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Using Cognitive Styles Typology to Explain Individual Differences in Dynamic Decision Making: Much Ado about Nothing

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Research Paper

Using Cognitive Styles Typology to Explain Individual Differences in Dynamic Decision Making: Much Ado about Nothing

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Introduction

It is unclear how many organizations currently use cognitive styles data. Most that we have talked with either have their personnel departments collect it and they really don't know what to do with it, or they have hired consultants who have used them as part of a larger program. From our experience, talking about cognitive styles is seductive. People are fascinated with the thought that these tests can reveal something about themselves that they didn't know or hadn't realized before. The tests seem non-threatening, and their basic premise is something that seems reasonable and logical. When Danny Kaye as Hans Christian Andersen announces that "[t]here are different ways of learning, schoolmaster," who isn't convinced that some people and some children perceive things and take in information very differently from others, and benefit greatly from the kind of didactic stories that Hans liked to tell. Most of us don't feel the need for scientific evidence or rigorous assessment to know that some people learn better in lectures and others thrive on group work and class discussion; that some people have a need to be organized and make lists while others are perfectly content to be less organized and more spontaneous; that some decision makers thrive on feedback while others abhor it. While it may seem perfectly obvious that there are many ways to both perceive and process information, it is much less obvious what this means. The authors of this paper are not convinced that these preferences can be translated into performance, productivity, or profits.

Although individual differences are emphasized in the field of personality psychology, there are other established psychological disciplines in which they are minimized. It's not that these disciplines don't acknowledge the existence of individual differences in such areas as cognitive styles and learning styles; it is simply that they view other determinants as more important and having a larger effect on behavior. For example, cognitive psychologists typically ignore individual differences in order to focus on the general abilities and limitations that all human minds have in common. (Gardner, 1985) Decades of experimental research in this field has shown that, regardless of individual differences, all human minds have unalterable cognitive limitations that constrain our ability to make decisions and solve problems. (Simon, 1956) Social psychologists also de-emphasize individual differences, but for a different reason. Decades of research in this field has shown that the strongest predictor of behavior is often the environment or situation in which the behavior occurs. (Ross and Nisbett, 1991) For example, although

some people are more introverted than others, everyone acts as if they are introverted during a church service. Thus, in the view of social and cognitive psychologists, although individual differences exist, their practical significance is questionable since their effects are so often overwhelmed by other cognitive and situational factors.

Summary of the Experiment and Results

Computer simulation games, or flight simulators, are often used as learning tools, particularly in corporate settings. The more complex the feedback structure of a particular problem, the more valuable computer simulation games are thought to be. Yet, performance on these games has historically exhibited wide variation across individuals. One question that naturally arises is whether this observed variation in ability is explainable.

The research reported here was initially undertaken to try and determine the extent to which individual differences in cognitive style can help explain individual differences in dynamic decision makig in a computer simulation game environment. More specifically, our research focuses on three cognitive styles instruments, the Myers-Briggs Type Indicator™, the Gregorc Style Delineator™, and a variation of Gordon's Cognitive Styles Indicator. These are coupled with the STRATEGEM-2 Microcomputer Simulation Game of the Kondratiev Cycle developed by Sterman and Meadows (1985) in an experimental setting (alpha testing) to determine if a cognitive styles approach might be valuable in the kind of non-laboratory settings (beta testing) where system dynamics and flight simulators are traditionally used. Preliminary results indicate that people who have certain cognitive styles, in particular those who score higher on the Abstract component of the Gregorc test, do have a significantly higher propensity to score well on the Kondratiev flight simulator.

As often happens, however, several other research questions were investigated during the course of our study. Do flight simulators, like the STRATEGEM-2 Microcomputer Simulation Game, help subjects learn? Can cognitive styles be used to predict who will have a greater propensity to learn from a flight simulator? Can differences in cognitive style help explain who enjoyed playing the flight simulator, or who tried harder to get a better score? Finally, we were curious to see if the various cognitive styles instruments were correlated with each other. In sum, the conclusions we reached were largely negative with regard to these ancillary questions. Although we were able to explain some of the variation in flight simulator *scores* across subjects, the scores themselves were not correlated with measures of *learning* which means that those who had better scores did not necessarily learn more. This renders the initial findings somewhat disappointing. In addition, cognitive styles were unable to help us understand who did, in fact, learn about Kondratiev cycles, or who liked the flight simulators, or who put more effort into their play of the game. Given that the authors of the various cognitive styles instruments are careful to point out that the tests only measure preferences, not ability or skill, it is surprising that we could not predict who would and would not be *motivated* in the different situations.

When we turned our attention to a second, related experiment which tried to explain performance over a much longer, seven week period, even the Gregorc instrument failed to produce significant results. In this respect, our research would begin to suggest that the efficacy of using cognitive styles instruments needs to be further researched, particularly in real-time learning environments as opposed to the highly compressed time inherent in the playing of computer simulation games. It also

suggests that encouraging people who play flight simulators to slow down and think about the bigger picture will improve performance.

Perhaps most important, however, is our finding that the different cognitive styles instruments weren't correlated with each other. This leads us to believe that the rather haphazard practice of choosing an instrument because of familiarity, cost, or accessibility may be misguided. Clearly the tests all base their theoretical underpinnings on the work of Carl Jung (1971), and even if their terminology is different, they all purport to test for the same kinds of things. But our finding that the tests are not correlated with each other indicates that they do not measure the same information, and they are not interchangeable.

