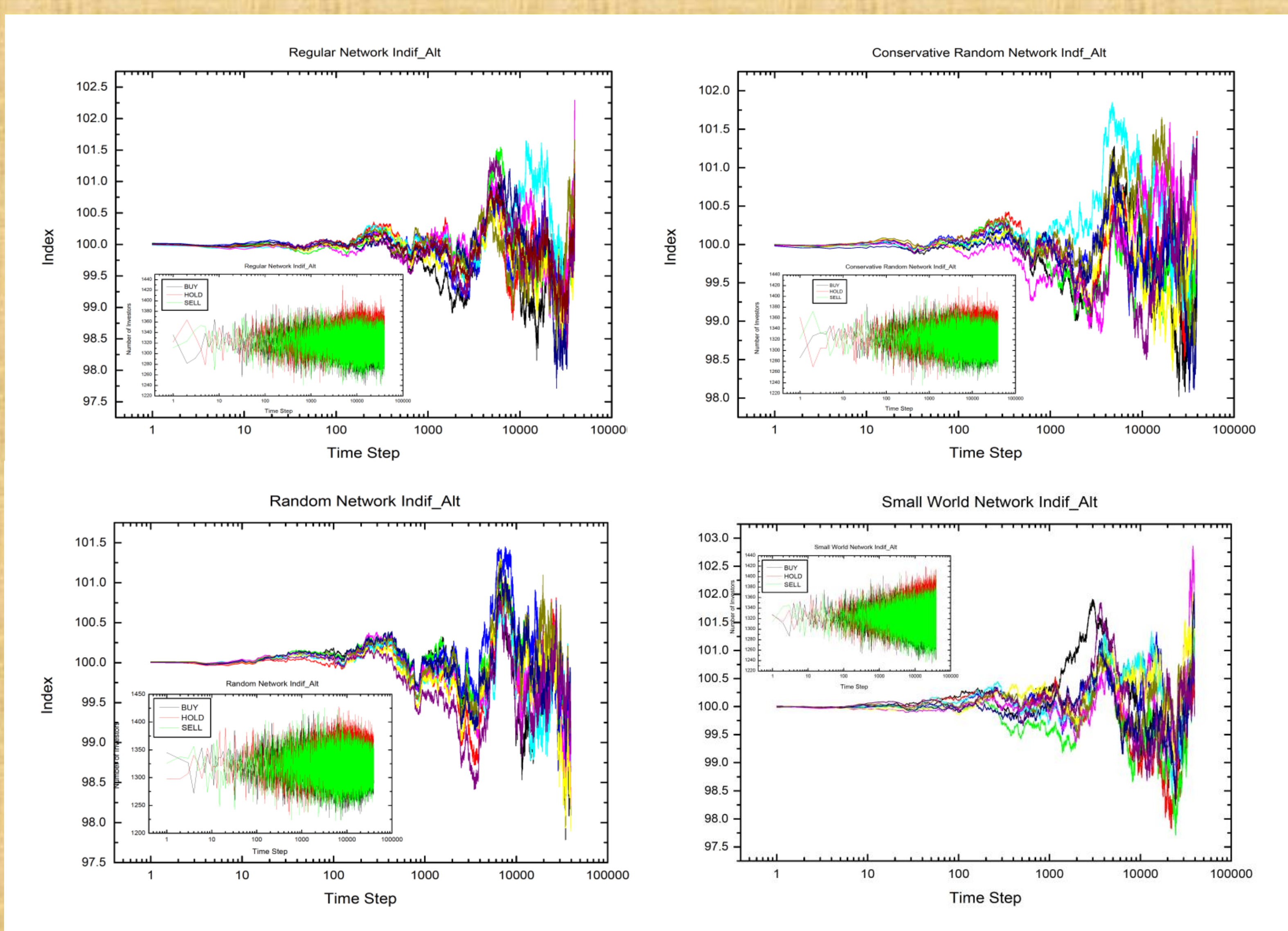

FIG. 8. The scenario of all Indifferent having the same initial condition doesn't influence the stock index. Upper panels: Left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

