STRATEGEM-2: A Microcomputer Based Operational Game on the Kondratiev Cycle

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ABOUT THE STRATEGEM SERIES

Within the IIASA's Project, *Integrative and Special Studies* (ISS), Institute staff members have been conducting a diverse research effort on techniques for marrying computer simulation models with management-training games. One phase of this project is a program of game development that draws on three specific components:

- sophisticated (though not necessarily large) simulation models of specific systems that are relevant to senior managers in the corporate and public sectors,
- inexpensive, portable microcomputers that can operate the models on the home ground of potential clients, and
- playing boards with associated pieces that offer players an accounting and communication aid while they are playing the game.

The games in this series are all called STRATEGEMS (Strategic Games for Educating Managers). Each game in this series is programmed in the BASIC computer language, so that it can be implemented on an extremely wide variety of small microcomputers. Each game kit is available from IIASA ready to play, and each is documented sufficiently well that users may customize it.

Information about the games that are so far available in this series may be obtained from IIASA. Write to: Shirley Wilson, IIASA, A-2361 Laxenburg, Austria, telephone 2236/715210.

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1. HISTORY AND PURPOSE OF STRATEGEM-2

The economic crisis of the 1980s has revived interest in the economic long wave or Kondratiev Cycle, a cycle of prosperity and depression averaging about fifty years (Kondratiev 1935). Most students of the subject believe that the depression periods in the 1830s, 1870s-90s, and 1930s were Kondratiev downturns. They suggest the difficulties of the 1970s and 80s are symptoms of the current downturn in the long wave. A substantial amount of evidence now supports the view that the long wave is indeed a real phenomenon (Bianchi, et al. 1983; Freeman 1983; Freeman et al. 1982; Senge 1982; Van Duijn 1983). The economics profession as a whole, however, has remained skeptical (Mansfield 1983, Rosenberg and Frischtak 1983). In part the skepticism arises from the lack of a well-developed theory to explain how such long fluctuations could arise.

Since 1975 the System Dynamics National Model, a large computer simulation model developed at MIT, has provided an increasingly rich theory of the long wave (Forrester 1976, 1977, 1979, 1981; Graham and Senge 1980; Sterman 1984a). The theory emerging from the National Model explains the long wave as the endogenous result of decisionmaking by individuals, corporations,

and government. The theory relates capital investment, employment and workforce participation, wages, inflation, debt, interest rates, monetary and fiscal policy, innovation and productivity, and even political values. The advantages of the National Model are its wide boundary and the rich detail in which economic behavior is represented. However, the complexity of the model makes it difficult to explain the dynamics underlying the long wave in a simple and convincing manner.

A simplified model of the long wave was developed to communicate the essence of the long wave (Sterman 1984b). The simplified model contains less than thirty equations, compared to about 1600 for the full National Model, and it can be simulated on a variety of personal computers. It has been used successfully in the classroom and as the basis for student projects. The simple model focuses on the role of capital investment in the genesis of the long wave. The model shows how the investment and production policies pursued by individual firms, though rational from the point of view of the individual actors, interact in the context of the whole system to produce "irrational" behavior--periodic over- and under-expansion of the economy.

However, even the simple model is too complex to convey the essence of the theory to people who have no training in mathematical modeling. Needed is an even simpler and more immediate way to demonstrate how long economic fluctuations can arise. This paper describes a simulation game which fulfills that purpose.

No modeling or quantitative skills (beyond simple algebra) are required to play STRATEGEM-2. The game can be played in about two hours and by individuals or teams. Like the simple model, the game illustrates how investment and production policies of individual firms can lead to over- and under-expansion of investment and production capacity for the economy as a whole. The game, simple model, and full National Model, each providing a mutually consistent account of the origin of the long wave but at vastly different levels of explanation and detail, together make a more compelling case for the theory of long waves than any one of them alone.

2. A THEORY OF THE KONDRATIEV CYCLE

The long wave is characterized by successive waves of over-expansion and collapse of the economy, particularly the capital-producing sectors. Overexpansion means an increase in the capacity to produce and in the production of plant, equipment, and goods relative to the amount needed to replace worn-out units and provide for growth over the long run. Overexpansion is undesirable because eventually, production and employment must be cut back below normal to reduce the excess. Figure 1, from a simulation of the National Model, shows the periodic buildup of real GNP followed by declining real GNP, falling employment, and lowered real wages.