The question then becomes what we expect to gain by possessing the knowledge regarding individual differences in cognitive style. To what end do organizations devote financial resources in the discovery of these individual preferences? Although our research is limited and certainly not definitive, our findings generally support the claim that the utility of using cognitive style instruments is minimal. True, we were able to generate some significant results using the Gregorc Style Delineator in the short run, but this is tempered by two facts: first, better scores didn't mean that more was learned, and second, none of the tests explained performance over a much longer time period.

In sum, if the goal of uncovering and discussing cognitive styles is simply to know more about ourselves, then the tests might have some value. If, on the other hand, the goal is ultimately about productivity and profits, there is much less reason for optimism.

Kondratiev Cycles and STRATEGEM-2

Most people are familiar with the concept of business cycles, the expansion and subsequent contraction of the economy which repeats itself on average every five years. Few people, however, are aware of the probable existence of Kondratiev cycles, or economic long waves, which last roughly fifty years in length from peak to peak or trough to trough. Even among those who have seen the data, which do show something that looks remarkably like a cycle occuring every half century, there is some skepticism that there could be a theoretical underpinning for such a long regularity in the economy. Economists in particular have questioned what might cause such a cycle.

The STRATEGEM-2 Microcomputer Simulation Game was specifically designed by Sterman and Meadows to address the issue of causality. Although there are many reasons why such cycles might arise, one of the most important is the decision making by the capital producing sectors of the economy. Because overexpansion and depression are necessarily tied to increasing productive capacity and then subsequently letting it depreciate, any plausible theory would have to include the dynamics of the decision making process involved in the ordering and reordering of capital. By focusing on this one explanation, STRATEGEM-2 supposedly helps those who play the game understand that Kondratiev cycles can be created by an endogenous force. In a pre-test administered to half the subjects engaged in our research, exogenous forces such as war and stock market volitility were routinely identified as possible causes of the long wave, but no one considered the possibility that human behavior itself could be the culprit.

Figure 1 about here

Figure 1 shows a sector diagram of the Kondratiev flight simulator, and reveals the deceptive simplicity of the underlying model. Desired production in the model is simply the backlog of orders to fill. These orders come from two sources, the goods producing sector and the capital producing sector itself. This "self-ordering" occurs in part because capital depreciates and needs to be replaced, and in part due to changes in the demand for capital by the goods producing sector (it takes capital to produce capital). The only decision that participants are asked to make is to order capital for the capital goods sector once every two time periods, and the goal is to keep production capacity equal to desired production. Before making each decision, participants are supplied with all relevant information except the order stream for new capital which eminates from the goods producing sector of the model. In this case, the exogenous orders from the goods sector followed a straightforward step function. The goods sector initially ordered 450 units of capital, but in period six this increased to 500 units, and remained at 500 for the rest of the game. Even though the step function is unknown to people playing the game, it might seem relatively easy to figure out. Yet, returning the system to equilibrium is problematic for most participants. As Sterman suggests, "the optimal path is at once too difficult to compute and too different from intuitive notions of reasonable strategy" (1989: 323).

Figure 2 about here

Figure 2 illustrates a typical play of the game. Notice that in the 72 time periods allotted this participant created three cycles or waves. In our sample, this pattern occurred 17 percent of the time. It should also be noted that the score on this play is 817, which means that *on average* the difference between production capacity and desired production is 817 units of capital at any given time during the play of the game.

Figure 3 about here

Figure 3 shows a case which is even more representative of our sample, in that it occurred some 30 percent of the time. Here the score is 1308, which is not as good as the 817, even though this subject created one less wave. It should be observed that the second wave in Figure 3 begins at approximately time period 50, which is more what we would have expected given historical data.

Figure 4 about here

Figure 4 is an example of someone who created a single wave. Production capacity increased so rapidly in the first few periods that it took the rest of the game for depreciation to even begin to bring the system back toward equilibrium. This situation happened approximately 15 percent of the time, and the resultant scores were not particularly good. In this case the score is 2670.

Figure 5 about here

Finally, Figure 5 illustrates a play where the subject was able to bring the system back into equilibrium. This happened about 17 percent of the time. As might be expected, the score of 440 on this play is much better than the previous examples. We are reluctant, however, to claim that this person "learned" any more than the person who generated the graphs in Figure 4. Often we learn from our mistakes, and it is conceivable that the first few decisions made during the course of the game are so disastrous that it is impossible given the number of periods remaining to score well.

Cognitive Styles

There is a plethora of literature and research related to cognitive styles. Just looking at a small sample of what has been written reveals how unsettled the field seems to be. Terminology is not consistent, there exists a wide assortment of competing instruments used to elicit cognitive styles, and there is much dissent regarding both the validity and consistency of the various tests. Most of the people writing on the subject are willing to admit that the source of their ideas spring from the writings of Jung, and there does seem to be a consensus that the main issues revolve around perceiving or taking-in information, on the one hand, and processing or using the information we have collected, on the other.

The most widely administered and well known of the cognitive styles instruments used in our research is the **Myers-Briggs Type Indicator**™, or **MBTI**™. This personality test pairs four scales, each of which has two opposites. Although all four of these scales can be found below (DiTiberio and Hammer, 1993), only two are commonly used in research, the "sensing-intuitive" and "thinking-feeling" scales.

