Taylor & Francis
Taylor & Francis Group

Chaos Theory and Institutional Economics: Metaphor or Model?

Author(s): Irene van Staveren

Source: *Journal of Economic Issues*, Mar., 1999, Vol. 33, No. 1 (Mar., 1999), pp. 141-167
Published by: Taylor & Francis, Ltd.
Stable URL: https://www.jstor.org/stable/4227418

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at https://about.jstor.org/terms

Taylor & Francis, Ltd. is collaborating with JSTOR to digitize, preserve and extend access to *Journal of Economic Issues*

JSTOR

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

JOURNAL OF ECONOMIC ISSUES
Vol. XXXIII No. 1 March 1999

Chaos Theory and Institutional Economics: Metaphor or Model?

Irene van Staveren

> *The growth and mutations of the institutional fabric are an outcome of the conduct of the individual members of the group, since it is out of the experience of the individuals, through the habituation of the individuals, that institutions arise; and it is in this same experience that these institutions act to direct and define the aims and end of conduct.*
>
> *—Thorstein Veblen, 1961*

> *In classical dynamics the "quality" of information is disregarded. This, in a sense, is quite logical if you deal with systems with a finite number of degrees of freedom. For example, we may deal with the system sun-earth-moon. The sun speaks to the moon, the moon speaks to the earth; there is no information escaping from these three actors. But LPS [Large Poincaré Systems or unstable dynamical systems] correspond to multiactor systems where the information is transmitted from one degree to another and finally disappears in a sea of highly multiple conditions.*
>
> *—Ilya Prigogine, 1993*

The Veblenian tradition of institutional economics is, unlike neoclassical, Marxist, or new institutional economics, firmly embedded in social, cultural, and political life. The tradition lends itself to rich descriptive analyses, recognizing the interplay of economic behavior with social, cultural, moral, and political domains of life and its institutions. This old institutional economics therefore is difficult to catch in mathematical terms, let alone in linear algebra. However, with recent developments in the natural sciences and mathematics (quantum mechanics, systems theory), it might become relevant to consider anew whether mathematical relationships

The author is guest researcher at the Faculty of History and Arts, Erasmus University, Rotterdam. This paper was awarded the Association for Evolutionary Economics 1997 Essay Prize. I am grateful to everyone who has commented on earlier versions of this paper. Special thanks go to the Association for instituting this prize and to the Foundation "Vereniging Trustfonds Erasmus Universiteit Rotterdam" for enabling the author to attend the 1998 AFEE annual meeting in Chicago to present this paper and to receive the award. Furthermore, two anonymous referees of this journal were very helpful in clarifying and improving the argument.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

could illustrate and support the theoretical endeavors of institutional economics.[1] This paper intends to provide some suggestions of how institutional economics might profit from mathematical metaphors or even models derived from chaos theory.

Although it is held that "there is a relatively common set of beliefs that unite the work of institutionalists . . ." [Samuels 1995, 571], institutional economics is not built upon a fixed set of assumptions as neoclassical economics is. The common set of beliefs held by institutional economists could be summarized in a very sketchy and highly incomplete manner, with the following characteristics.[2] Institutional economists recognize the complexity of economic life and the ambiguities and social, cultural, normative, and political character of economic behavior as essentially a process of interaction among persons based on values and habits that shape and reshape institutions. The assumption of methodological individualism central to many other economic theories is rejected. This position implies that economic processes cannot be explained in terms of the aggregated result of individual actions assuming fixed preferences, utility maximization, and (im)perfect information on market prices. Institutional economics, and especially evolutionary economics, concerns itself with dynamics, not with comparative statics. Economic change in institutional economics is considered to be historical and contextual, influenced by and shaping institutions. The process of change hence is irreversible. Also, institutionalists generally regard change as involving a transformation of structures, not as an outside shock to a structure. The economy is viewed as a moving system without determinate optimum equilibrium solutions. Means and ends, causes and effects, are often unstable and difficult to distinguish. "Institutionalists have been holistic . . . Pursuit of the mechanics of price determination trivialises what the economy is all about, and excludes considerations of social control and social change and all that they entail" [Samuels 1995, 575]. This implies that institutionalists regard interaction in the economy not only as complex, but also as highly interdependent, which calls for a holistic explanation of economic phenomena.

Writings in institutional economics have been mainly theoretical, explaining economic behavior with descriptions, historical narratives, and with the help of ad hoc illustrative metaphors. The method is pluralist, even eclectic, but generally confined to the narrative format, rather than to a mathematical one. Besides some exceptions in technology and a few other fields in institutional economics, there is not much of an institutional econometrics, since it does not lend itself easily to linear modeling. Some even indicate that mathematics is impossible and/or undesirable in institutional economics [Mirowski 1981]. Contrary to this view, Michael Radzicki [1990] introduced mathematics and ideas from chaos theory in institutional economics and argued that it would make sense in institutional economics. Radzicki [1990, 95] concludes optimistically that ". . . it is possible to envision the institutional dynamics models of the future portraying the processes (or results) of instrumental valu-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

ation and social conflict, not with noise, but with structures that produce chaos." Unlike standard economic modeling, chaos theory is characterized by nonlinearity, path dependence, feedback loops, bifurcations, endogenous change, attractors in phase space, and non-stable interaction between variables. The properties of nonlinear mathematics suggest links between chaos theory and institutional economics, according to Radzicki. The nature of the connections, however, has not been elaborated extensively yet.

This paper will go a bit deeper into the issue raised by Radzicki and will provide suggestions as to what extent institutional economics might profit from an engagement with chaos theory. This will be done by discussing the metaphorical strength of chaos theory for institutional economics, ranging from a weak analogy to modeling. A case study based on research by Caroline Moser on household provisioning in Ecuador will illustrate the discussion with a model.

Chaos Theory and Metaphors

Within and outside academic discourses, chaos theory has gained the image of a trendy metaphor. Often the status of this metaphor remains unclear. Here, the increasing metaphorical use of chaos theory is the starting point for further inquiry. Chaos theory originated in mathematics and physics and has developed over the last two decades; it is related to other developments in mathematics and (social) systems theory (a standard source on the issues is Prigogine and Stengers [1984]). The theory has evolved from analyses of nonlinear dynamic open systems that reveal unstable behavior between variables. Although chaos shows unstable behavior between variables, it is not stochastic. The unstable pictures of nonlinear models are seemingly random but hide a pattern. Therefore, the idea of chaos should not be confused with randomness. Random behavior is unpredictable and independent of the initial position of the model. Randomness is contingent, without any underlying order, whereas chaotic behavior is also unpredictable but very much dependent on the initial condition of the model.[3] Chaos thus is not randomness—it hides a particular pattern. This pattern is referred to as a strange attractor. An attractor shapes the dynamic behavior of a nonlinear model into a certain order—the order in chaos. Attractors are sets of uncountable points that represent a force of attraction that guide a system's behavior but do not completely determine it. Paths toward the points of attraction are never followed twice, and the attractors are not reduced to a point, but they embody a basin of attraction. That is why they are labelled strange attractors.

Since nonlinearity is a basic characteristic of chaos, it is informative to distinguish nonlinear models from linear models, following Douglas Kiel and Euel Elliott [1996].

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

1. Linear equations are typified by the superposition principle, which implies that two solutions of a linear equation can be added to form a new solution. This allows linear equations to break down problems into pieces (think about the *ceteris paribus* assumption in economics and the modeling of partial equilibria). The superposition principle does not hold for nonlinear dynamics: a nonlinear equation cannot be broken down into bits and then reformulated to obtain a solution.
2. A simple nonlinear equation can generate chaotic behavior over time, within defined parameters. Linear models do not necessarily lead to stable equilibria, but they never result in chaos.
3. Linear systems, characterized by stable relationships between variables, change only because of external shocks and typically bring the system back to equilibrium. Nonlinear systems may periodically behave like linear systems, but during other time periods the relationships between variables may change. Such a transition is called a bifurcation. Three types of dynamic behavior can be distinguished:

    a. Stability–a fixed point equilibrium.
    b. Oscillation–a periodically stable movement of the system between two or more points.
    c. Chaos–a divergence of the system toward one or more attractors.

4. Nonlinear systems exhibit sensitive dependence on initial conditions—the often referred to example of a butterfly in China causing a hurricane in Jamaica. This feature distinguishes chaotic behavior from random behavior, which is insensitive to its initial condition. A stochastic term could be used in a nonlinear model as well, but only to add some "noise" to the model. The irregularity does not come from the error term, but from a bifurcation of the model to chaos.
5. Even without a stochastic element, nonlinear systems exhibit uncertainty. The outcome of subsequent bifurcations that result in changing variable interactions cannot be known. This implies that a wide variety of possible outcomes is inherent to nonlinear systems, which makes prediction impossible, contrary to linear systems.

Kiel and Elliott [1996, 2] conclude their summary of nonlinear dynamics as thus: "In all nonlinear systems, however, the relationship between cause and effect does not appear proportional and determinate but rather vague and, at best, difficult to discern." This fuzzy idea does not seem to be a good candidate for economic modeling, since most economic models are constitutive of a theory and are instrumental in prediction. These are strong demands of a model, which in a general sense is only a strong version of a metaphor. According to Arjo Klamer and

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Thomas Leonard [1994], a model is a sustained and systematically elaborated metaphor. A looser type of metaphor is represented by images that facilitate understanding. Still less explicit are symbolic metaphors, which suggest a similarity in meanings. Below, these three types of metaphors will be considered, in ascending order of analogous strength: symbolic metaphor, iconographic metaphor, and extended metaphor, or model.