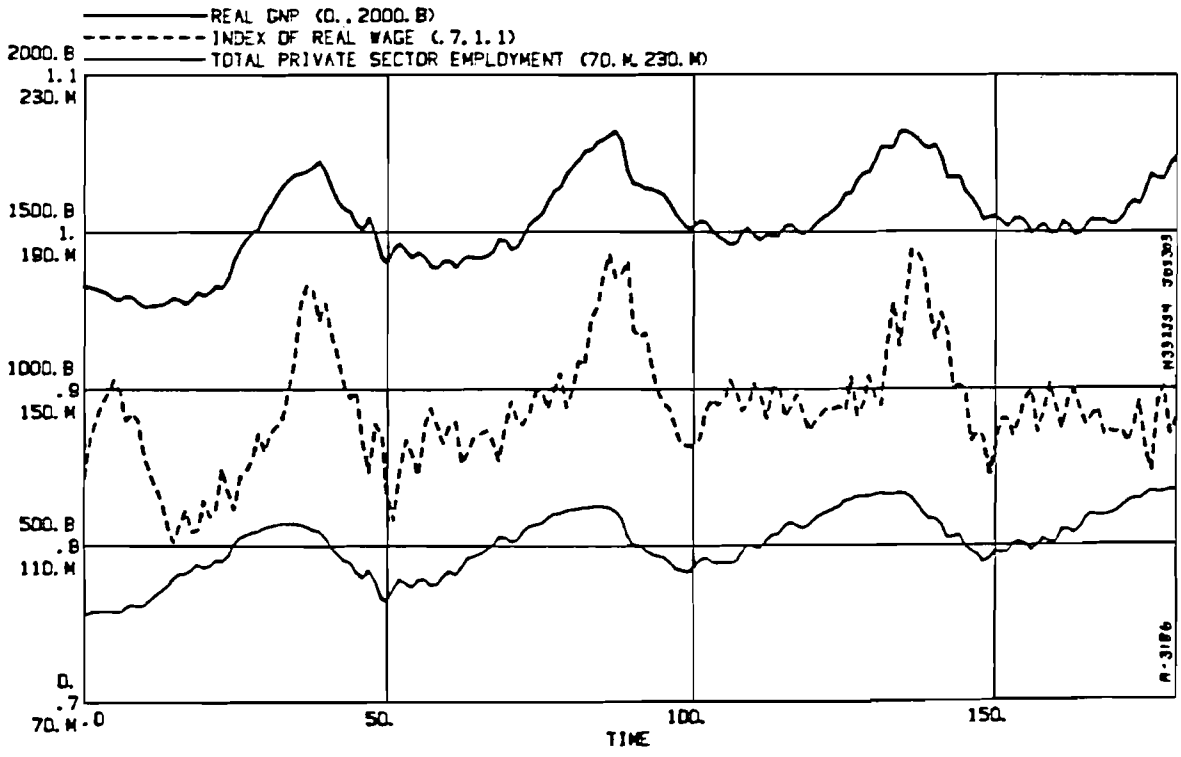

Figure 1. National Model Simulation of Real GNP, Employment and Real Wage. Source: Sterman 1984b.

How does the long wave arise? In particular, how does overexpansion of production capacity in the economy arise? The National Model identifies several distinct processes which contribute to overexpansion. One of the most fundamental is capital self-ordering, the basis for STRATEGEM-2.

Consider the economy divided into two parts: the capital goods sector and the consumer goods sector. The capital-producing industries of the economy (construction, heavy equipment, steel, mining, and other basic industries) supply each other with the capital plant, equipment, and materials each needs to operate. Viewed as a whole, the capital sector of the economy orders and acquires capital from itself, hence "self-ordering."

If the demand for consumer goods and services increases, the consumer goods industry must expand its capacity, and so it places orders for new factories, equipment, vehicles, etc. To supply the higher volume of orders, the capital-producing sector must also expand its capital stock and so places orders for more buildings, machines, rolling stock, trucks, etc., causing the total demand for capital to rise still further, a self-reinforcing spiral of increasing orders, a greater need for expansion, and still more orders. The surge in orders not only boosts desired production directly, it swells the backlogs and depletes the inventories of capital producers, further adding to the pressure for more capital.