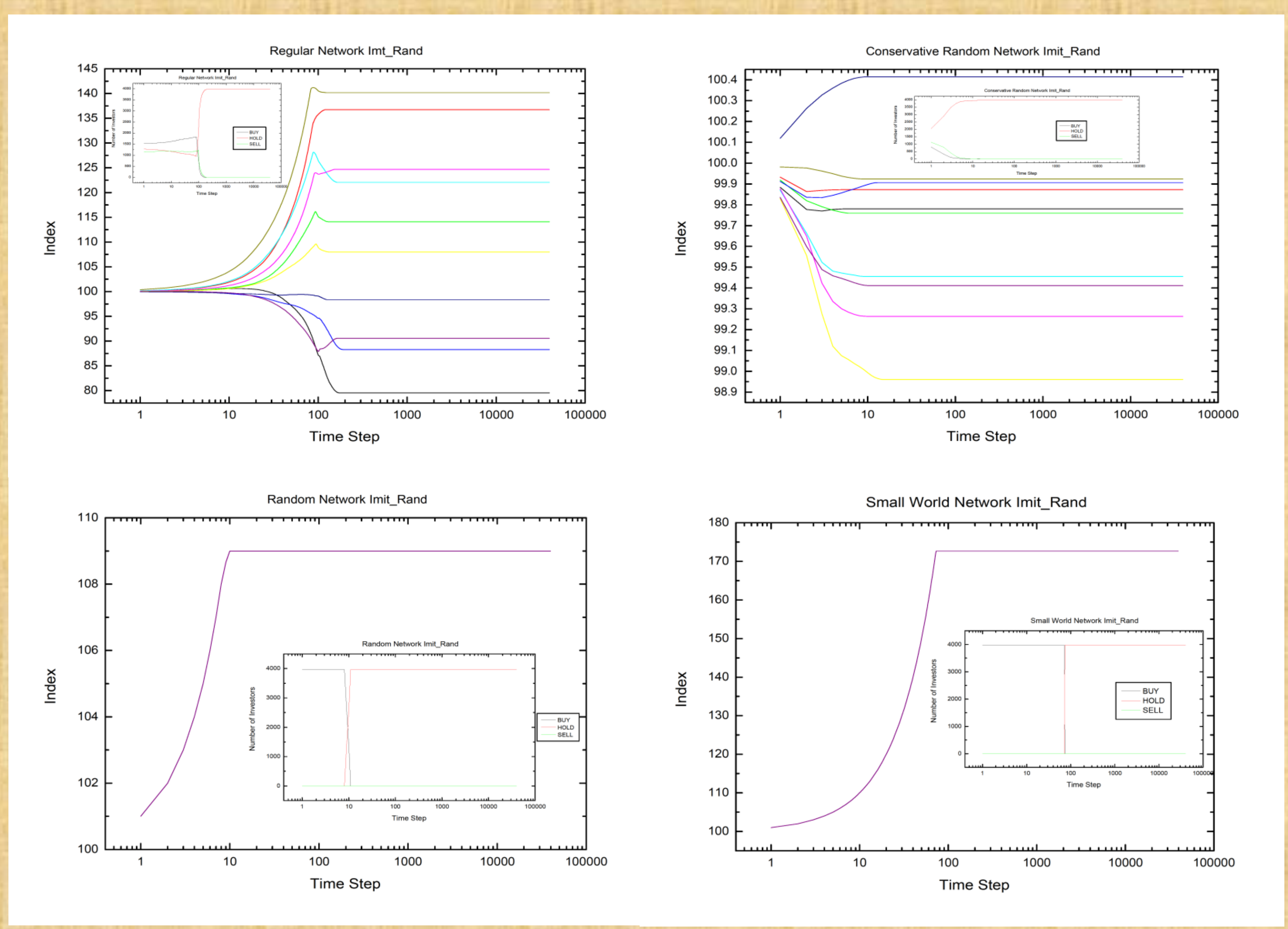

FIG. 9. The scenario of all Imitators having the same initial condition - Random does influence the stock market index. Upper panels: left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