Chaos Theory as Symbolic Metaphor

A symbolic metaphor appeals to meanings like, for example, "hard science" versus "soft science." A set of symbolic metaphors, like in this example, implies both a dualistic distinction (such as between quantitative physical sciences and qualitative social sciences) and a hierarchical, normative distinction with universal implications, which generally ascribes a higher status to the first mentioned pole. Implied in the dichotomy of meanings is often a reference to gender—masculine ("hard") and feminine ("soft") meanings.

In economics, symbolic metaphors often implicitly support the dominance of neoclassical theory. Efficiency is favored over equity, positive methodology over normative, quantitative method over qualitative method, self-interest over altruism, and logic over emotions. The second terms in each pair are generally ascribed to "other" economic theories,[4] such as institutional economics or feminist economics, as in "A" versus "not-A" [Chick 1995; England 1993; Jennings 1993; Nelson 1993; Waller 1994]. Such a dichotomous positioning of meanings also occurs with the designation of chaos theory versus accepted theories in physical science. But this dichotomizing is exactly what chaos theorists resist [Prigogine and Stengers 1984]. In their view, systems can both exhibit chaos and order. Chaos is even conceptualized as a precondition for order, and both can interchangeably arise. In economics, Sheila Dow [1990] has proposed a similar breakdown of symbolic dualism. Victoria Chick [1995] goes further and suggests the point of view of complementarity instead. For example, for the dualism of certainty/uncertainty or predictability/unpredictability, she proposes ambiguity in modeling, which also steps outside the old masculine/feminine divide implied in the dualisms.

The risk with linking chaos theory to institutional economics only at the symbolic level is that perceived dichotomies between neoclassical and institutional economics are sustained instead of contested. This leads us to consider a different type of metaphor.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Chaos Theory as Iconographic Metaphor

Chaos theory provides a particular set of visual, iconographic metaphors that not only possess cognitive value that enhance understanding of complex dynamic processes through images, but also aesthetic value through the beauty of the icons generated by computer models. Chaos theory as an iconographic metaphor implies, according to David Harvey and Michael Reed, that ". . . the gaze is more important than deductive logic in grasping the evolution of a chaotic structure" [Harvey and Reed 1996, 310]. Indeed, this is what Figure 1 illustrates. It is an image of chaos, but it shows an amazing underlying order.

Chaos theoretic icons are the visual representations of strange attractors and have a mathematical symmetry because they are derived from fractals, which have a repetitive structure. The gravitating but not determining force of strange attractors suggests an analogy to the guiding but not deterministic force of norms and values as represented by institutions in institutional economics. Drawing on this analogy, the icons hint at a visual representation of institutions: the gravitating forces at work

Figure 1. Order in Chaos: The Lorenz Model—"The Butterfly"

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

in the icons might be thought of as reflecting institutional mediation. They are not constraints, as in some strands of new institutional economics, but are intangible norms and values that guide behavior toward some balanced pattern of action. Iconographically, the strange attractors guide behavior by attracting toward a pattern, not by stabilizing the picture in an equilibrium. Icons representing various strange attractors could then be regarded as illustrating collisions in economic behavior resulting from the functioning of a variety of guiding norms in social and economic behavior at the same time. An example of an informal institution that may function as a strange attractor is the social norm of neighborly help. It does not determine individual behavior, but it may explain an underlying order in the survival of individuals who live outside families and who are temporarily unable to care for themselves.

The value of chaos theoretical iconography to institutional economics thus could be found in a metaphorical similarity between strange attractors and institutions. This iconographic metaphorical connection provides us with a possible starting point for connecting chaos theory and institutional economics more closely through modeling.

Chaos Theory as Model

Although the attempt in this section is to suggest chaos theory as an extended mathematical metaphor, particularly for institutional economics, it has to be acknowledged that new developments in neoclassical and Post Keynesian economics seem to proceed in the same direction.[5] However, the basic characteristics of chaos theory as explained earlier contradict many standard economic assumptions, such as the assumption of market equilibrium, which can only be assumed in closed systems and not in open systems in which chaos operates.[6] It remains to be seen, therefore, whether the attempts to marry chaos theory with neoclassical and Post Keynesian economics will be fruitful. According to Philip Mirowski, if chaos models were followed to their bitter conclusions, they would render neoclassical economics meaningless: ". . . What the chaos literature will not do is augment or save neoclassical economic theory" [Mirowski 1990, 305].

From the analogies mentioned thus far, some basic ingredients of chaos theoretic modeling in institutional economics will be discussed below.

Level of Analysis

Institutionalism. The level of analysis is social, not merely individual. The focus is determined by methodological holism, not individualism. The aggregation of par-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

tial analyses is impossible, since parts cannot be considered independent from the whole.

Chaos theory. The level of analysis is an open system. The focus is not on a dependent variable, but on phase space, and, with higher dimensions of a system, the analysis is of a manifold.[7] The degrees of freedom determine the dimensions, which in dynamic economic models could be paralleled by time periods of t, t-1, t-2, and so on. Equations cannot be broken down since the superposition principle does not hold. So, it is impossible to break down the level of analysis from the system as a whole to particular relationships within the system, keeping other variables constant.

A model may exist of a one-dimensional difference equation such as the following:

$$X_{t+1} = f\alpha(Xt) = \alpha X_t(1-X_t) \qquad (1)$$

A well-known three dimensional model is the Lorenz model:

$$dX/dt = a(X_t - Y_t) \qquad (2)$$

$$dY/dt = X_t(b - Z_t) - Y_t \qquad (3)$$

$$dZ/dt = X_tY_t - rZ_t \qquad (4)$$

Role of Institutions

Institutionalism. Next to formal institutions, such as laws and organizations, institutions reflect intangible human norms and values. These intangible institutions, such as discrimination against minorities or neighborly help, guide human behavior in a certain direction. As Mark Granovetter wrote [1985], behavior is neither undersocialized or completely autonomous nor oversocialized or completely dictated. This idea of a mediation role for institutions has been formulated in institutional economics as the aim ". . . to avoid the pitfalls of voluntaristic individualism on the one hand, and structural determinism on the other. There is no single or clearly marked route to success, but it is a direction worth taking nevertheless" [Hodgson 1988, 66].

Chaos theory. Strange attractors guide a system's behavior, but they do not completely determine it. An attractor has zero volume, which may be seen as an analogy to the intangibility of the norms and values shaping institutions [see also a suggestion in this direction in de Greene 1996]. Kenneth Bailey [1994] refers to strange attractors in terms of entropy (H) (the opposite of which—negentropy—could be regarded as knowledge, technology, and social norms) in a system. According to the second law of thermodynamics, entropy increases to its maximum, thereby lowering the level of organization and complexity until a system becomes predictable and sta-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

bilizes in equilibrium. Entropy in this sense is similar to the development of an egg (low entropy but much potential) into an adult chicken and through various stages until it is dead (no potential anymore but high entropy). Kenneth Boulding [1993] has illustrated the dynamics of the economic system with the help of entropy from an ecological point of view. He argues that the economy is an open system that needs constant energy inputs to survive—a resource that will sooner or later become exhausted. "In the energy system there is, unfortunately, no escape from the grim second law of thermodynamics; and if there were no energy inputs into the earth, any evolutionary or developmental process would be impossible" [Boulding 1993, 301]. He also suggests that human knowledge and technology may counter the threat, albeit not completely stop it.

The basic equation for entropy is from Prigogine:

$$dS_t = dS_i + dS_e \tag{5}$$

dS_t = total entropy change in the system
dS_i = change in internal entropy
dS_e = change in external entropy

However, the increase of entropy to its maximum and a stable equilibrium only count for closed systems, in which there is no import and export of entropy, information/energy (negentropy), and matter. Social systems are open systems. In terms of Equation 5 above, internal entropy may increase, but there may be external entropy inflow that is negative. And if $d|S_e| > d|S_i|$, total entropy change may be negative instead of positive. In open systems, such as social systems, it seems that human behavior is able to offset the increase in entropy by importing negentropy into the open system, which makes the system more organized, contrary to the prediction of the second law of thermodynamics. "If all human action were random, with no replication, then H would be maximum. If all human actions were identical, then H would be the minimum, or zero . . ." [Bailey 1994, 247]. Bailey explicitly connects this to institutions: "In reality, H is generally somewhere in between. Purposive action guides systems—not return to equilibrium. This purposive action is guided by customs, laws, five-year plans, short-term goals, etc. It thus is to some degree 'rational' and replicated, thus keeping H below the maximum. It is also imperfect and subject to error, thus keeping H above the minimum" [1994, 247]. It is especially this property of chaotic systems that suggests strange attractors as suitable candidates for modeling institutions: they keep the economic system evolving on a path somewhere between static equilibrium and randomness.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Endogenous Change

Institutionalism. Dynamics come not only from external shocks, but most often from inside. Change in the economic process arises from transformations of institutions, for example, through an accumulation of knowledge through learning or an increase in technology through creativity. These induce changes in the relationships between variables in the economic process, changing parameter values at particular thresholds. A threshold may trigger the spread of certain destructive norms that have devastating effects on the economy, such as the leisure of the elite as described by Veblen [1931]. In the long run, a threshold could be seen in population growth or decline above or below a certain level, accumulating or breaking down a necessary critical mass for the adherence to certain economic behavior [Day and Walter 1989]. The movement of business cycles may be reflected in changes of attractors from fixed equilibria (recessions) to chaotic behavior (booms) by an increasing level of information and knowledge. The new cognitive field may function as an informal institution, guiding learning and the further growth of knowledge [de Greene 1996].