Once a capital expansion gets under way, the self-ordering loop amplifies and sustains it until production catches up to orders, excess capacity is built up, and orders begin to fall. At that point, the self-ordering loop reverses: a reduction in orders further reduces the demand for capital, leading to a contraction in the capital sector's output, followed by declining employment, wages, aggregate demand, and production of goods and services. Capital production must remain below the level required for replacement and growth until the excess capacity is depreciated--a process that may take a decade or more due to the

long lifetimes of plant and equipment. Once the capital stock is worn out, investment rises, triggering the next upswing.

To illustrate, consider the development of the U.S. economy after World War II. The capital stock of the economy was old and severely depleted after 15 years of depression and wartime production. Demand for all types of capital--factories, machines, roads, houses, schools--surged. A massive rebuilding began. In order to replace worn-out capital, fill pent-up demand, and rebuild the capital and infrastructure, the capital-producing sector had to expand beyond the long-run needs of the economy. The necessary overexpansion of the capital sector was exacerbated by self-ordering. As the demand for consumer goods, services, and housing rose, manufacturers of capital plant and equipment had to expand their own capacity, further swelling demand. The resulting high backlogs, spot shortages, high capacity utilization, and rapid growth all reinforced the total demand for capital, helping to ensure that demand did indeed grow. Thus self-ordering boosted the boom of the 1950s and 1960s.

By the late 1960s, however, the capital stock had been largely rebuilt, and investment began to slow to a level consistent with replacement and long-run growth. Excess capacity and unemployment began to show up in basic industries. Faced with excess capacity, investment in these industries was cut back, further reducing the need for capital and reinforcing the decline in investment as the economy moved through the 1970s and into the 1980s.

3. OPERATION OF THE GAME

This report contains almost everything required to play the manual version of the game. The game's Playing Board, the Steps of the Game, and the Record Sheet are all included here, and extra copies of each may be ordered in bulk from IIASA. Lacking are only the markers that are used to represent the stocks and flows of capital and orders on the board. These are represented by markers of four different colors, coded for denominations of

10, 50, 100, and 500; all amounts are rounded to the nearest 10 units. These markers may be provided by coins, a German Halma set (which contains 20 each of red, blue, green, and yellow figures), or other available pieces. When the computer program is not used, it is also helpful for each game to be supplied with a simple calculator to make easier the calculation of the fraction of production that will be shipped to the capital and the goods sectors in those periods when the backlog of unfilled orders is greater than actual production.

The computer program that is listed in this report may be used to implement the game on any microcomputer that runs BASIC. Notice that a few minor changes will be necessary to adapt the program to any microcomputer other than the NEC PC-8201. In particular, the plotting routine will have to be changed or omitted and the memory clear prompt should be removed. In most cases, however, the changes will take only a little effort. The game may be played entirely on the computer. However, it is much better for the computer program to be used only to perform all calculations, while the markers are moved on the playing board to represent the state of the system at each period of play, and the player enters all data by hand on the Record Sheet. This latter approach is strongly recommended, because the physical buildup of the markers on the board and the statistical record on the sheet make a dramatic impression on players and help anchor the game in reality.

The game works very well with a variety of individuals ranging from undergraduates to professional systems analysts and economists. One useful protocol for running the game with any of these players is as follows. Introduce the game as an exercise designed to explore investment behavior. Describe the division of the economy into capital- and goods-producing sectors, and point out that the production capacity of the capital sector can only be increased by self ordering. Do not introduce the phenomenon of the Kondratiev Wave before the game. Describe the game board and rules, and "talk through" a sample round to

demonstrate the mechanics of ordering, producing, and record keeping. Even if the computer program is being used, the players should record all data on the Record Sheet. Describe the scoring rule. Encourage players to ask questions about any aspect of the game. During the game, impose no overt time pressure. Questions that arise during the game should also be answered.

To run the game, the orders for capital placed by the goods sector must be specified. Though a variety of order patterns for the goods sector are possible, the most effective for first-time players is a simple step function in which orders from the goods sector rise from 450 to 500 after the second period and remain at 500 thereafter. Three sheets that may be cut up to provide a deck with this order stream for the manual version of the game are included in this report. This step increase is also incorporated in the computer program for the game. The pattern of orders should not be revealed to the players in advance.