E (Extraversion) People who prefer Extraversion focus on the outer world and pay attention to events in their external environment

I (Introversion) People who prefer to focus on their own inner world. They pay attention to their own thoughts, feelings, and impressions.

S (Sensing) People who are aware of what is real, what is actually happening. They focus on practical matters in the here and now.

N (Intuition) People who are aware of meanings and relationships that go beyond the information that is given. They focus on the big picture and possibilities for the future.

T (Thinking) People who prefer deciding things objectively, based on their analysis of the logical consequences of alternatives.

F (Feeling) People who prefer to base their decisions on subjective, person-centered values.

J (Judging) People who prefer to structure and organize the world. They like to make decisions and then move on. They like to have things settled.

P (Perceiving) People who prefer to adapt to the outer world. They like to keep their options open to whatever new experiences or information comes along.

It is important to note that the MBTI does not purport to measure intelligence, aptitude, or achievement. Rather, it reflects what an individual *prefers*.

The second of the cognitive styles tests chosen for our research is the **Gregorc Style Delineator©**. Similar to the MBTI in that it requires the test taker to explicitly choose preferences among sets of alternatives, the Gregoric Styles Delineator nonetheless has its own unique lexicon, and the results of our research suggests that it tests significantly different preferences than the MBTI. Following Gregorc's terminology, there are four "Mediation Channels" which can apply to any individual. The Mediation Channels are (Schulz, 1993):

A (Abstracts)
People who prefer to learn deductively, with the big picture, concepts, and theory first, followed by examples.

C (Concretes)
People who prefer to learn inductively, starting with specific and practical examples, followed by an understanding of the pattern, followed by the theory.

S (Sequentials)
People who prefer to learn step-by-step in a very organized way.

R (Randoms)
People who prefer to learn creatively in different ways at different times and certainly not linearly.

These four components are then combined to form four learning style preferences: **CS**, **AS**, **AR**, and **CR**. Unlike the MBTI, where a person must fall into one or the other of the ordered pairs, the Gregoric can type a person as belonging to one, two, or even three learning styles simultaneously.

The third cognitive styles test we administered was a variation of Gordon's Cognitive Styles Indicator. This test is very different from the others in that it does not explicitly ask participants to reveal preferences. At no time during the completion of the test instrument does a subject know how the information is to be used. The Cognitive Styles Indicator only has two components:

> **Diff (Differentiation)**: People who score "high" on this cognitive style demonstrate an ability to pick up on nuances and subtle distinctions which can be useful in diagnosing problems and setting a direction for tackling them.
>
> **RA (Remote Association)**: People who score "high" on this cognitive style have an ability to solve problems which are fairly well defined, for which the solution is not known or even implied by the problem statement, but is easily and quickly recognizable once it appears. They do not need logical linkages between the elements of a solution, and they can see connections that cannot be explained by extrapolation.

People score either "high" or "low" on each of these cognitive styles, and the resulting information is used to form a matrix of four types: **Integrator** (high Diff and high RA), **Problem Finder** (high Diff and low RA), **Problem Solver** (low Diff and high RA), and **Implementor** (low Diff and low RA).

It is interesting that there is little written about how the three tests compare to each other, even in theory. Gordon's Cognitive Style Indicator is not well known, and is not in broad use, so it is not surprising that such comparisons are hard to come by. The MBTI and the Gregorc Style Delineator,

however, are well known and have been used extensively, and rough theoretical similarities can be drawn as follows.

Purpose	MBTI	Gregorc Style Delineator
Perception	Sensing (S) Intuitive (N)	Concrete (C) Abstract (A)
Judgment	Thinking (T) Feeling (F)	Sequential (S) Random (R)

Of course, these comparisons can be statistically tested, since the MBTI and Gregorc Style Delineator were administered to the same people, or experimental cohort.

Experimental Cohort

There are two experimental cohorts. The subjects of the first experiment were 56 students enrolled in a psychology class at Worcester Polytechnic Institute . The second group of subjects who were used in a followup study were 59 students enrolled in a System Dynamics class, also at Worcester Polytechnic Institute. None of these subjects were paid for their participation, nor were their grades affected by either participation or performance. Although this calls into question the motivation that some subjects might have had (many students admitted on a post test that they did not try very hard to score well on the flight simiulator), the cognitive styles tests could well be expected to explain who was motivated and who was not given the nature of the tasks involved.

Research Results

Without manipulating data, none of the three cognitive styles tests was able to explain the variation in scores on the STRATEGEM-2 Microcomputer Simulation Game at any reasonable level of significance. Using simple linear regression techniques, and looking at R-square values, ANOVA tables, t-stats, even correlation coefficients, not a single variable or group of variables proved able to explain student performance. In fact, R-square values were often so close to zero (to three or four decimal points) that they were remarkable in their insignificance. When groups of variables were used, adjusted R-square values were almost all negative, and R-square values were less than .05.

With some rather straightforward data manipulation, however, we were able to obtain significant results, but only with the Abstract components of the Gregorc Style Delineator. Recognizing that a few of the flight simulator scores were unusually large, observations were deleted, one at a time, in descending order based solely on reported scores on the Kondratiev game. Certainly one could make the argument that there was something unusual about a score of 97,000 in light of a median value of 1,793 and a mean of 6,466. Table 1 shows the results as outliers were systematically deleted.