Chaos theory. Dynamics are endogenous and are reflected in changes in the attractors. They can move from a stable point to periodic oscillation or to chaos—and back again. Endogenous change is caused by changing relationships between the model's variables: parameter values change from one stage to another. Such shifts in the parameters may be substantial and result in bifurcations of the model from stable equilibrium to oscillations or chaos. For example, learning may increase the parameter value of α below, which may move the dynamics of the model into another stage.

An example is again Equation 1:

$$X_{t+1} = \alpha X_t(1-X_t) \tag{1}$$

As parameter α is increased from zero, the trajectories of X can be seen to exhibit bifurcations. Starting from an initial condition in the interval (0,1) we have:

$0 < \alpha \leq 1$ monotonic contraction to $X = 0$
$1 < \alpha \leq 2$ monotonic growth converging to $X = (\alpha-1)/\alpha$
$2 < \alpha \leq 3$ oscillations converging to $(\alpha-1)/\alpha$
$3 < \alpha \leq 4$ continued oscillations of X

And for α larger than 4, X will show chaotic behavior.

Path Dependence

Institutionalism. Change in economic processes is embedded in a historical and cultural context. History matters, and therefore changes are unique and not univer-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

sally valid. In a world influenced by institutions and reshaping institutions, what are perceived as small institutional changes at time X_1 may later appear to have been big changes in time X_2; for example, large changes in demand would occur if a company would use only a fraction of genetically manipulated soya beans in the production of baby food.[8]

Chaos theory. Chaotic systems exhibit sensitive dependence on initial conditions. This path dependence makes change every time unique and not reproducible. To remind the reader, this has to be distinguished from randomness, which is not dependent on initial conditions. Sensitive dependence on initial conditions occurs because the distance δX between two neighboring trajectories with only slightly different initial positions increases exponentially when we use a quadratic model. The difference—of one butterfly in China inducing a hurricane in Jamaica and another butterfly not even causing a bit of wind—occurs because each trajectory develops dynamic behavior that builds on past behavior. Each stage in the process may move the evolution one trajectory further away from the development occurring in the other trajectory.

Now we have some basic ingredients of chaos theoretic modeling in institutional economics. Below, a possible model will be illustrated with help of a case study of the process of provisioning in an endogenously and exogenously changing environment.

A Model: A Case Study from Guayaquil

We now will turn to a case study of Guayaquil in Ecuador. Caroline Moser [1989] has studied the combined impact of recession and adjustment policies on low-income women and their households in a poor community in the city of Guayaquil. Of course, many case studies involving common characteristics of chaos theory and institutional economics, such as social norms and a macro level of analysis, could have been chosen. Among them are other studies of provisioning through both paid and unpaid work [as, for example, by O'Hara 1995]. But the present case study was deemed particularly suitable because it has (1) a clear-cut categorization of social norms expressed through informal institutions such as gender and various roles in provisioning; (2) rich anthropological descriptions of role combination and its failure; and (3) the suggestion of a "chaotic" result for a particular group in the case study.

The question now is whether a chaos theoretic model can further our understanding of the case study, particularly on the findings of different groups and a seemingly chaotic result for one of these groups. Because of limited space, Moser's study will be summarized very shortly—leaving out some interesting background information and insights. In the years before adjustment, life expectancy had increased significantly in Ecuador, infant mortality rates had decreased dramatically,

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

and primary school enrollment was almost 100 percent. GDP growth followed the increase in oil export revenues. Financing of the expansion of public expenditures in the 1970s became heavily dependent on oil revenues and external borrowing. The years 1982-1988 saw a serious recession with decreasing oil revenues, increasing interest rates on foreign debts, difficulties with obtaining new credit, and strong international competition for Ecuadorian industry when protection was diminished.

In 1982, a stabilization policy was introduced and was followed by more measures over the following years. Stabilization, and later economic reforms, consisted of devaluation of the currency; control of imports; decrease in public sector expenditures; liberalization of prices; reduction in food, energy, and fuel subsidies; and liberalization of imports and exports, which resulted in one success story emerging in 1986, i.e., shrimp production and exports. In 1986, interest rates were made flexible, and control of foreign exchange was stopped, as required by the International Monetary Fund (IMF). Public sector spending, however, still increased due to the demands of powerful interest groups. On top of this, in 1988 agricultural and textile production stagnated because of falling purchasing power.

Guayaquil is an important city and port of Ecuador, attracting rural migrants and amounting to a population of about 2 million in 1988. The neighborhood examined by the case study is called Indio Guayas. Earlier research in 1978 had shown most households were headed by men, based on free unions between men and women, and average household size was 5.8 persons. Most labor was unskilled and low paid. Jobs for men included mechanics, construction, tailors, and factory workers. Jobs for women included domestic servants, washerwomen, cooks, sellers, and dressmakers. The community was poor but upward aspiring, struggling to improve living conditions, especially for the children.

After recession and adjustment measures, the following changes were registered in women's provisioning roles.

1. Productive Role. Unemployment increased rapidly and wages decreased. The demand for male labor decreased quickly, although the emerging shrimp industry attracted migrant workers who only spent one weekend in three at home. Hence, more women had to seek paid work, increasing female participation rates from 40 percent in 1978 to 52 percent in 1988. Many women became the only reliable earner. But wages had fallen a third to their 1978 value in female occupations. Because of the decline in wages and the rise in prices for basic needs, such as food, women worked more hours than before, often 60 hours per week, and combined two or even three jobs of domestic service. The women started to work earlier, when their children were younger than before, sometimes leaving them unattended. The number of female-headed households had increased from 12 percent to 19 percent, which was related to the out-

This content downloaded from 132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

migration of men and to a decrease in male responsibility for household support when taking up a new household in the rural areas.

2. Reproductive Role. More outside paid work and no tendency to a redistribution of unpaid work toward men resulted in less time available for unpaid work. Some women got up at 4 or 5 a.m. in order to cook a meal for the children, who remained alone the rest of the day. At the same time, household tasks demanded more time than before the crisis. Savings on electricity for refrigerators and on luxury food with short cooking times made it necessary to shop more often and to spend more time cooking. Half of the women suffered from an increase in male violence, often related to their demands for cash for household necessities. Daughters lent substantial support to the more demanding household tasks, so their school attendance and homework suffered, which had implications for their future careers. Sons often exhibited the opposite behavior, lingering in the streets, dropping out of school, and getting involved in street gangs and drug use. This tendency was aggravated when the responsibility of the father also disappeared.
3. Community Management Role. Cutbacks in infrastructural spending by the government has made room for NGO (Non-Governmental Organization) provisioning of community development, which, however, demands much time from women in negotiating for the services and in actually controlling the systems. Daughters also support in community management, i.e., by attending Saturday and Sunday meetings. User fees were introduced in health care, but the quality of the services decreased. A preschool program by UNICEF commanded parents' help in construction of a building and in participating in the program. The primary school lacked adequate equipment and suffered from a low quality of teaching. Both boys and girls were sent to school as long as possible to gain a qualification, which became more and more necessary in the overcrowded labor market.

The study concludes that ". . . the real problem is not the length of time women work but the way in which they balance their time between their reproductive, productive and community management roles" [Moser 1989, 159]. The study continues by concluding that about 30 percent of the women are just "coping" with the difficulties, 15 percent are no longer coping but "burned out," whereas 55 percent of the women are still "hanging on," trying to balance their three roles and invisibly at risk. The productive and community management roles appeared to become prioritized over women's reproductive roles since "the need to get access to resources has forced women to allocate increasing time to productive and community management activities, at the expense of reproductive activities, which in many cases have be-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

come a secondary priority. This has a significant impact on children, on women themselves and increases the likelihood of disintegration in the household" [Moser 1989, 159].

We can simulate the case study with two different types of chaos theoretic models, a one-dimensional quadratic map and a three-dimensional model of differential equations, as introduced above.[9]

1-D model:

$$f(X_t) = \alpha X_t(1 - X_t) \tag{6}$$

X = provisioning by women in their three roles.
α = women's capacity of balancing their three roles.
t = months -> 120 periods from January 1978 until December 1988.

3-D model (Lorenz model):

$$f(X_t) = a(X_t - Y_t) \tag{7}$$

$$f(Y_t) = X_t(b - Z_t) - Y_t \tag{8}$$

$$f(Z_t) = X_t Y_t - rZ_t \tag{9}$$

X = women's productive role in provisioning.
Y = women's reproductive role in provisioning.
Z = women's community management role in provisioning.
a, b, r = parameters balancing each role vis-à-vis the other roles.
t = quarter of a year -> 40 periods from X_0 (first quarter of 1978) to X_{40} (last quarter of 1988).