The player, or team of players, takes the role of manager for the entire capital-producing sector of the economy. There is only one decision in the game that is left to the descretion of the player--how much new capital to order for the capital sector each two-year period. This decision may be made by one player alone or in consultation with one or two others. A team with two players per board is most effective for learning, since it forces each player to express verbally the reasons for his actions.

The player's goal is to keep production capacity as closely matched to the demand for capital as possible. The game is won by the person or team with the lowest score. The score is the average absolute deviation between production capacity and desired production. Players are thus penalized for excess capacity (which implies underutilized capital) and also for insufficient capacity (which causes shortages of goods elsewhere in the economy).

Time is divided into two-year periods. At the beginning of each period, orders for capital are received from two sources: the goods sector and the capital sector itself. Orders for capital arriving from the goods sector are exogenous and determined by drawing a card at the start of each period, or they are specified by the computer printout. Orders for capital that are moved into the unfilled order backlog are those placed by the player himself during the previous period. Orders placed by the goods and capital sectors accumulate in the corresponding halves of the rectangle containing the backlog of unfilled orders. The sum of the backlog of orders placed by the goods and capital sectors equals desired production for the current two years, since players wish to produce enough to eliminate the total backlog within one two-year period. Production itself is the lesser of desired production or production capacity. Production capacity is determined by the capital stock of the sector. Capital stock is decreased by depreciation and increased by shipments derived from production. The game therefore captures the self-ordering hypthesis.

If capacity is inadequate to meet demand fully, available production of capital is allocated between the capital and goods sectors in proportion to their respective backlogs. For example if the backlog from the capital sector were 500 and the backlog from the goods sector were 1000, desired production would be 1500. If actual production were only 600, 200 units would be shipped to the capital sector and 400 would be shipped to the goods sector. Any unfilled orders remain in their respective backlogs to be filled in future periods. Proportional allocation of output implies that the individual orders for capital placed by firms within the goods and capital sectors each have an equal probability of being filled. Players may wish to experiment with other allocation rules, such as priority for the capital sector.

4. EQUATIONS AND PARAMETERS

The following equations correspond exactly to the structure of the game (see also the simple model in Sterman 1984b).

PRODUCTION(t) = MIN[DESIRED PRODUCTION(t),CAPACITY(t)]

Production over the current two year cycle is the lesser of desired production or production capacity.

CAPACITY(t) = (dt)[CAPITAL(t)/CAPITAL-OUTPUT RATIO]

CAPITAL-OUTPUT RATIO = 2 years

Annual production capacity is given by capital stock divided by the capital-output ratio. Capacity for the next time period of length (dt) is the annual rate times (dt), which is two years. For simplicity, the capital output ratio is assumed to be two, and thus production capacity for each two year period equals the capital stock.

CAPITAL(t+dt) = CAPITAL(t) + SHIPMENTS TO CAPITAL SECTOR(t) - DEPRECIATION(t)

The capital stock is increased by shipments of capital to the capital sector and decreased by depreciation.

DEPRECIATION(t) = (dt)[CAPITAL(t)/AVERAGE LIFETIME OF CAPITAL)

AVERAGE LIFETIME OF CAPITAL = 20 years

Depreciation is proportional to the capital stock. The average life of capital is assumed to be 20 years, so in each period of two years, 10 percent of the capital is lost.

SHIPMENTS TO CAPITAL SECTOR (t) = PRODUCTION(t) * [BACKLOG OF CAPITAL SECTOR(t)/DESIRED PRODUCTION(t)]

SHIPMENTS TO GOODS SECTOR(t) = PRODUCTION(t) * [BACKLOG OF GOODS SECTOR(t)/DESIRED PRODUCTION(t)]

Available capital is allocated between the goods and capital sectors in proportion to their backlogs.

DESIRED PRODUCTION(t) = BACKLOG OF CAPITAL SECTOR(t) + BACKLOG OF GOODS SECTOR(t)

Desired production is the sum of the backlogs of unfilled orders for capital placed by the goods and the capital sectors. The normal delay in receiving capital is therefore (dt) or two years.