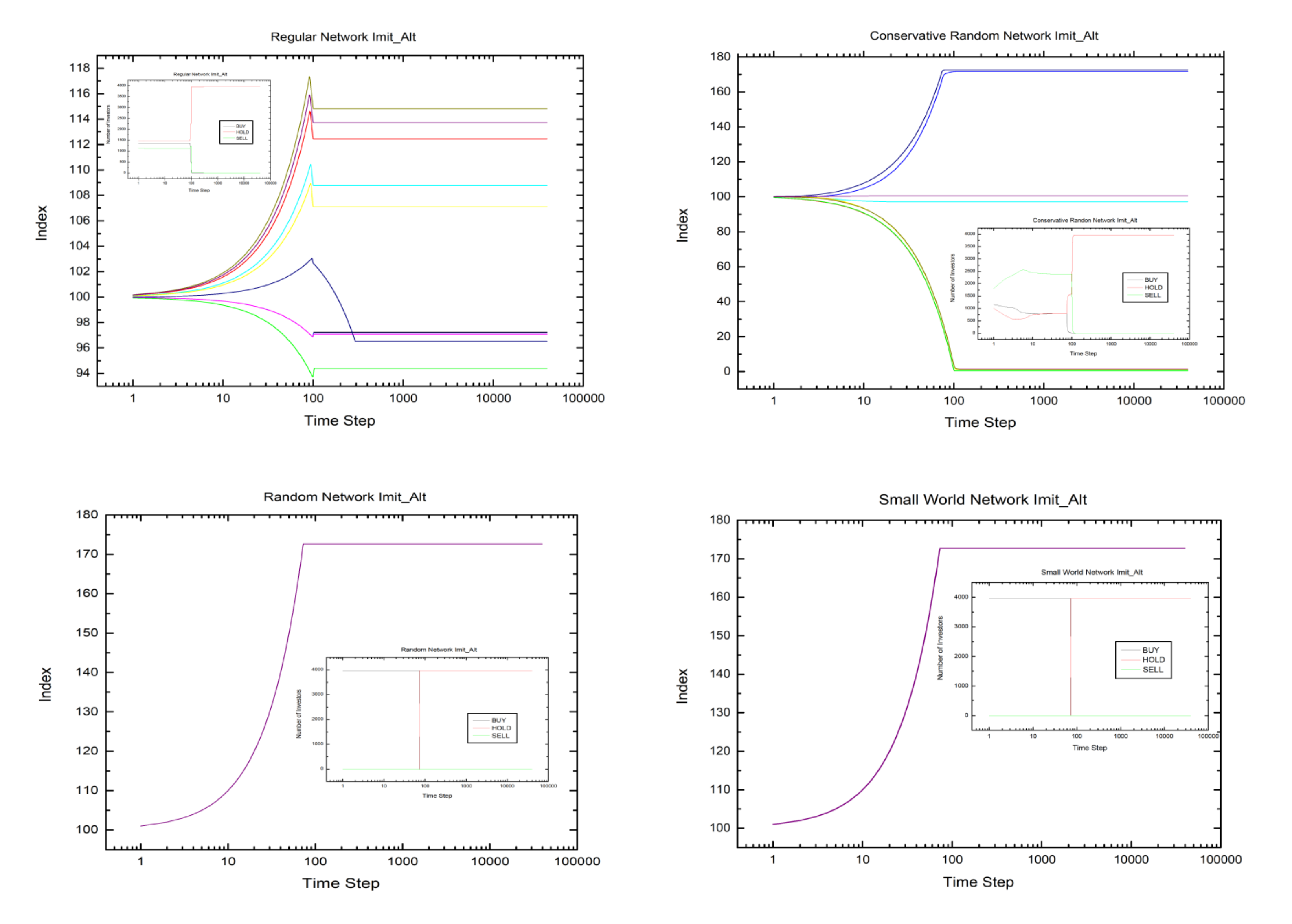

FIG. 10. The scenario of all Imitators having the same initial condition - Alternate does influence the stock market index. Upper panels: left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