Variables X, Y, and Z only refer to women's provisioning, not to men's. Another variable could be added to represent men's single gender role in provisioning—income earning—which is similar to the variable X for women, but that would complicate the model.[10] Parameters α, in the one-dimensional model, and a, b, and r, in the three-dimensional model, represent the capability of women to balance the three roles.[11]

Following the earlier formulated suggestion of chaos theory as an iconographic metaphor for institutionalism, each institutional sphere in provisioning—production, reproduction, and community management—could be illustrated by an attractor, representing the institution attracting women's behavior in that particular sphere. In the 3-D model, a balance between the three roles is illustrated as a collision of the three attractors in a point—an equilibrium. This could represent a situation in which women and men share the provisioning process, so that there are enough time resources available in the household to be allocated to each role. This may result in a stable situation. A situation of pressure toward disbalance generates oscillatory at-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

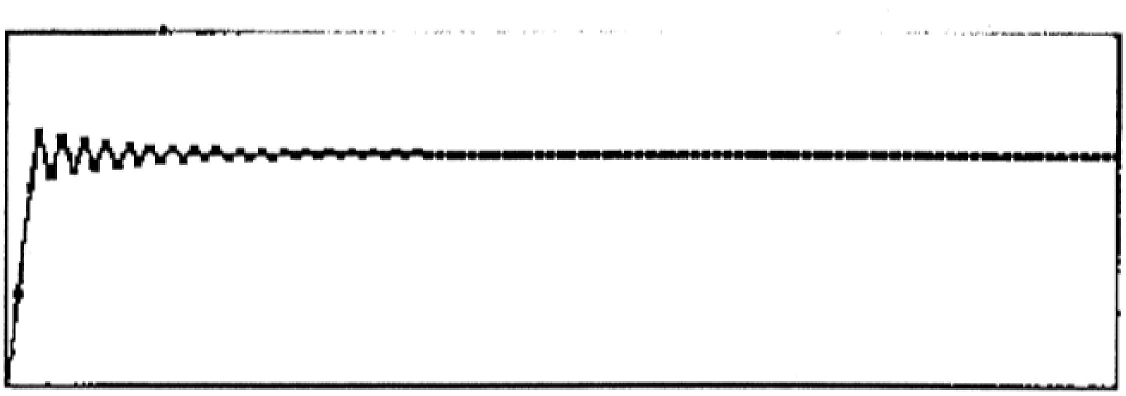
tractors, for example, in a three-period cycle, indicating a regular shift in emphasis from one role to the other. This may be an illustration of a situation of male unemployment and a subsequent increasing pressure on women's time. The allocation of women's time may then be determined by seasonal jobs, children's school holidays, and other periodic influences on their roles. A situation of complete disbalance changes the attractors into strange attractors and results in a chaotic movement in the basins of attraction. This could represent a situation of female-headed households with degenerating relationships and insufficient levels of provisioning. Each role may compete with the others on an ad hoc basis, for example, upcoming income earning opportunities, sudden demands in community work and organizations, and demands by sick children, sons caught by the police, or daughters leaving housework and unattended younger siblings behind. The three different types of dynamics are represented in the models by changes in parametric values.

First, the 1-D model and the parameter value of α in various stages will be discussed. The division into three groups, each representing a particular stage in the dynamics, is derived from Moser.

- $2 < \alpha \leq 3$: Oscillations between the three attractors but moving toward a new, lower level equilibrium, illustrating the 55 percent group (Figure 2).
- $3 < \alpha < 4$: Continuing oscillations between the three attractors, illustrating the 30 percent group (Figure 3).
- $\alpha \geq 4$: Transition to chaos, illustrating the 15 percent group (Figure 4).

The figures presented here and later on can be taken as iconographic metaphors. They indicate the dynamics of household provisioning under difficult circumstances. In Figure 2, we see a stabilization of the model toward a new equilibrium, as is the case in standard, linear dynamic models. In Figure 3, the parameter value of α is larger, representing an increased pressure on women's capability to balance their

Figure 2. 1-D Time Path for 55 Percent Group: Move to Equilibrium



This content downloaded from 132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Figure 3. 1-D Time Path for 30 Percent Group: Oscillations

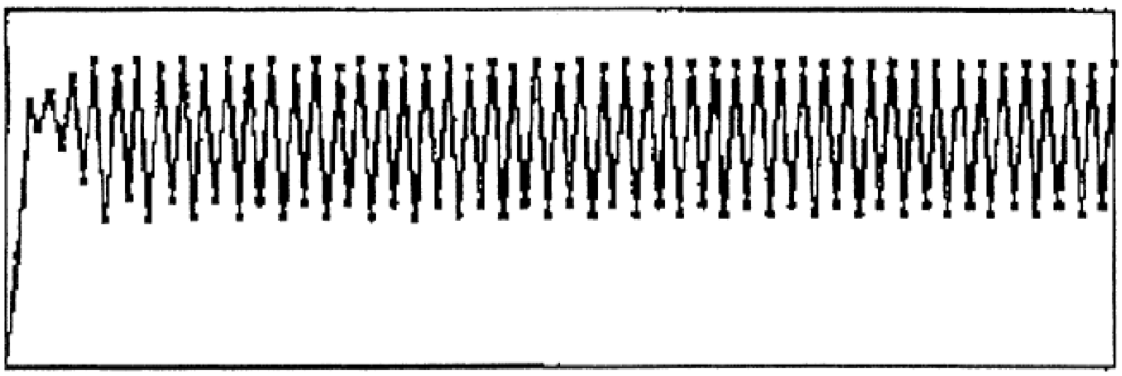
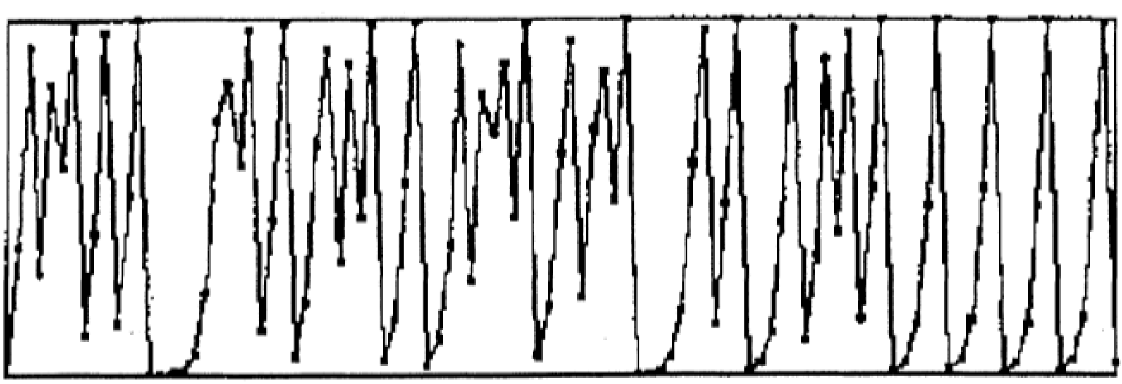


Figure 4. 1-D Time Path for 15 Percent Group: Chaos



economic roles. The iconographic result is an oscillatory pattern, suggesting a regular shift in activities from one role to another. In Figure 4, the pressure on women's balancing capability has become overwhelming. Women in this group are no longer able to combine their roles adequately. They fail to provide a reliable living for their families.

The 3-D Lorenz model has three variables, X, Y, and Z, each representing one role in provisioning. The dynamics are more complicated than in the 1-D model and will be illustrated below. A stable equilibrium was found at parameter values (a, b, r) of (8.00, 19.00, 12.00) shown in Figure 5 for the reproductive role, Y. Oscillations moving toward a stable equilibrium were found at parameter values (3.00, 2.67, 28.0) in Figure 6 for the community management role, Z. A stable 12-cycle was found for higher parameter values, i.e. (4.40, 4.40, 40.0), in Figure 7 for the productive role, X. Since each period represents a quarter of a year, a 12-cycle implies a cycle occurring over three years, moving the emphasis from the one role of women's provisioning to another each quarter of the year. This cycle may be ex-

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

plained by factors such as seasonal work (for example, when a member of the household works in the shrimp industry), school holidays, poor health, and other cyclic influences. Figure 8 indicates chaos for parameter values (13.0, 2.66, 31.0), illustrated for women's productive role, X. This could imply complete unreliability of paid work as in labor on a day-to-day basis. The figures illustrate the dynamic behavior of the three-dimensional model along two axes. So, each time only two of the three variables (X, Y, Z) are shown.