BACKLOG OF CAPITAL SECTOR(t+1) = BACKLOG OF CAPITAL SECTOR(t) + NEW ORDERS FROM CAPITAL SECTOR(t) - SHIPMENTS TO CAPITAL SECTOR(t)

BACKLOG OF GOODS SECTOR(t) = BACKLOG OF GOODS SECTOR(t) + NEW ORDERS FROM GOODS SECTOR(t) - SHIPMENTS TO GOODS SECTOR(t)

The backlogs of the goods and capital sectors are increased by the new orders placed by each sector and decreased by shipments to each sector. New orders for capital placed by the capital sector are determined by the player. New orders for capital placed by the goods sector are exogenous.

$$\text{SCORE} = \frac{\text{SUM } [|\text{DESIRED PRODUCTION}(t) - \text{CAPACITY}(t)|]}{\text{NUMBER OF PERIODS}}$$

The player's score is the absolute deviation between desired production (demand and production capacity (supply) averaged over the number of periods played.

The game is initialized in equilibrium with a capital stock of 500 units and total backlog of 500 units. Desired production and production capacity are therefore in balance. The backlog of the goods sector is 450 units and that of the capital sector is 50 units, just enough to offset the impending depreciation of 50 units of capital.

5. DEBRIEFING THE GAME

At least 30-60 minutes should be allowed at the end of the game for debriefing. This is essential if the fun experience of playing STRATEGEM-2 is to be converted into an effective source of insights about reality. First get the players to perceive and agree on the major perceptions, behavior modes, and motivations they experienced during the game. Then discuss the structural basis in the game for these outcomes. Finally discuss as a group the counterparts to these structures in real life and the extent to which outcomes like those in STRATEGEM-2 have been observed in real economies. The references in this paper will be particularly helpful in this last phase of the debriefing.

The leader should first have the players compute their scores and announce the "winner." The pattern of orders, production, and capacity for each player should then be plotted. The juxtaposition of the tiny increase in orders from the goods sector against the hugh expansion of capacity makes a dramatic impression and clearly shows that it is the internal management policies followed by each that creates the instability, and not external events that causes the problem. Ask players to describe their feelings during the game, particularly during the phase when capacity was inadequate and at the point where capacity suddenly became excessive. Discussion of their decisions and rationale should be encouraged. Through questions the leader should get the players to piece together the various stages of their individual order cycle and to relate the results and the causes to factors in the real world.

Good leading questions to aid the discussion include: "Did you feel in control of the situation or at the mercy of outside forces?"; "What happened that was most surprising?"; "Why did you order x units in year t (indicate a particularly large order near the peak of orders)?"; "Why did it take so long for you to raise production to desired levels?"; "How did you feel when capacity rose above desired production?"; "Why did it take so long for production capacity to fall back to acceptable levels?"; "Were you ordering enough at the end of the game to avoid another shortage of capacity?"

Emphasize the common pattern of behavior in the different games despite the differences in individual decision, strategies, and personalities. Point out that though they felt they had little control over the system, they were in fact the only source of change and were fully responsible for the behavior. Discussion of the reasons for this apparent contradiction should be lively. Ask in what ways this aspect of the game might be true for real world managers. The leader should also explain why some overshoot of capacity above demand is inevitable, so as not to leave the players with too great a feeling of incompetence.

Indicate that in almost every game, players increase capital sector orders sufficiently to produce an overexpansion of capacity and subsequent "depression" as investment falls below depreciation and capital is underutilized. Often overcapacity becomes severe enough to cause players to cut orders back to zero. Overexpansion of capacity is not surprising. Since production cannot immediately rise, the increase in demand cannot immediately be met. Thus backlogs are certain to result. To meet the long-run demand and fill the orders in the backlog, capacity must expand above the equilibrium level. But the magnitude of the capacity overshoot is surprising.

The step increase in orders from the goods sector need only stimulate a rise of just ten percent in the total demand for capital. Due to self-ordering, the equilibrium capital stock rises from 500 to 560, that is 500 to supply the goods sector and 60 to replace depreciation (10% of 550 is 60 when rounded to the nearest 10). But while orders from the goods sector increase only by 10%, production capacity often expands by many times that amount. Such overexpansion is followed, of course, by long periods of depression required to permit depreciation of the excess capital. When the average lifetime of capital is 20 years, it takes almost 15 years for depreciation alone to reduce the capital stock by 50%. The average period of the cycle, measured from the first increase in orders to the second, is generally 40 - 50 years.

