

From Sociodynamics to Synergistics: Understanding the Wealth of Nations using Simulations

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Abstract: Wealth creation is the main aim of many human activities; yet our understanding of the dynamics of the creation of wealth for whole societies or countries in the modern world is very limited. How is capital created and increased? Why are certain nations rich and other poor? What is the relationship between micro- and macro-economics? Explorations with Sociodynamica, an agent based computer simulation model, suggests that optimal behavior of individuals differs between different economies and type of societies. For example, hunter-gatherers require different individual and social skills than members of an agricultural society and those forming and industrial society. The simulations show a strong correlation between successful economies and the amount of business minded agents engaged in win-win interactions with their fellows. The simulation effort concludes that the main emergent product of societies is the creation of synergisms, which can be catalyzed through technologies that allow an accelerated increase in wealth. The results presented here show how computer simulations can aid in conceptualizing and clarifying basic theoretical problems in economics and in deepening our understanding of the historical dynamics of human societies

1. Introduction

Why are some nations rich and a great many of them poor? Is there a key for achieving success in economic development? These questions have bothered humanity for a long time. Since Adam Smith (7) first opened the debate in 1776, many scholarly works have been written, but no satisfactory answers to these questions have yet been found. One reason why a simple answer to these questions eludes human intellect may be simply that the problem is complex. Borrowing the interdisciplinary views and methods of Complex System Sciences, the question of how wealth is created and aggregated can be approached using tools from sciences such as history, geography, economy, politics, sociology, law, chemistry, biology and physics (6). Some approaches attempted from the fundamentals of modern economic sciences, pioneered by the International Monetary Found, The World Bank and the United Nations Development Program, seem to get us close in finding an answer to these questions. Yet as soon as we seem to grasp theoretically, with our intellect, the underlying forces responsible for creation and aggregation of wealth, the economic and political realities seem to stubbornly resist our explanations and contradict our predictions. Thus, new tools seem to be required in order to escalate our battle in understanding the dynamics of the wealth of nations.

This intellectual exercise leads to the recognition that new types of sciences, handling powerful new tools, are required for the study of complex systems (6). One such tool that might help in addressing the problem of understanding the harmonious and sustainable creation of wealth is computer simulation. Specifically, computer simulations build upon the premise that they must help in the analysis and conceptual understanding of the underlying dynamics of social systems. One such framework for social simulations is the computer program Sociodynamica (8). This program aims at helping in the construction of a new science which I propose to call Sociodynamics, which inspired by thermodynamics, behavioral economics, evolutionary sciences, behavioral ecology, evolutionary economy, complex systems, and many other disciplines, should contribute in providing a sound bases for a deeper understanding of the interacting web of biological, social and economic behavior that guide our societies. Sociodynamics aspires to be a quantitative experimental interdisciplinary science focusing on the study of social phenomena, bridging the gap between the mind of a natural scientist and a social one. One of the main tools of Sociodynamics is computer simulations not only to try to model known reality but which are used to help to explore conceptually and quantitatively complex social problems. Here I want to provide an example of how social simulations may be used to reinforce and re-build our theoretical and conceptual basis of economic and social phenomena.

The computer model Sociodynamica allows for the exploration of the feasibility of such an approach. It allows running virtual experiments with artificial societies that are designed to analyze specific aspects of real life. This approach is based upon the belief that the best way of advancing knowledge using science is to demonstrate the usefulness of novel approaches, ideas and methods with concrete falsifiable examples. Yet conceptual clarification of the underlying theories is an important step in that direction. That is the *leit-motiv* of the present paper.

2. The Model:

Sociodynamica (8) is an agent based model where each individual agent suffers its own *umwelt* and interacts with other agents forming a social web and producing a cultural *gestalt*. The model allows exploring the underlying dynamics of the creation of wealth. The actions of the agents are transparent, allowing testing the effect of chosen individual behaviors on the aggregate characteristics of the simulated society. The model simulates a continuous two-dimensional toroidal world through which different types of agents wandered with Brownian motion, each at its proper speed. The speed of this motion (m) ranged from 0-30 pixels / time step. Agents do not learn. The simulations tested for the survival abilities of agents under variable circumstances. As dead agents were substituted by new ones, which had their parameters assigned at random, the simulations served as a way of weeding out those combination of parameters that conferred low fitness or low survival capabilities to agents, selecting those agents possessing parameters that conferred them larger survival possibilities. Agents do not inherit their parameters, as Sociodynamica is a metaphor for a society of agents living in a free competitive market.