Finally, some phase diagrams will be shown, indicating a single strange attractor in the 1-D model and three strange attractors in the 3-D model. The single attractor could be thought of as representing some balance between women's three roles, although not stability. The three attractors could be thought of as illustrating the vulnerability of keeping three roles in balance, with each role vulnerable to the influences of the other two roles. The attractors can be thought of as picturing the informal institutions that guide each role. But their attracting forces are undermined

Figure 5. 3-D Time Path: Role Combination Moves to Equilibrium

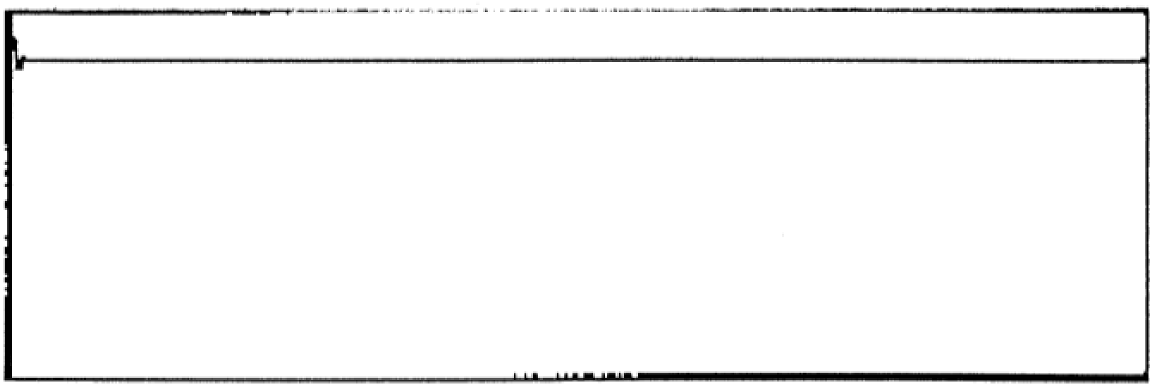
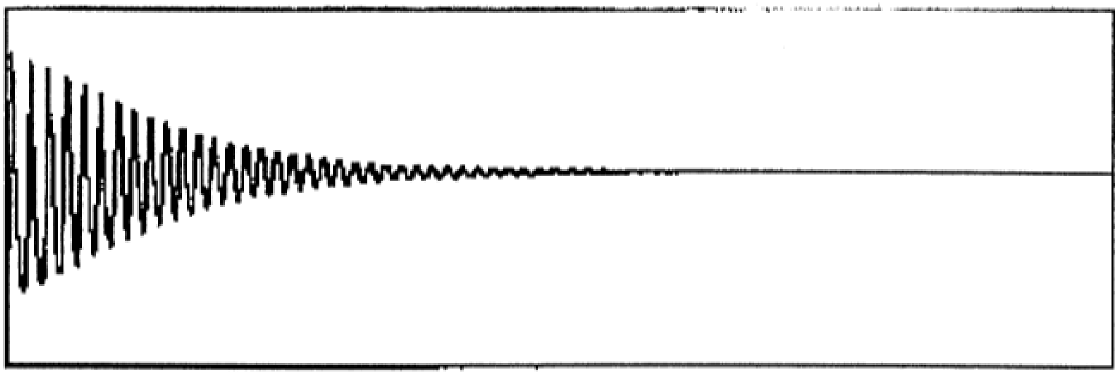


Figure 6. 3-D Time Path: Dampening Oscillation in Role Combination



This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Figure 7. 3-D Time Path: Stable Cycle between the Roles

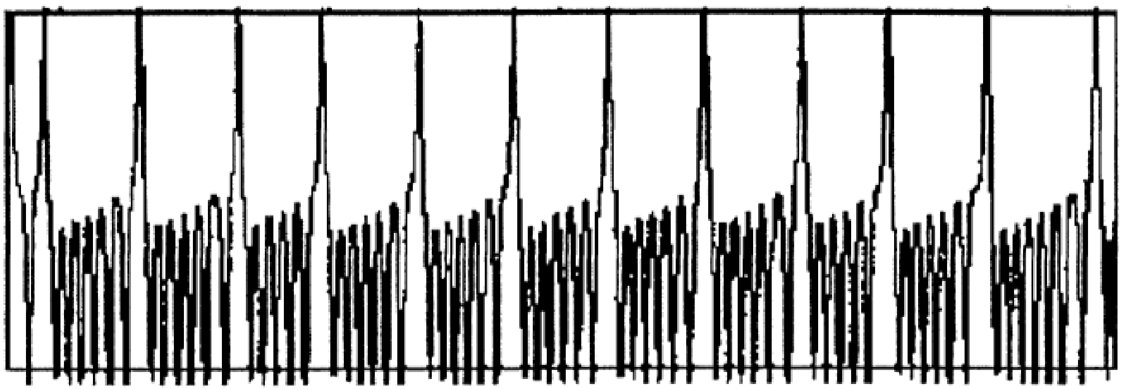
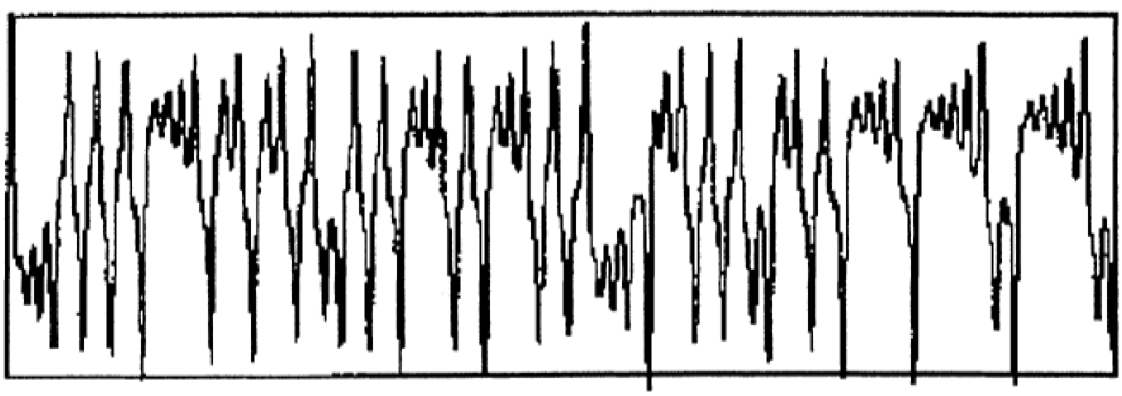


Figure 8. 3-D Time Path: Chaos in Role Combination



by the effects of the macroeconomic recession and reform policies. So, provisioning is insecure—the system is highly unstable—leading 15 percent of the women in Indio Guayas to destitution, resulting in disintegrating households, absolute poverty, and negative effects on children. However beautiful the pictures may be, they are illustrations of the failure of household provisioning at minimum necessary levels. Figure 9 maps a single attractor in the (X-Y) space with parameter values (a, b, r) of (4.0, 4.0, 35.0), suggesting some balance between roles. Figure 10 represents an icon of three attractors in the (X-Y) space, with parameter values (a, b, r) of (10.0, 10.0, 45.0), suggesting an unstable but nevertheless patterned movement of the model between the institutions representing roles.

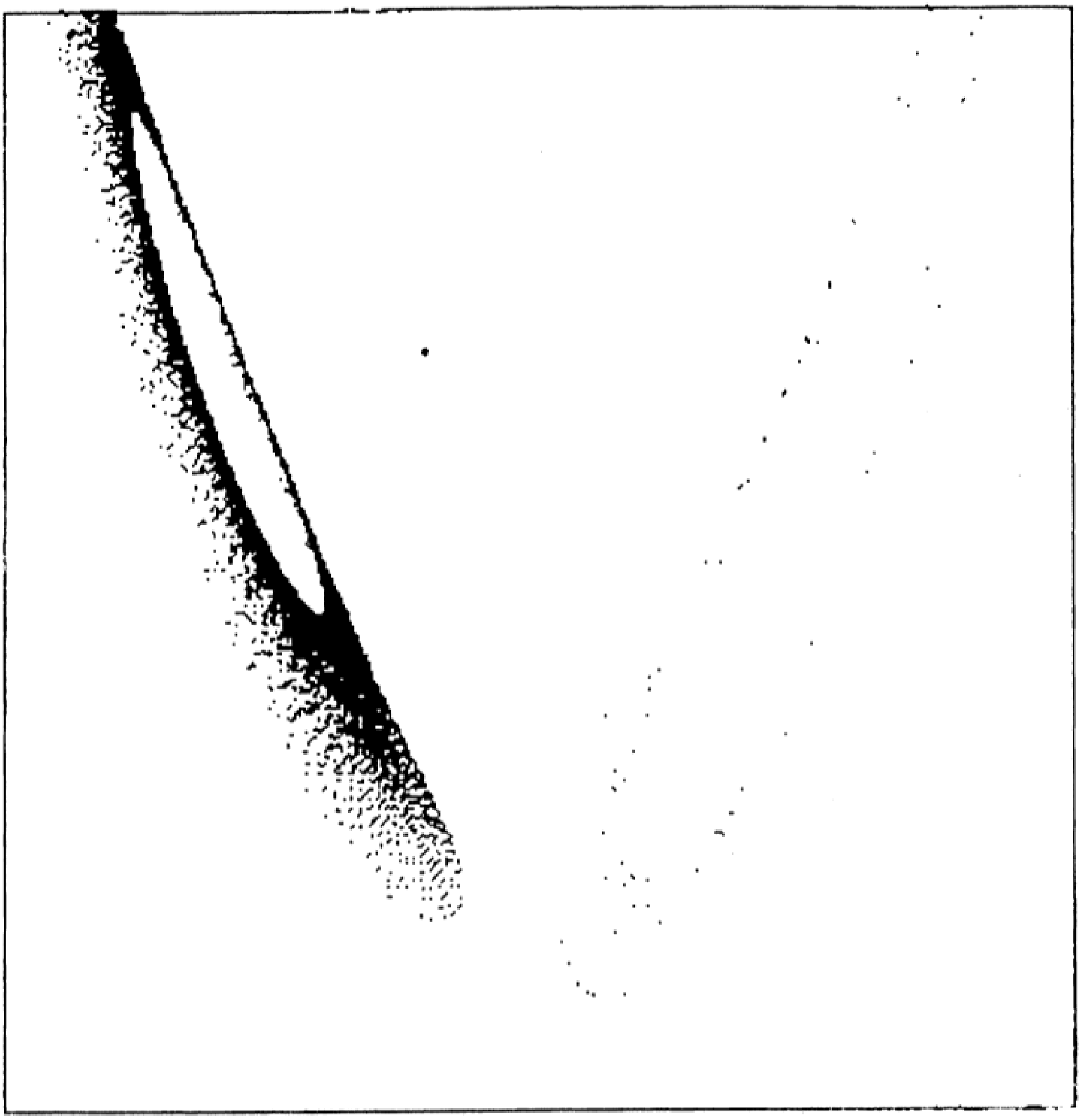
In Moser's case study, this group of women was no longer able to balance their roles. They were labelled as "casualties and burned out" [Moser 1989, 160]. But the pattern of the attractors suggests something else. Although the outcome in terms of the level of provisioning may look "chaotic"—the term used in daily language—the pattern suggests that this group of women still adheres to their roles. They still feel

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

responsible for earning money, contributing to community organizing, and caring for children. But they cannot cope anymore with the unfavorable economic circumstances, the lack of cooperation from their husbands, and the subsequent tensions created by other members of their family.