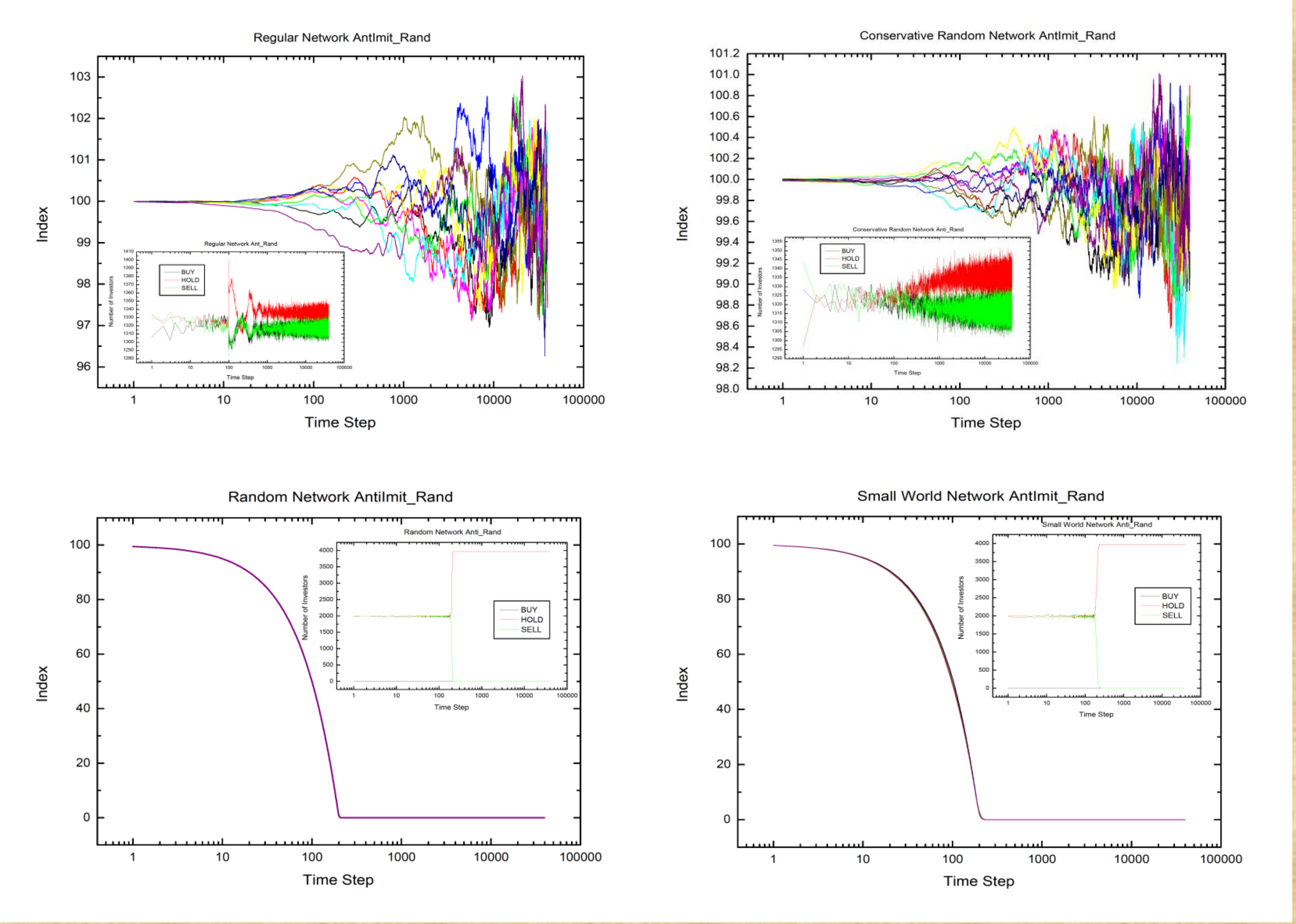

FIG. 11. The scenario of all Anti-Imitators having the same initial condition - Random. The morphology has a strong influence over dynamic. Upper panels: left Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