The toroidal world is supplied with patches of agricultural land (food resources) and mines (non renewable resources). Each time an agent happens to land over one of these resources while walking randomly around, they acquire a units of the corresponding resource, accumulating wealth, either as food (w_f) and/or as mineral wealth (w_m). Agents spend some of their wealth in food in order to survive, consuming food at a basal constant rate. This basic setting allows for the simulation of farmers, miners, traders, money, altruism, division of labor vs. no division of labor, variable economic externalities vs. homogeneous predictable externalities, etc.

The simulations explored the effect of the various degrees of work efficiency (e) and environmental riskyness or “generic dangers” (d), and sensitivity towards altruistic punishment (p) on wealth accumulation in virtual societies. The model simulates a continuous two-dimensional spherical world in which agents search for resources (R) in order to survive. Simulating a continuous sphere (the earths surface for example) eliminates any border effects in the simulations. Two types of resources were simulated “food” (R_f) and “minerals” (R_m) and both came in units w_{f0} and w_{m0} respectively. Each time a generalist agent or an agriculturalist agent encountered R_f , it increased its accumulating wealth (w_f). Equivalently, each time a generalist agent or a miner agent encountered R_m , it increased its accumulated wealth w_m . Agents spend some of their wealth w_f in order to survive, consuming wealth at a basal constant rate (b), which is a fraction of the resource unit; whereas w_m did not degrade with time. The wealth of each agent changed each time step:

$$Dw_f = -b + w_{f0} \quad \text{where } w_{f0} = 0 \quad \text{if no resources are encountered.}$$

b determined the degree of external constraints or of competitiveness of the environment. Agents with no resources left ($w_f = 0$) perished. This can be related to the natural metaphor in which organisms die, or to the social metaphor in which companies go bankrupt and dissolve. Another source for death was d that affected positively the odds that a given agent was eliminated randomly each time step. The odd of this random elimination was inversely proportional to w_m the agent possessed. Each eliminated agent was substituted by a new one where the type of agent and the amount of w_f (1-10) and w_m (1-10) was defined randomly.

Agents displaced themselves in random directions each time step producing a Brownian motion of variable speeds depending on the value of m (range of variation from 0-30 pixels / time step). The movement simulated could represent either physical distance or a two dimensional form of social distance. Each time an agent met another at a distance smaller than a given contact radius (r : 20 pixels in the simulations presented here), an interaction could be triggered depending on the labor specialization of the

agents involved and the difference in wealth ($w_1 - w_2$) between the two agents. The interactions tested with simulations were:

1- No division of labor: All agents were generalist, they could exploit R_f and R_m and could interchange excess w_m for equivalent amounts of w_f or vice versa with other agents. When acquiring w_m , the agent increased its wealth by the factor e

2- Division of labor: Agents were either R_f collectors called “farmers”, R_m collectors called “miners”, or “traders”. Here only traders could exchange excess w_m for equivalent amounts of w_f or vice versa with other agents. When acquiring w_m , only traders increased its wealth by the factor e

Resources were replenished each time step and were concentrated in a patch of 200 w_m and 100 w_f occupying 200 and 100 pixels respectively. Each resource patch was initially located at random in the landscape and remained there until the end of the simulation.

For each simulation, the total wealth accumulated by a population (GDP, for gross domestic product) of all agents (i) was calculated as $GDP = \sum (w_f + w_m)_i$. As the simulations contained highly stochastic aspects, such as the movement of the agents and the location of the resources, at least 100 simulation were run for each graph presented here.