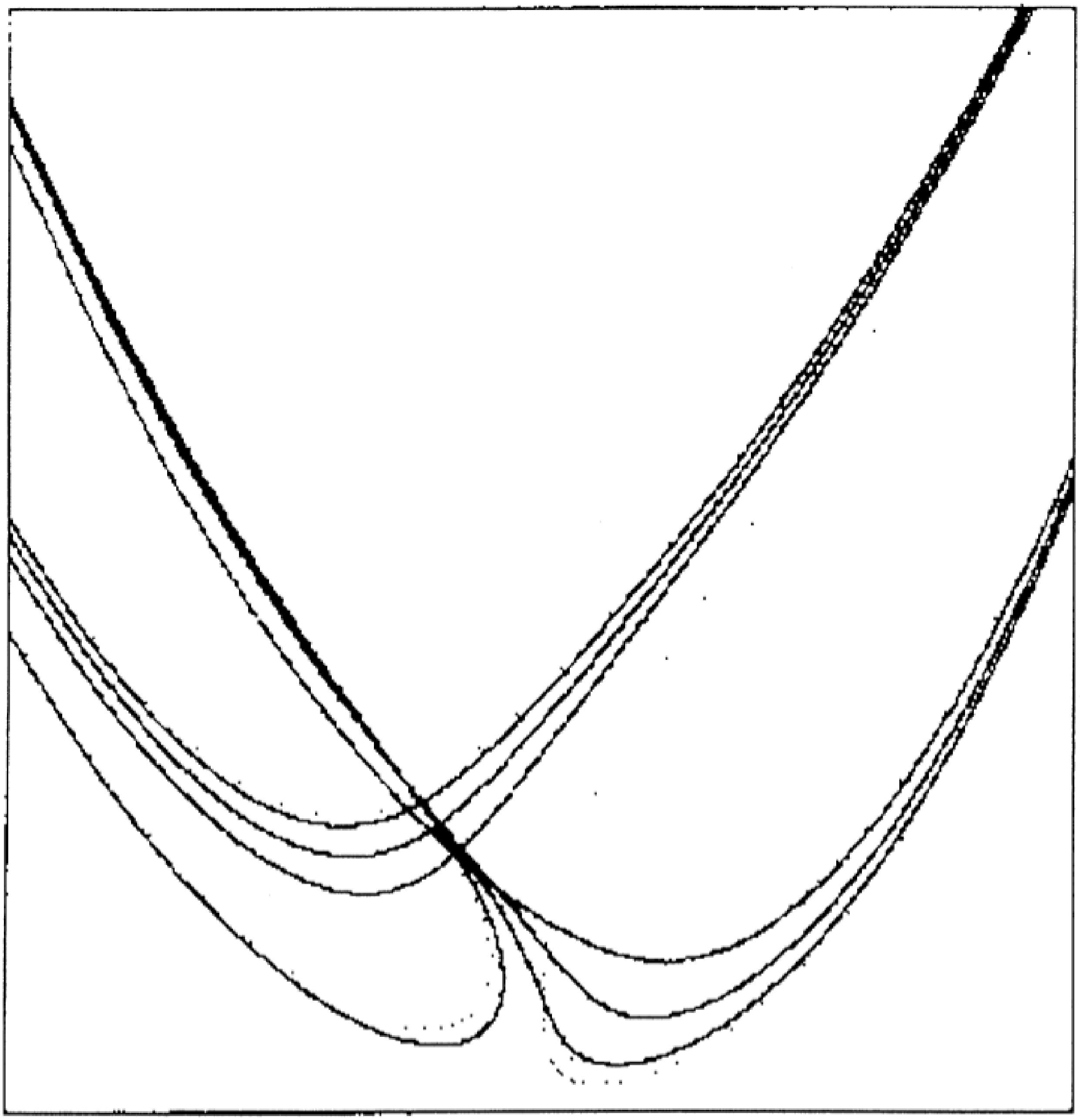
Figure 11 shows a bifurcation diagram for the 1-D model for α values moving from α = 2 to α = 4. The diagram illustrates the thresholds for X to move from equilibrium to a two-period oscillation, through a three- and four-period oscillation to chaos, thereby indicating where the three groups of women are located in the

Figure 9. 3-D Phase Diagram: Role Combination around Strange Attractor



This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

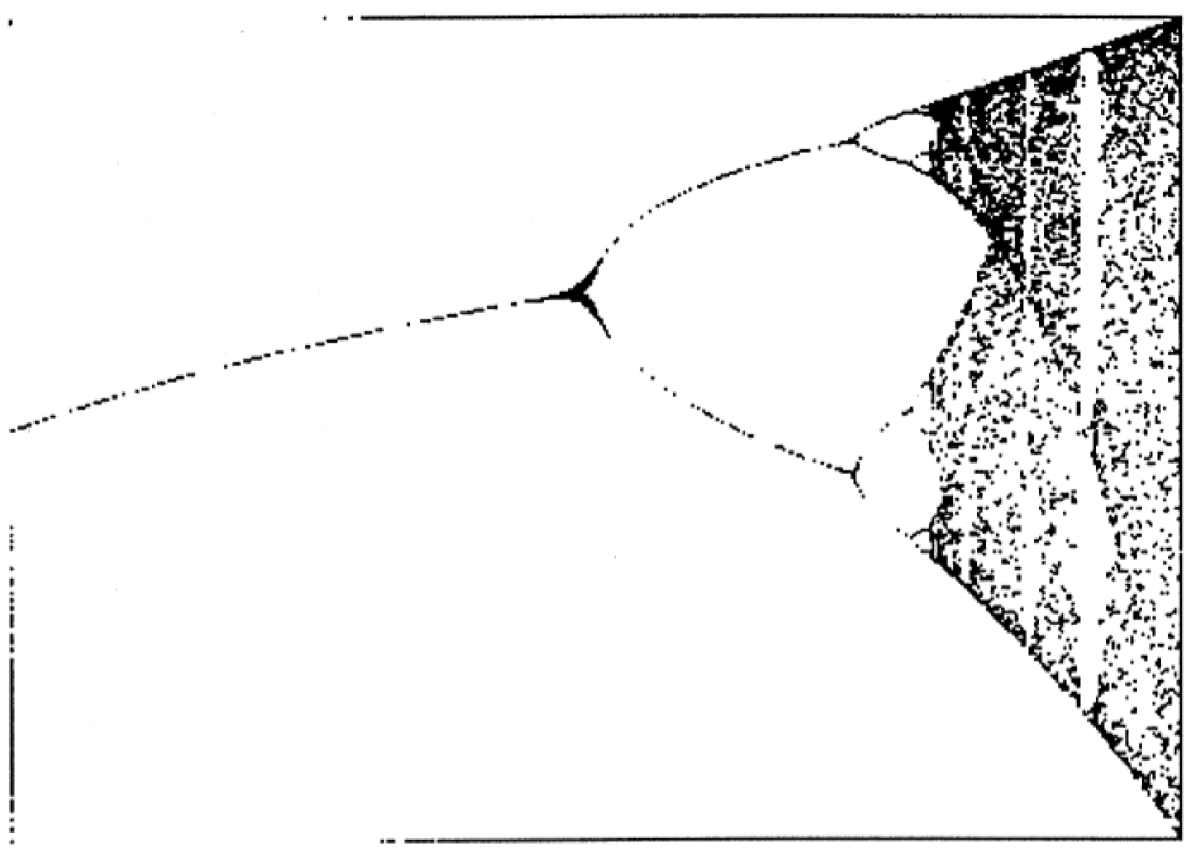
Figure 10. 3-D Phase Diagram: Each Role Behaves as a Strange Attractor



process of provisioning. The 55 percent group of women hanging on is on the left-hand side of the diagram, with low α values. The intermediate 30 percent group of coping women is in the middle of the diagram, and the 15 percent burned out group can be found on the right-hand side, where the model's dynamics transcend to chaos.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Figure 11. 1-D Bifurcation Diagram for Increasing Parameter Values