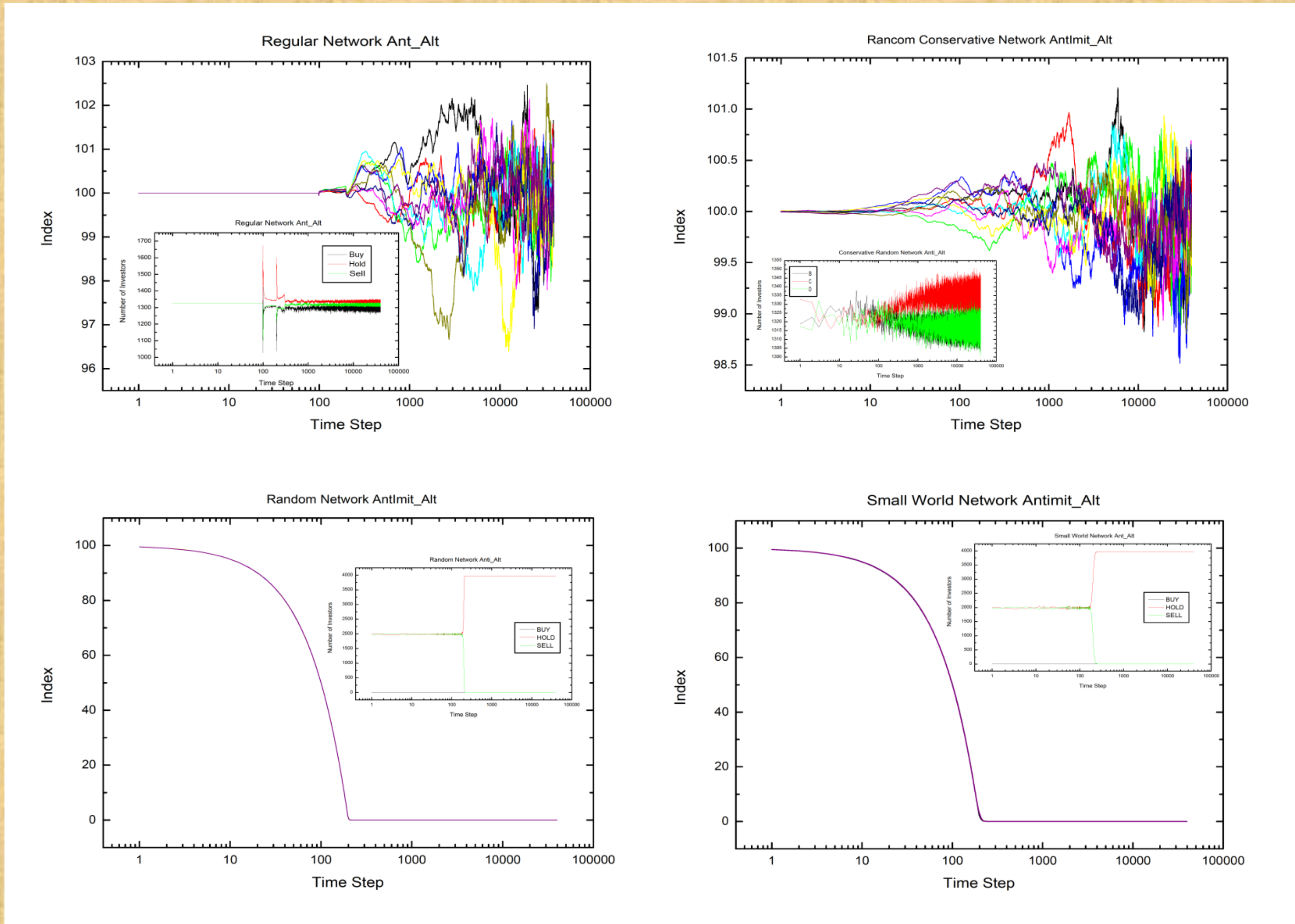

FIG. 12. The dynamic is under a strong influence from the network morphology. The scenario is built of all Anti-Imitators having the same initial condition - Alternate. Upper panels: left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