Table 1 about here

After deleting seven outlier observations, all with Kondratiev flight simulator scores in excess of 5,500, R-square improved to .23 (adjusted R-square was .18), and both of Gregorc's mediation channels reflecting a preference for an Abstract perception (AS and AR) are now statistically significant at the .01 and .02 levels, respectively. The coefficient estimates of -144 and -110 are seemingly quite large in light of the fact that both AS and AR range in value from a low of 10 to a high of 40 with means of 23.92 and 23.19 and standard deviations of 4.2 and 5.2, respectively. Simply put, as the Abstract score on the Gregorc Style Delineator™ rises, the score on the Kondratiev flight simulator becomes smaller (better).

Unfortunately, scores on the flight simulator do not explain scores on a post test administered shortly after subjects played the Kondratiev game. This post test, scored from 0 to 5, was designed to see if subjects *learned* about economic long waves. Although a tentative finding, it suggests that the process of learning may have little to do with performance per se on flight simulators. This is not to say that flight simulators, as learning tools, are ineffective, but rather that we need to be careful in deciding what constitutes a successful play of the game.

At the same time, none of the cognitive styles tests, including the Abstract parts of Gregorc, explain scores on the post test either. What this indicates is that even though we have had limited success using cognitive styles to predict performance on a specific flight simulator, we have had no success in predicting who would best learn from it. This certainly makes the earlier findings seem less important.

At odds with other recent findings (Maxwell, 1995), we were also unable to use cognitive styles to explain who preferred learning by using flight simulators and interactive software. The post test included thirteen questions, each of which students ranked from 1 to 7. These included:

"Did you enjoy the game?"
"How difficult was it?"
"How hard did you try?"
"How carefully did you read the instructions?"
"Did you have a plan before starting?"
"How much did you learn?"
"Is this a good way to learn?"

None of the questions was correlated with cognitive style. This is a rather surprising finding given the emphasis that is placed on preferences as opposed to abilities or skill.

As sobering as the reported results have been so far, the most disturbing finding might be that the three cognitive styles tests are not correlated with each other. Given our study, we would have to conclude that the tests are not measuring the same information. While this might not surprise the authers of the MBTI, or Gregorc, or Gordon, it certainly seems antithetical to the claim that they all share the same historical roots, and that they are all basically trying to get at the same information. Further, if the tests are not interchangable, then assessment of the various cognitive styles instruments should be more rigorous and holistic, and should be more accessible to potential users. Any number of researchers (and

consultants) have admitted that they use tests that they are familiar with, that they have access to, and that are cost effective. To be honest, our research is just as guilty on this count as most others.

Because some concerns could be raised regarding the narrowness of the task we asked subjects to perform, we decided to conduct a second, followup experiment. Given that cognitive styles tests purport to measure preferences, not skills, we typed a second group of students and followed their progress in mastering an introductory System Dynamics class which met over a seven week period. Theoretically, students who may lack some ability but like the particular way that system dynamicists view the world and the way they organize and use information would have more of a chance to demonstrate their preference for this kind of course. Conversely, those whose cognitive style is at odds with thinking through complex problems fraught with delays, limits, feedback, and non-linear growth, and those who are not prone to use computers and models to solve problems, might be discouraged, frustrated, or unhappy and not perform as well over the long haul. Of course, the reason for choosing this class is that the computer simulation model underlying STRATEGEM-2 is a System Dynamics model, and it was felt that much the same kinds of difficulties and expectations were inherent in both the Kondratiev Game and System Dynamics course.

In at least one respect this second experiment yielded results which were at odds with the first.experiment. The Gregorc Styles Delineator, the only cognitive styles test administered to all 59 students, could not help explain the large variation in student mastery of the material. This, however, is not surprising. The flight simulator used in the original experiment took most students less than a half hour to play, and within the first few decisions made in this short time period scores could escalate out of control. It was critical to a good play of the game that students understood the goal and had some concept of the "bigger picture" and underlying theory. In other words, those who are predisposed to take in information in an Abstract way. Students who dove into the play of the game with little rhyme or reason, perhaps expecting to "figure it out" as they progressed, were at a significant disadvantage. In the second, follow-up experiment, which looked at performance over a seven week period, students were forved to slow down and think about what they were doing. The implication is that in more "real-time" situations, which are probably much more indicative of the business world, the differences between Abstracts and Concretes disappears, and the usefulness of cognitive styles test are greatly diminished.

Conclusion

The results of cognitive styles tests can't help us determine who is a better dynamic decision maker or who is better at learning system dynamics, and thus it is unclear to us that the resources spent investigating individual differences in cognitive style are justified. The only positive use of cognitive styles suggested by our research is to identify people in a time-compressed learning environment, like that presented by flight simulators, who need to be coached to take their time and think about how the decisions they make fit into a larger scheme or whole. It should be remembered that this is a very tentative finding.

A final comment is that of the three cognitive styles instruments we used, only the Gregorc seemed useful at any level. The MBTI produced data which were not useful in explaining dynamic decision making and performance on either short term or longer term tasks. In addition, the MBTI is more expensive to use and cannot be self-scored, meaning that feedback to participants is delayed.

Even more discouraging, the modified Gordon instrument has little chance of ever being useful unless it is rewritten and updated. As it now stands, the Gordon test cannot be administered to anyone whose primary language is anything other than English as spoken in the United States, and the word associations in the Remote Association part of the test requires cultural knowledge which is not current.