Discussion of the Value Added of the Chaos Theoretic Model

Moser's case study supports widespread qualitative findings that structural adjustment policies increase poverty and gender inequality. Some sources even use the characterization of "chaos" to illustrate the disequilibrium situations that evolve [see, for example, Dwyer 1992]. However, a first insight from the chaos theoretic simulation model for Moser's case study is that the deteriorated economic situation on the household level cannot be characterized in terms of "chaos" as it is used in everyday language. Moser's qualitative and partial quantitative analysis suggests that women in the 15 percent group are no longer able to live up to their provisioning responsibilities. The women in this group are depicted as "casualties," or victims. But the pattern of strange attractors in the simulation model indicates that these women still do adhere to their roles and do try to live up to their responsibilities—but they fail. The informal, intangible institutions characterizing the roles of provisioning still continue to guide their behavior. But this underlying pattern of role combination remains hidden in the analysis as reported by Moser. In nonlinear economic dynamics, such norm-guided behavior is located in endogenous effects, leading to the evolvement of strange attractors [Brock and Durlauf 1997; Durlauf

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

1996]. Endogenous effects have been defined as the propensity of an individual to behave in a particular way, varying with the prevalence of that behavior in a group. Since the gender-role distribution in Indio Guayas assigns to all women three roles (but only one role to men), there could be an endogenous effect from this gender role stereotyping: women tend to behave similarly in the sense that they all try to keep their three roles without any tendency to specialize in just one role or to dismiss a role. Therefore, in a situation that appears "chaotic," women still hold on to their roles—though they are often very unsuccessful. Men do specialize in the single role of breadwinner and do not take on complementary roles when their masculine role fails as a result of unemployment. Boys and girls are socialized into the masculine and feminine roles, which sustains the traditional gender role distribution. This socialization effect can be related to what Durlauf [1996] has called associational distribution: the distribution of people over socioeconomic groups. Gender can be thought of as such a distribution, resulting in a distribution of men over only one role and women over three roles.

A second insight of chaos theoretic modeling that adds to the original case study is that the distinction between the different groups of women is not gradual. The case does not give any information on the character of the division between the groups. But the simulation model suggests the occurrence of sudden changes in the relationships between the variables—bifurcations—which represent thresholds. In the case study, one such threshold may be seen in male responsibility, which takes the form of a discrete choice: either male responsibility is fulfilled through the contribution of income to the household, or male responsibility is not fulfilled because of unemployment or the start of a new household with new employment found elsewhere. An important consequence of thresholds is feedbacks [Brock and Durlauf 1997]. In the case study, feedbacks from decreasing male responsibility are found in terms of serious poverty, increasing male violence toward women, lack of time for women to care for children, and lack of fatherly guidance of sons who disrupt household life and contribute to neighborhood crime. Another feedback was found in girls' early involvement in the traditional gender-role distribution, undermining their human capital formation. The original case study did not locate these feedbacks in the process of provisioning, but as another direct effect from economic recession and adjustment. Chaos theoretic simulation locates their origin in bifurcations in the role performance. The feedbacks can deepen the crisis, which makes it even harder to find economic balance [for this argument, see, for example, Krugman 1996].

A third contribution from the chaos theoretic simulation is that it may picture a social multiplier that results from social interaction [Durlauf 1996]. In the case study, this social multiplier, or social capital, is generated by women in their three provisioning roles. Because of this social multiplier, macro effects of recession and adjustment are accommodated—up to a certain point. Thus, the negative effects of

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

the macroeconomic shock are dampened by the institutional setting of the three provisioning roles. This is what the case study also suggests. But it could not have resulted from standard economic models, where any institutional mediation between an external shock and individuals' reactions is absent. But the accommodation of the shock is not inelastic: it is limited because of the inequality inherent in the associational distribution. Durlauf indicates that the more unequal associational distribution is, the less optimal well-being will be. Referring to the case study then, if gender roles would have been distributed more equally, macroeconomic effects might have been accommodated more easily. Men's adherence to a single gender role prohibits them culturally and socially from taking up the other two roles, i.e., reproduction and community management. This is suboptimal, since with the high level of male unemployment, some households would probably have done better with women specializing in paid work and men specializing in the two unpaid provisioning roles. This was suggested by Moser but without linking the positive effect of multiple role fulfillment to the negative effect of unequal role distribution between men and women. Besides, the model simulation suggests the working of social capital, so often used lately when unpaid provisioning in families and communities is analyzed. Moser did not refer to such a factor.

Finally, chaos theoretic modeling introduces the concept of the "edge of chaos," which has been applied to ecological and political economic problems [Brock 1997]. The "edge of chaos" refers to a delicate balance in a system between stability and full chaos. If a system crosses the edge, it will require a lot of "over-undoing" by policy measures. This is indeed what Moser's case study suggests, when one looks at the negative long-term effects such as the decline of child nutrition, the decrease in girls' human capital formation, and the tendency of boys to gravitate toward criminality and drug abuse. In Moser's study and other studies in the same volume, policy implications relate to a softening of the impact of structural adjustment measures through social funds for the poor. But the simulation exercise suggests that it may be more effective if attention were given to the gender distribution of roles and to support for women and men to carry out these roles of provisioning.

In sum, the value added of the chaos theoretic simulation model to the case study of provisioning in Guayaquil seems to lie in at least four suggestions.

1. The disclosure of a pattern in seemingly "chaotic" behavior in the group that could hardly cope with the crisis. Chaos involves an underlying order, guided by the institutional setting of roles.
2. The insight that the transition from one group to another follows particular thresholds instead of a gradual change. These thresholds appear to be crucial in the distinction between the groups.
3. The insight of a link between role combination and inequality and an underlying influence of a social multiplier.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

4. The suggestion that policy intervention should probably concentrate on the influential endogenous factors through, for example, a redistribution of and support for the three roles of provisioning, rather than a focus on an exogenous policy measure such as the supply of a social fund.

Within institutional economics, we know already that ". . . institutional adjustment—not the price system—is the 'balancing wheel' of the social provisioning (i.e., economic) process" [Whalen and Whalen 1994, 29]. It seems that chaos theory is able to further our understanding of how this balancing wheel operates in particular contexts.

Conclusions

Although the symbolic and iconographic types of metaphors provided by chaos theory have some value for institutional economics, it seems that the strongest type of metaphor, the model, may serve institutionalism best. But the lack of large data sets in institutional analysis (except, perhaps, in some strands of institutional game theory and transactions costs economics) is a serious barrier to chaos theoretic modeling. Therefore, only simulation models seem to be available to institutional analysis. The moderate function of simulation models leaves space for the use of the symbolic and iconographic metaphors, which can provide institutionalism with a quick, intuitive, and visual understanding, without going into the mathematics of modeling.

A consequence of the utilization of simulation models instead of "hard" models is that chaos theoretical models cannot become constitutive for institutionalism, pressing it into a mathematical straitjacket. This is clearly different from the function that linear models have in neoclassical economics, where the models have strongly influenced and restricted the assumptions, methodology, and data selection in neoclassical theory [Mirowski 1989]. Instead, simulation models limit themselves to descriptive and illustrative functions. We can conclude therefore that chaos theoretic simulation models provide institutional economics with a complementary, heuristic analysis to the narrative, not a constitutive algorithm. This is a different and more modest conclusion than the one reached by Radzicki [1990]. Contrary to his hopes, chaos theory seems unable to provide institutional economics with the function that models have in neoclassical economics. Besides, institutionalism has good reasons to resist a sacrifice of its rich qualitative analysis for the sake of formalist modeling.

But chaos theory does offer additional understanding to institutional analysis, with the help of a variety of metaphorical levels. After all, what more is a simulation model than merely a metaphor?

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Notes

1. From here on, the label of "old" will be disregarded and the term "institutionalism" will refer to the tradition established by the "old," or Veblenian, institutionalists.
2. These characteristics draw on Hodgson [1988], Samuels [1995], and Hodgson, Samuels, and Tool [1994].
3. To discern randomness from chaos, several statistical tests have been developed, of which the BDS test is best known [Brock, Dechert, and Scheinkman 1986].
4. Or not as economic at all, but as part of sociology, anthropology, or psychology.
5. Over the past decade, there has been a flourishing literature on chaos theoretic models for neoclassical queries and Keynesian studies, often of general equilibrium models or models with various kinds of expectations [see, for example, Barnett, Geweke, and Shell 1989; Brock, Hsieh, and LeBaron 1991; Grandmont 1985; Pesaran and Potter 1993; Hommes 1991]. The mathematics is sophisticated and detailed, as in much linear econometrics. In evolutionary economics, chaos theory has been introduced also in close connection with the use of systems theory [Day and Chen 1993; Khalil and Boulding 1996]. The Keynesian economics' use of chaos theory enables models to endogenize the dynamics of business cycles, sometimes called "deep modeling" [Barnett and Choi 1989, 143].
6. For example, chaos theoretic article in economics holds that "markets will be assumed to clear in the Walrasian sense at every date, and traders will have perfect foresight along the cycles" [Grandmont 1985].
7. A vector or a set of vectors in a matrix represents a two-dimensional space for mathematical representations in linear economic models.
8. Although chaos theoretic economic models are unable to predict, the demand effect is indeed anticipated by large producers of baby food, such as Nutrica, which therefore have announced to their customers that they will not use genetically manipulated soya in the production of baby food. This suggests that the prediction function of linear models could be replaced by other methods of forecasting, not necessarily making the lack of prediction a crucial standard for accepting or rejecting chaos theoretic modeling.
9. A simulation model will be employed since there are not enough quantitative data for the generation of a "hard" model.
10. That would lead to variables X_f for the productive role of women and X_m for the productive role of men. Y_m and Z_m—men's reproductive and community management roles—would be close to zero, following the prevalent gender role distribution in provisioning in Indio Guayas.
11. Parallel parameters for men do not exist, since traditional gender role distribution ascribes only one role to men, which they either perform or do not perform, as in the case of unemployment. The parameters α, a, b, and r thus reflect responsibility for provisioning. Women's gender role responsibility requires them to seek a balance between three roles. Men's gender role responsibility is different and takes the shape of a discrete value, depending on the availability and location of paid work.