Other parameters that were explored in the simulations presented in the paper were:

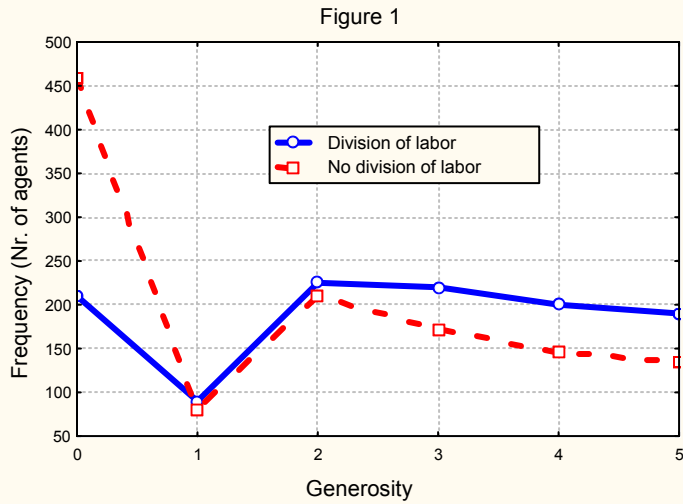
1- The amount of altruistic punishment dispensed, which was regulated by the amount of agents acting as “altruistic punishers” in the population. This amount was kept constant during each simulation run. The altruistic punisher reduced the wealth of the agent it encountered, if the degree of generosity of the encountered agent was $g \leq 1$ (agents that gave less than 10 % of their wealth when encountering poor agents, see above), at a cost to its own wealth.

2- The reaction of agents when punished. This was coded as “sensitivity to punishment”, which regulated the degree to which punished agents increased their generosity after receiving a punishment. This increase could vary from 0 to 5 deciles of w_f .

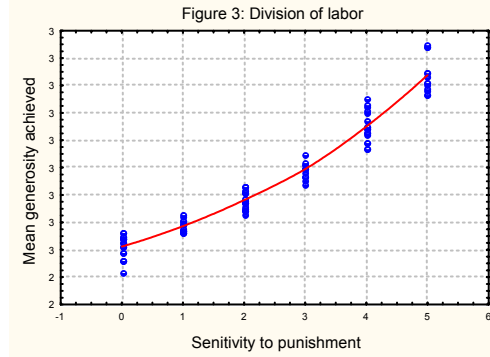
In the simulations presented here, the cost to the punisher was fixed at 10 % of its w_f , and equaled the cost the punished agent paid. The values of parameters not specifically analyzed or described as being fixed in a simulation, were allowed to vary randomly among agents in the ranges mentioned above. Unless stated otherwise, simulations were run 200 times with 500 agents for 100 time steps. Although the configuration of populations never stabilized completely, after 60 time steps changes were very small. Thus, the populations of agents reached a stable state after time interval of 100 time steps.

3. Results:

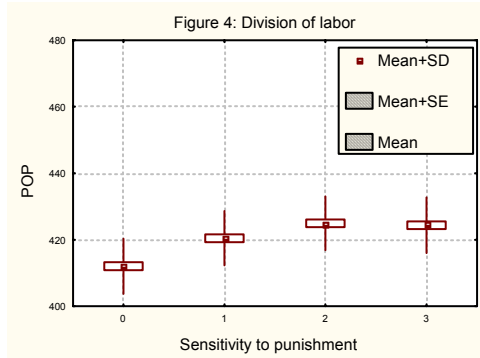
Different scenarios were explored where all variables were set initially with the same values, except that in one set of simulations, all agents were equivalent, i.e. no division of labor was simulated, whereas in another set of simulations, agents were segregated into 3 types, farmers, miners and traders, simulating societies with division of labor, showed that the dynamics of both type of societies differ. These simulations can be run by downloading the program (8) and running the demos files, or by introducing the values at will. Here I will present only three examples of such comparative experiments. For example, in Figure 1, we observe that the distribution of generosity among the agents of the population, under a given conditions of parameters, and after the system stabilized, varies significantly between both type of societies



When altruistic punishment was simulated (5), so that non-generous individuals were punished at a low probability, both types of societies showed different susceptibility to this kind of punishment, measured as sensitivity to change generosity after an altruistic punishment was received. This difference can be observed comparing Figures 2 and 3.