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Figure 1: Sector Diagram of the STRATEGEM-2 Microcomputer Simulation Game

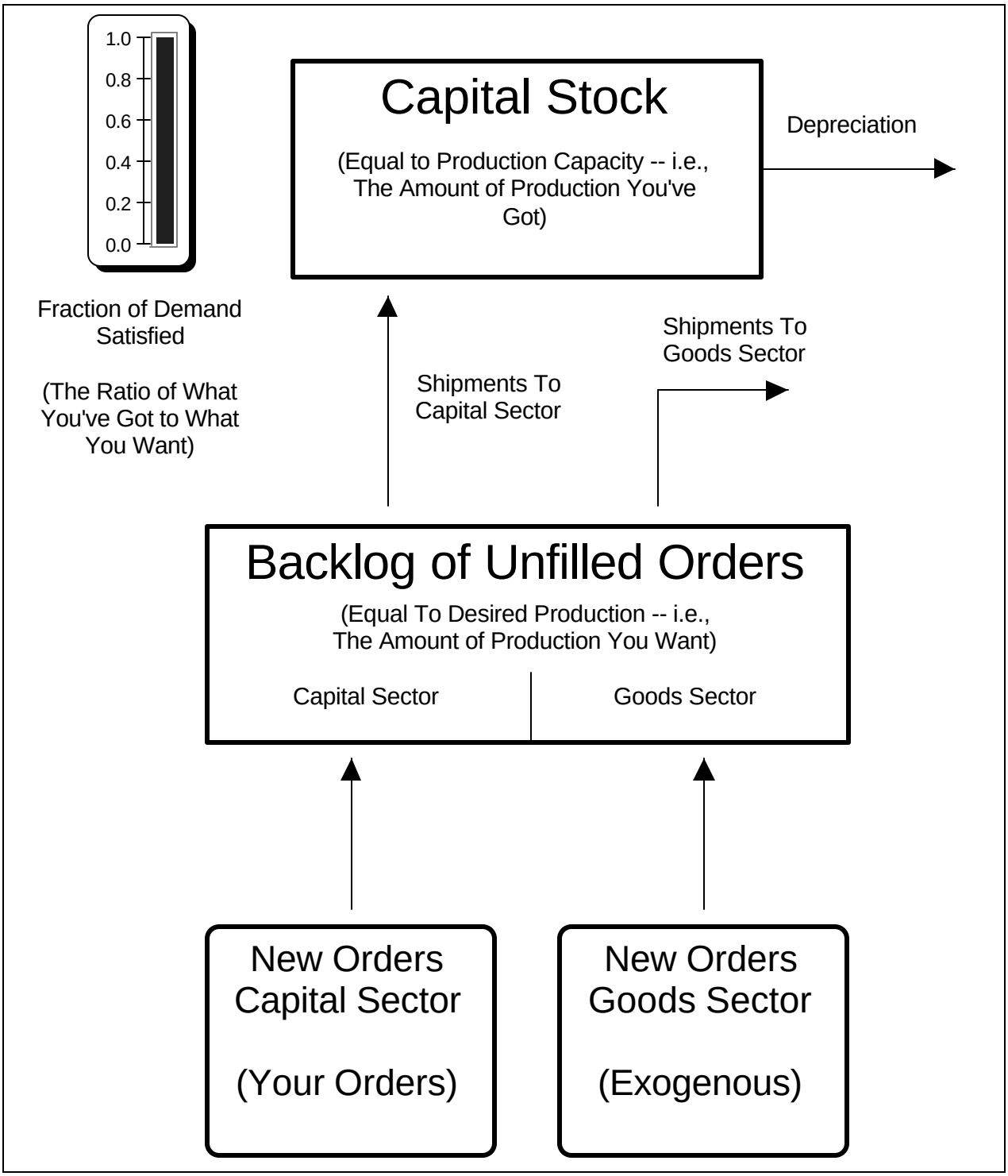
1.0
0.8
0.6
0.4
0.2
0.0
Fraction of Demand Satisfied
(The Ratio of What You've Got to What You Want)
Capital Stock
(Equal to Production Capacity -- i.e., The Amount of Production You've Got)
Depreciation
Shipments To Capital Sector
Shipments To Goods Sector
Backlog of Unfilled Orders
(Equal To Desired Production -- i.e., The Amount of Production You Want)
Capital Sector
Goods Sector
New Orders Capital Sector
(Your Orders)
New Orders Goods Sector
(Exogenous)