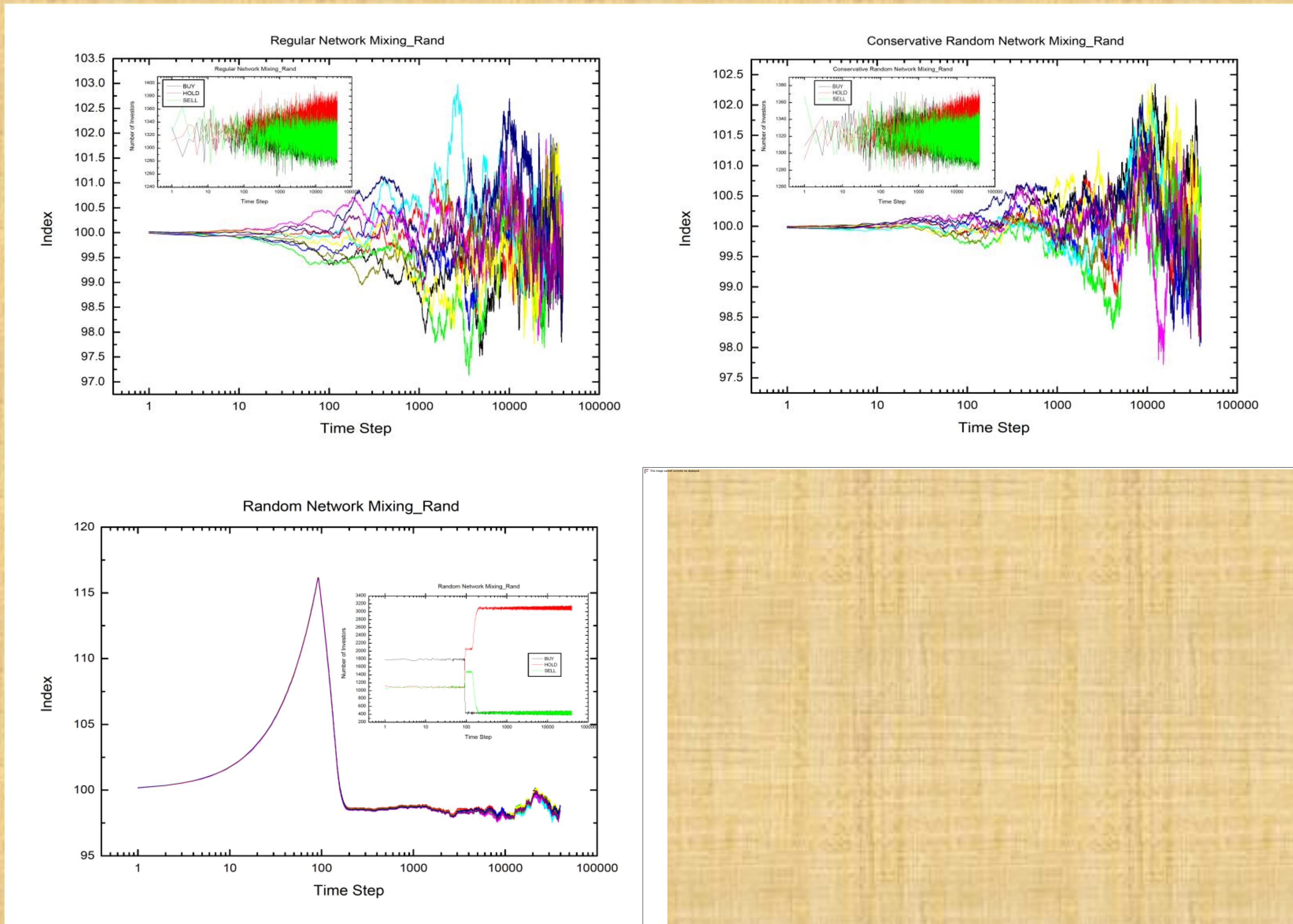

FIG. 12. The dynamic is under a strong influence from the network morphology. The scenario is built of Mixing (1/3 of Imitators, 1/3 of Anti – Imitators and 1/3 of Indifferent) having the same initial condition - Random. Upper panels: left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

RESULTS

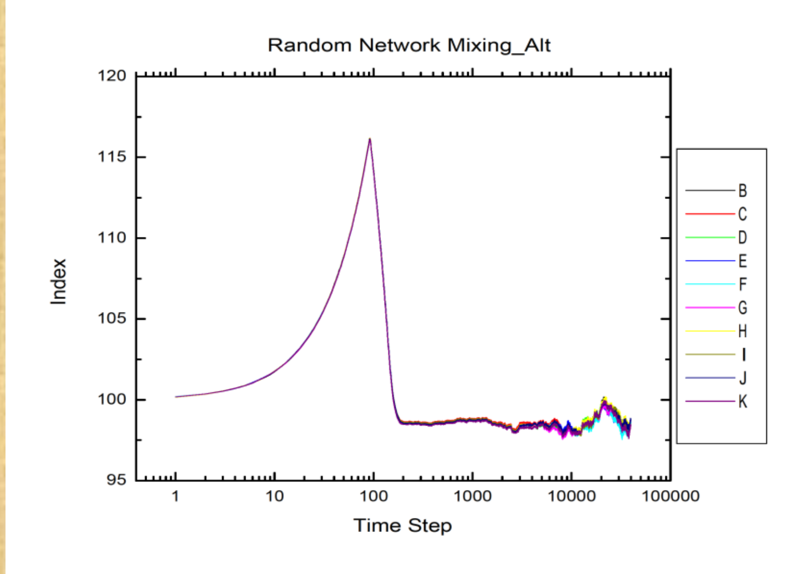

FIG. 12. The dynamic is under a strong influence from the network morphology. The scenario is built of Mixing (1/3 of Imitators, 1/3 of Anti – Imitators and 1/3 of Indifferent) having the same initial condition - Alternate. Upper panels: left-Regular Network; right-Conservative Network. Bottom panels: left-Random Network; right-Small World Network.

CONCLUSION

In this paper we have extended a Cellular Automata model of investors' behavior in the stock market using different kinds of neighborhood by building four network morphologies to show how the morphology will alter the dynamic of the investors in a system. We have simulated several scenarios which are driven by trust network of investors and their psychological profile (imitators, anti-imitators and indifferent). We have studied the influence of the trust network morphologies in the stock index oscillations and have observed that Random and Small World Networks lead to unexpected results when they are compared to the Regular and Conservative Random cases. Simulations results have shown that there is a connection between the network morphology and the stock market index oscillations indicating that the investors trust network morphology determine the behavior of the stock market index altering the dynamic of the stock market index in each case. To our knowledge, this result has never been reported before.

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