References

Bailey, Kenneth D. *Sociology and the New Systems Theory: Toward a Theoretical Synthesis*. New York: State University of New York Press, 1994.

Barnett, William A., John Geweke, and Karl Shell, eds. *Economic Complexity: Chaos, Sunspots, Bubbles and Nonlinearity*. Cambridge: Cambridge University Press, 1989.

Barnett, William A., and Seugmook S. Choi. "A Comparison Between the Conventional Econometric Approach to Structural Inference and the Nonparametric Chaotic Attractor Approach." In *Eco-*

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

nomic Complexity: Chaos, Sunspots, Bubbles and Nonlinearity, edited by William A. Barnett, John Geweke, and Karl Shell, 141-212. Cambridge: Cambridge University Press, 1989.

Boulding, Kenneth. "The Economics of the Coming Spaceship Earth." In *Valuing the Earth: Economics, Ecology, and Ethics,* edited by Herman Daly and Kenneth Townsend, 297-309. 1966. Reprint. Cambridge: MIT Press, 1993.

Brock, William. "Background Notes and References for a Talk at the Land Institute." Unpublished paper, Department of Economics, University of Wisconsin, 1997.

Brock, William, W. D. Dechert, and J. Scheinkman. "A Test for Independence Based on the Correlation Dimension." Manuscript. University of Wisconsin/University of Chicago, Madison/Chicago, 1986.

Brock, William, and Steven Durlauf. "Discrete Choice with Social Interactions II." Unpublished paper, Department of Economics, University of Wisconsin, 1997.

Brock, William, D. A. Hsieh, and B. LeBaron. *Nonlinear Dynamics, Chaos and Instability. Statistical Theory and Economic Evidence*. Cambridge: MIT Press, 1991.

Chick, Victoria. "Order out of Chaos in Economics?" In *Keynes, Knowledge and Uncertainty*, edited by Sheila Dow and John Hillard, 25-42. Aldershot: Edward Elgar, 1995.

Day, Richard, and Ping Chen, eds. *Nonlinear Dynamics and Evolutionary Economics*. Oxford: Oxford University Press, 1993.

Day, Richard, and Jean-Luc Walter. "Economic Growth in the Very Long Run: On the Multiple-phase Interaction of Population, Technology and Social Infrastructure." In *Economic Complexity: Chaos, Sunspots, Bubbles and Nonlinearity,* edited by William A. Barnett, John Geweke, and Karl Shell, 253-290. Cambridge: Cambridge University Press, 1989.

de Greene, Kenyon B. "Field-Theoretic Framework for the Interpretation of the Evolution, Instability, Structural Change, and Management of Complex Systems." In *Chaos Theory in the Social Sciences: Foundations and Applications*, edited by Douglas Kiel and Euel Elliott, 273-294. Ann Arbor: University of Michigan Press, 1996.

Dow, Sheila C. "Beyond Dualism." *Cambridge Journal of Economics* 14 (1990): 143-157.

Durlauf, Steven. "Associational Redistribution: A Defense." SSRI Paper, University of Wisconsin. Social Systems Research Institute, 1996.

Dwyer, G. P. "Stabilization Policy Can Lead to Chaos." *Economic Inquiry* 39 (1992): 40-46.

England, Paula. "The Separative Self: Androcentric Bias in Neoclassical Assumptions." In *Beyond Economic Man: Feminist Theory and Economics,* edited by Marianne A. Ferber and Julie A. Nelson, 37-53. Chicago: University of Chicago Press, 1993.

Ferber, Marianne A., and Julie A. Nelson, *Beyond Economic Man: Feminist Theory and Economics*. Chicago: University of Chicago Press, 1993.

Grandmont, Jean-Michel. "On Endogenous Competitive Business Cycles." *Econometrica* 53, no. 5 (1985): 995-1045.

Granovetter, Mark. "Economic Action and Social Structure: The Problem of Embeddedness." *American Journal of Sociology* 3 (1985): 481-510.

Harvey, David L., and Michael Reed. "Social Science as the Study of Complex Systems." In *Chaos Theory in the Social Sciences: Foundations and Applications,* edited by Douglas Kiel and Euel Elliott, 295-323. Ann Arbor: University of Michigan Press, 1996.

Hodgson, Geoffrey M. *A Manifesto for a Modern Institutional Economics*. Cambridge: Polity Press, 1988.

Hodgson, Geoffrey M., Warren J. Samuels, and Marc R. Tool. *The Elgar Companion to Institutional and Evolutionary Economics*. Aldershot, U.K.: Edward Elgar, 1994.

Hommes, Cars. *Chaotic Dynamics in Economic Models: Some Simple Case Studies*. Groningen: Wolters-Noordhoff, 1991.

Jennings, Ann L. "Public or Private? Institutional Economics and Feminism." In *Beyond Economic Man: Feminist Theory and Economics,* edited by Marianne A. Ferber and Julie A. Nelson, 111-129. Chicago: University of Chicago Press, 1993.

Khalil, Elias L., and Kenneth E. Boulding. *Evolution, Order and Complexity*. London: Routledge, 1996.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms

Kiel, Douglas L., and Euel Elliott. *Chaos Theory in the Social Sciences: Foundations and Applications*. Ann Arbor: University of Michigan Press, 1996.

Klamer, Arjo, and Thomas C. Leonard. "So What's an Economic Metaphor?" In *Natural Images in Economic Thought*, edited by Philip Mirowski, 20-51. Cambridge: Cambridge University Press, 1994.

Krugman, Paul. *The Self-Organizing Economy*. Cambridge and Oxford: Blackwell, 1996.

Mirowski, Philip. *More Heat Than Light: Economics as Social Physics, Physics as Nature's Economics*. Cambridge: Cambridge University Press, 1989.

________. "From Mandelsbrot to Chaos in Economic Theory." *Southern Economic Journal* 57 (1990): 289-307.

Moser, Caroline. "The Impact of Recession and Adjustment Policies at the Micro-Level: Low Income Women and Their Households in Guayaquil, Ecuador." In *The Invisible Adjustment: Poor Women and the Economic Crisis*. 2d revised ed. Santiago: UNICEF, 1989: 137-166.

Nelson, Julie A. "The Study of Choice or the Study of Provisioning? Gender and the Definition of Economics." In *Beyond Economic Man: Feminist Theory and Economics*, edited by Marianne A. Ferber and Julie A. Nelson, 23-36. Chicago: University of Chicago Press, 1993.

O'Hara, Phillip Anthony. "Household Labour, the Family, and Macroeconomic Instability in the United States: 1940s-1990s." *Review of Social Economy* 53, no. 1 (1995): 89-120.

Pesaran, M. Hashem, and Simon M. Potter. *Nonlinear Dynamics, Chaos and Econometrics*. Chichester, U.K.: John Wiley and Sons, 1993.

Prigogine, Ilya. "Bounded Rationality: From Dynamical Systems to Socio-economic Models." In *Nonlinear Dynamics and Evolutionary Economics*, edited by Richard H. Day and Ping Chen, 3-13. Oxford: Oxford University Press, 1993.

Prigogine, Ilya, and Isabelle Stengers. *Order out of Chaos: Man's New Dialogue with Nature*. New York: Bantam, 1984.

Radzicki, Michael. "Institutional Dynamics, Deterministic Chaos, and Self-Organizing Systems." *Journal of Economic Issues* 24, no. 1 (1990): 57-102.

Samuels, Warren J. "The Present State of Institutional Economics." *Cambridge Journal of Economics* 19 (1995): 569-590.

Veblen, Thorstein. *The Theory of the Leisure Class: An Economic Study of Institutions*, edited by B. W. Huebsch. 1899. Reprint. New York: The Viking Press, 1931.

________. *The Place of Science in Modern Civilisation and Other Essays*. 1919. Reprint. New York: Russell & Russell, 1961.

Waller, William. "Technology and Gender in Institutional Economics." In *The Economic Status of Women Under Capitalism*, edited by Janice Peterson and Doug Brown, 55-76. Aldershot, U.K.: Edward Elgar, 1994.

Whalen, Charles, and Linda Whalen. "Institutionalism: A Useful Foundation for Feminist Economics?" In *The Economic Status of Women Under Capitalism*, edited by Janice Peterson and Doug Brown, 19-34. Aldershot, U.K.: Edward Elgar, 1994.

This content downloaded from
132.174.249.27 on Sun, 21 Jan 2024 19:27:51 +00:00
All use subject to https://about.jstor.org/terms