Figure 2: A Play of the Kondratiev Game Exhibiting Three Waves

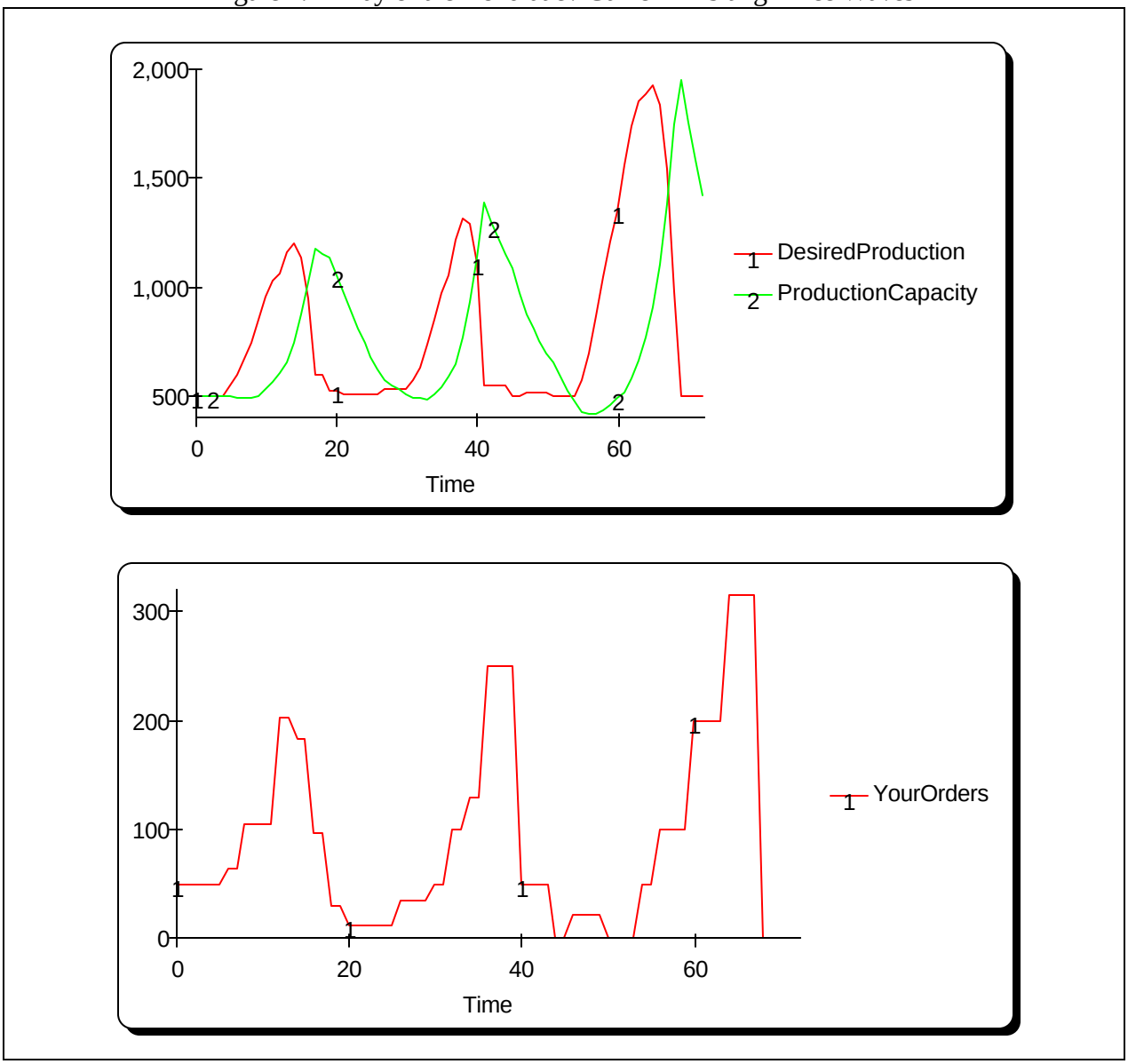

Figure 3: A Typical Play of the Kondratiev Game Showing Two Waves

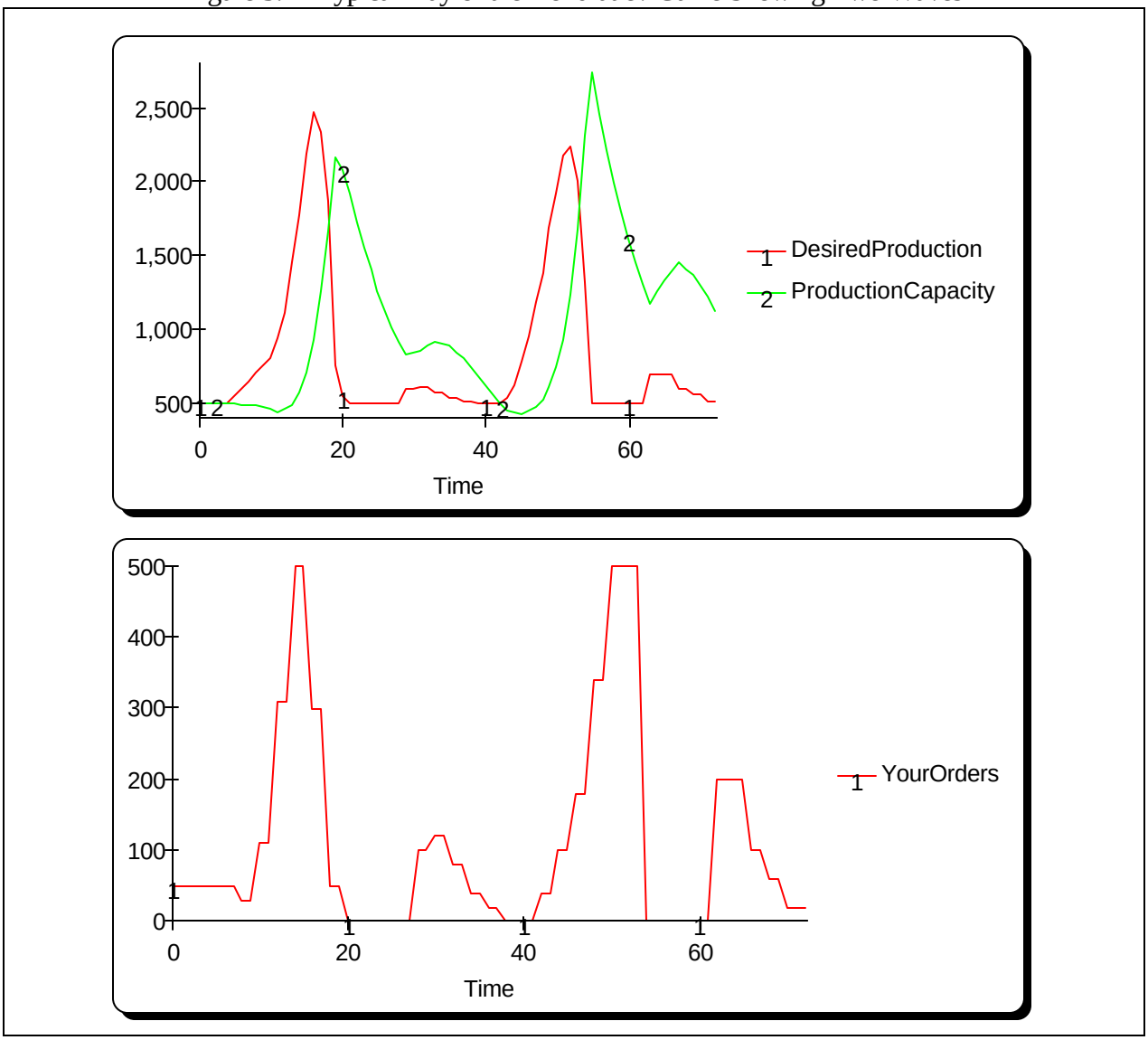

Figure 4: Another Example of the Results from Playing the Kondratiev Game

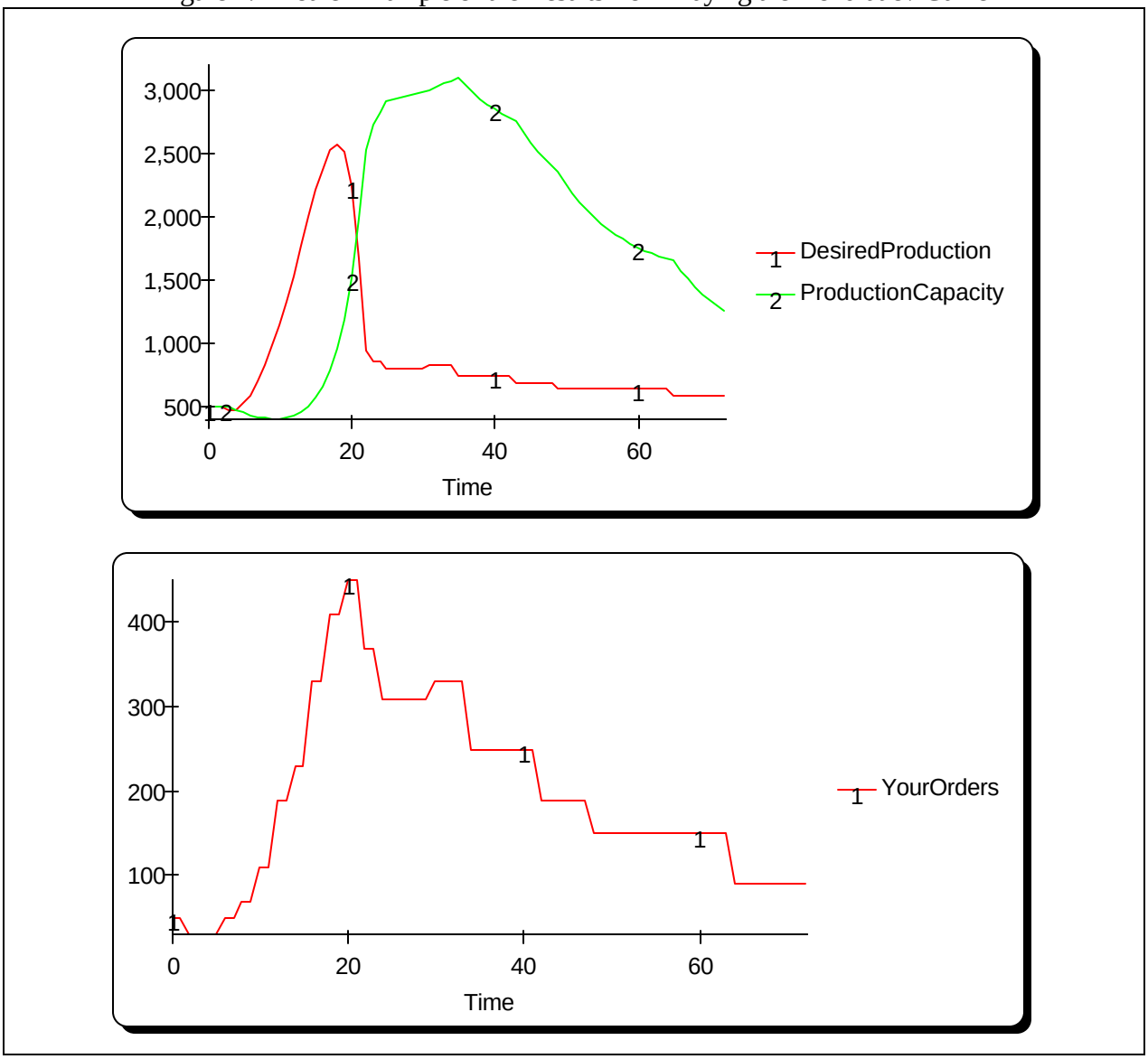

Figure 5: An Example Showing the System Being Brought into Equilibrium