It is very important that players learn not to blame the outcome of the game on matters outside their knowledge or control. Point out that the structure and rules of the game are fully known to the players. The state of the system is also fully known. There are no random events or exogenous disturbances after the initial increase in orders. Players were permitted to place any orders they wished, and they suffered little from time pressure. Yet long wave behavior always results. Despite the perfect information and extreme simplicity of the game compared to the actual economy, the cause-effect relationships in the game (and in the real economy) mean that players are not able to follow what might be termed the optimal strategy. The debriefing should help them understand the causes of this result.

After the debriefing has covered the players' experience, it is also crucial to help them understand that these did not result from judgemental errors or statistical aberrations that are unrelated to real systems. Rather, they illustrate well the principles and consequences of bounded rationality. In the real economy information is much less complete and much less certain than it was in STRATEGEM-2, and the structure of the economy, particularly the interconnections amoung firms, is not fully appreciated. In addition, the long time required in real life for the consequences of self-ordering to manifest itself reduces the likelihood that corporate and public managers will learn from experience. Learning is also hindered by the heavy weight placed on relatively recent information compared to what happened in previous decades. A particularly ironic example is the behavior of the banking system in the current international debt crisis--a nearly exact replica of the 1920s and 30s (Sterman 1982). And over a fifty year cycle, many of the leaders who experienced the transition from expansion to contraction have retired or died by the next expansion period.

6. CONCLUSION

STRATEGEM-2 provides a simple and dramatic demonstration of the way in which investment decisions can lead to instability in the economy, and to long waves in particular. It shows how micro-level decisions lead to the macrobehavior of systems. In particular, it illustrates the principles of bounded rationality by showing how individual decisions, though seemingly rational at the time, can lead to undesirable behavior for the system as a whole, even when perfect information is available and the full structure of the system is known. It points out the importance of considering both stock and flow variables, particularly the importance of disequilibria, such as the buildup of backlogs, in the genesis of dynamic behavior. The game illustrates the extent to which dynamic behavior is created by the internal structure of systems and not by external events. It provides a good introduction to the use of behavioral models in the study of economic dynamics. Finally, it illustrates the educational power of simple games when they are based on small but sophisticated computer models.

REFERENCES

Bianchi, G., G. Bruckmann, T. Vasko (1983) Background material for a meeting on long waves, depression and innovation, Siena-Florence, October 26-29, 1983. CP-83-44. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Forrester, J. (1976) Business structure, economic cycles, and national policy. *Futures* 8:195-214.

Forrester, J. (1977) Growth cycles. *De Economist* 125(4):525-543.

Forrester, J. (1979) An alternative approach to economic policy: macrobehavior from microstructure, in *Economic Issues of the Eighties*, edited by N. Kamrany and R. Day. Baltimore: Johns Hopkins University Press.

Forrester, J. (1981) Innovation and economic change. *Futures* 13:323-331.

Freeman, C. (1983) *The Long Wave and the World Economy.* Boston: Butterworths.

Freeman, C., J. Clark, and L. Soete (1982) *Unemployment and Technical Innovation: A Study of Long Waves and Economic Development.* Westport, Connecticut: Greenwood Press.

Graham, A., and P. Senge (1980) A long-wave hypothesis of innovation. *Technological Forecasting and Social Change* 17:283-311.

Kondratiev, N. (1935) The long waves in economic life. *Review of Economic Statistics* 17:105-115.

Mansfield, E. (1983) Long waves and technological innovation. *Papers and Proceedings*, American Economic Association, 73(2):141-145.

Rosenberg, N., and C. Frischtak (1983) Long waves and economic growth: a critical appraisal. *Papers and Proceedings*, American Economic Association 73(2):146-151.

Senge, P. (1982) The economic long wave: a survey of evidence. Working paper D-3262-1. Cambridge, Massachusetts: Systems Dynamic Group, MIT.

Sterman, J. (1982) Amplification and self-ordering: causes of capital overexpansion in the economic long wave. Working paper D-3366. Cambridge, Massachusetts: Systems Dynamics Group, MIT.

Sterman, J. (1984a) A behavioral model of the economic long wave. *Journal of Economic Behavior and Organization*. (forthcoming).