Other differences between both types of societies were evidenced with simulations exploring the effect of p on the population size at equilibrium (POP). These differences are exemplified in Figures 4 and 5.



Several other differences between optimal values for parameters guiding the behavior of individual agents on the maximization of aggregate wealth are reported elsewhere (see ref 4,5)

Other experimental results using Sociodynamica, presented in more detail elsewhere (3,5) show that when constructing these models, no wealth creation can be simulated unless some space for synergism is allowed. In summary, we can describe any behavior of an individual in a society and its effect on aggregate wealth with the equations

$$S = \int_t (A + B) - K > 0 \quad \dots 1$$

$$I = \int_t B - K < 0 \quad \dots 2$$

Where: K = cost of altruism, B = self benefit, A = benefit to others, S = Social benefits, I = Individual benefits. Based on the possible vales of equation 1 and 2, we are able to classify all behaviors in four distinct categories:

Action	Effect	Interaction	Benefits
Wise	$S > 0$ and $I > 0$	Social investment	Group and actor
Egoist	$S < 0$ and $I > 0$	Destructive egoism	Actor at a cost to group
Altruist	$S > 0$ and $I < 0$	True altruism	Group at a cost to actor
Stupid	$S < 0$ and $I < 0$	Destructive behavior	Neither group nor actor

The only category of actions that increased in all cases the aggregate wealth of societies was the one described as Wise. The work with Sociodynamica, contrasted with what we assume to know about what happens in real societies, leads us to conclude that the creation of wealth is only possible if social interactions achieve social investment and allow creating synergies that catalyze ever more efficient uses of natural resources and information. In the artificial societies analyzed here, the creation of wealth is dependent on the creation of synergies and its preservation and accumulation is depended on “wise” action by the agents.

4. Conclusion

The simulations show that even in the simple societies analyzed here, non intuitive complex behavior emerges from the system. The examples shown here reveal that optimal behavior for agents in a non-structured society, of the type probably formed by hunter-gatherers of Neolithic times, differ markedly from those of agents inhabiting societies with a minimum of division of labor, such as those in agricultural societies. If differences in the social dynamics between societies with no division of labor and those having a very simple division of labor, are apparent with simple artificial societies, we might expect that strong differences in the dynamics of more structured societies, like those of the industrial and postindustrial economies, exist. Based on the insight gained with our simulations we might expect that an important part of the dynamic properties of complex societies will arise from the behavior of the agents integrating the society. This behavior, our simulations suggests, will be different for societies optimizing different values or developing different economies. Many such differences could be uncovered using methods from experimental economics and from comparative behavioral sciences. For example, anthropological research showed that the economy or forms of livelihood of pre-literate societies correlated very precisely with child rearing practices, where education in hunter gatherer societies stress greater independence, whereas agricultural societies stress obedience (9-10)

Evidence from macro-economics indicates that the industrial revolution unleashed economic forces that allowed for an accelerated economic growth (6). Experimental data on per capita energy consumption of human aggregates indicate that societies form synergistic associations which make energy consumption more efficient as human aggregates get larger (1). The insight gained from our simulations leads us to conclude that the creation of wealth is only possible if social interactions create synergies that allow for ever more efficient uses of natural resources and information. Thus, different approaches suggest that the understanding of the creation of wealth is dependent on our understanding of the creation of synergies.

This leads us to propose to continue in the construction of a science for the study of the nature of synergies (2), with a strong participation of social simulations. This science of the synergies or *Synergetics* could explore analogies and homologies between the synergistic emergence of structure in physics, chemistry, biology, sociology and economics. Clearly, this new challenge can only be met with a true and deep interdisciplinary effort to understand the fundamentals that allow for synergies to emerge in different

circumstances. Such efforts have been initiated before, and some of them have shown to be extremely productive in advancing our scientific and technological knowledge. But the fundamental questions of how synergies emerge from complex dynamic interactions, remains largely unresolved. I believe that computer simulations of social systems are a perfect tool for addressing these fundamental questions.

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