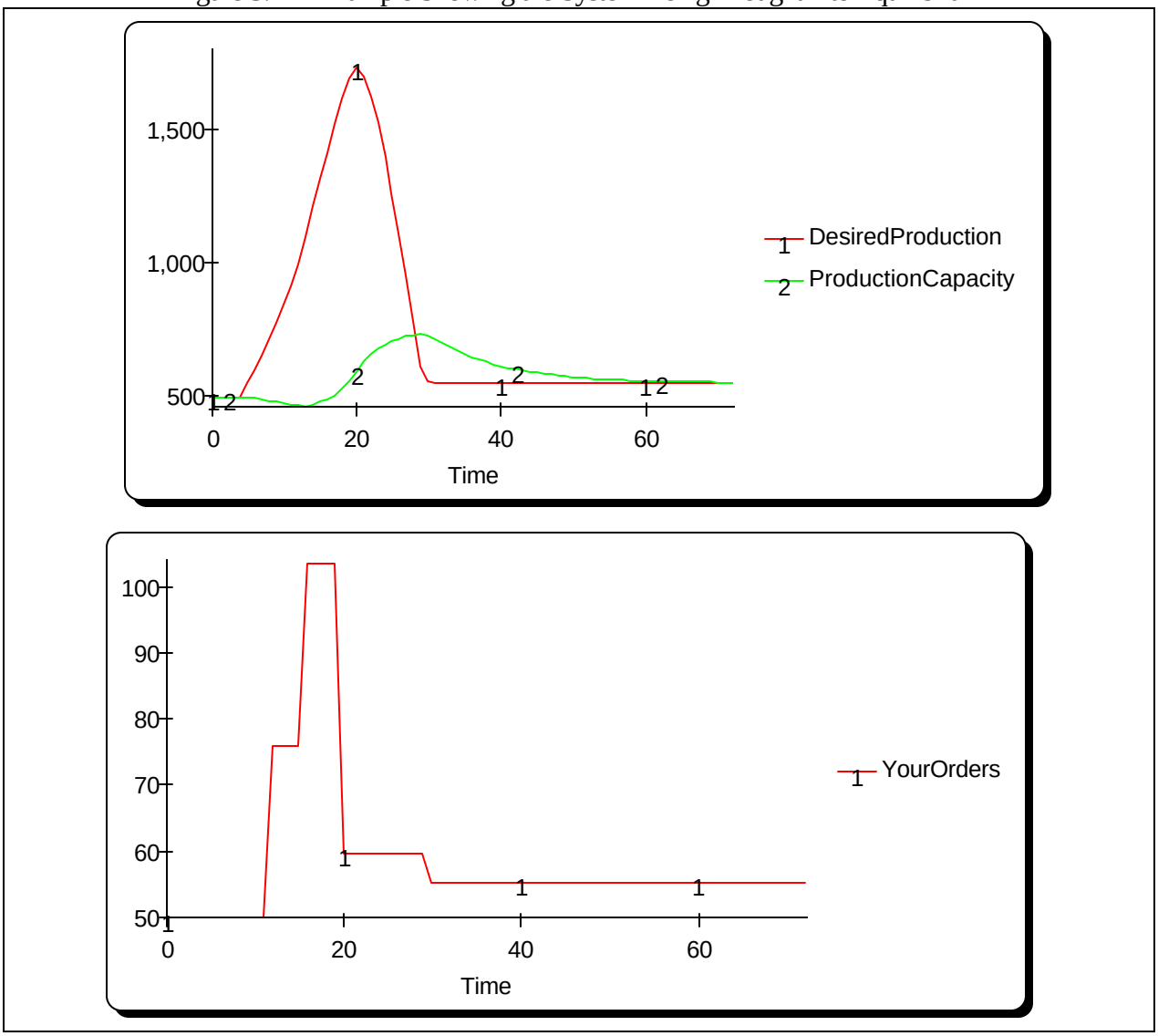

Table 1: Results of the First Experiment as Observations are Systematically Deleted

Score Deleted	R-square	Coefficient Estimates	t-stats	P-values
none	.027	AS = -413 AR = -659	AS = -0.49 AR = -0.96	AS = 0.63 AR = 0.34
97,855	.015	AS = -64 AR = -179	AS = -0.19 AR = -0.66	AS = 0.85 AR = 0.51
32,982	.012	AS = -60 AR = -106	AS = -0.29 AR = -0.61	AS = 0.78 AR = 0.54
22,749	.098	AS = -31 AR = -150	AS = -0.28 AR = -1.61	AS = 0.78 AR = 0.12
11,331	.158	AS = -41 AR = -142	AS = -0.51 AR = -2.15	AS = 0.62 AR = 0.04
7,030	.091	AS = -46 AR = -101	AS = -0.64 AR = -1.65	AS = 0.53 AR = 0.11
5,749	.168	AS = -129 AR = -116	AS = -1.93 AR = -2.22	AS = 0.06 AR = 0.03
5,509	.239	AS = -144 AR = -110	AS = -2.61 AR = -2.55	AS = 0.01 AR = 0.02