Sterman, J. (1984b) An integrated theory of the economic long wave. Working paper 1563. Cambridge, Massachusetts: Systems Dynamics Group, MIT.

DECK OF ORDERS FROM THE GOODS SECTOR

Cut these into separate orders. Place the deck of 70 orders face down in the Playing Board rectangle for New Orders-Goods Sector. The two orders for 450 should be face down at the top of the deck.

450	450	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500

500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500	500	500
500	500	500	500		

LISTING OF THE OPTIONAL COMPUTER PROGRAM

```
1000 'STRATEGEM-2
1010 '
1020 'KONDRATIEV WAVE GAME
1030 '
1040 'copyright August 8, 1984
1050 '
1060 'c/o Integrative & Special
1070 '    Studies Project
1080 'IIASA, A-2361 Laxenburg, AUSTRIA
1090 'Telephone: 02236/715210
1100 '
1110 'Memory Clearance for the NEC-PC8201
1120 '
1130 CLS:INPUT "DID YOU CLEAR MEMORY 300,60000? Y/N";C$
1140 IF C$="Y" THEN GOTO 1190 ELSE 1150
1150 IF C$="y" THEN GOTO 1190 ELSE 1160
1160 CLS:PRINT "Please enter BASIC, type CLEAR 300,60000"
1170 PRINT "then run KWAVE once again"
1180 END
1190 CLS
1200 'Initial Values
1210 '
1220 DIM R(5,40)       'Matrix of Results
1230 DIM M$(7)         'Matrix of Plot Labels
1240 PC=500            'Initial Production Capacity
1250 NC=50             'New Orders, Capital Sector
1260 BC=0: BG=0        'Initial Backlogs
1270 S1=0: S2=0        'Initial Scores
1280 '
1290 'Calculation Cycle
1300 '
1310 FOR T=0 TO 70 STEP 2
1320 IF T<=2 THEN NG=450 ELSE NG=500  'New Orders, Goods Sector
1330 BC=BC+NC          'Backlog Unfilled Orders, Capital Sector
1340 BG=BG+NG          'Backlog Unfilled Orders, Goods Sector
1350 DP=BC+BG          'Desired Production
```

```
1360 PC=PC+SC-D        'Production Capacity
1370 S1=ABS(DP-PC)     'Score for Period T
1380 S2=S2+S1          'Cumulative Score
1390 S=S2/((T/2)+1)    'Average Score
1400 IF PC>DP THEN PR=DP ELSE PR=PC   'Production Rate
1410 '
1420 'Storing the Results in the Output Matrix
1430 '
1440 R(2,T/2+1)=NC     'New Orders, Capital Sector
1450 R(1,T/2+1)=NG     'New Orders, Goods Sector
1460 R(3,T/2+1)=PR     'Production Rate
1470 R(4,T/2+1)=PC     'Production Capacity
1480 R(5,T/2+1)=DP     'Desired Production Rate
1490 '
1500 'Calculate New Rates
1510 '
1520 D=INT((PC*.1/10)+.5)*10      'Depreciation
1530 SC=INT((PR*BC/DP)/10+.5)*10 'Shipments to Capital Sector
1540 SG=PR-SC                     'Shipments to Goods Sector
1550 '
1560 'Print Current Period Values & Input C.S. Orders
1570 '
1580 PRINT "Year ";T
1590 PRINT USING "1. Backlog of Capital Sector   ####";BC
1600 PRINT USING "   New Orders from Goods Sec.  ####";NG
1610 PRINT USING "2. Backlog of Goods Sector     ####";BG
1620 PRINT USING "3. Desired Production          ####";DP
1630 PRINT USING "4. Capital Stock               ####";PC
1640 INPUT "5. New Orders for Cap. Sector";NC
1650 PRINT USING "6. Production                  ####";PR
1660 PRINT USING "7. Depreciation                ####";D
1670 PRINT USING "8. Ship. to Capital Sector     ####";SC
1680 PRINT USING "9. Ship. to Goods Sector       ####";SG
1690 '
1700 INPUT "<return> to continue, <q> to quit";C$
1710 '
1720 BC=BC-SC          'B. C. after Shipments to the Capital Sector
1730 BG=BG-SG          'B. G. after Shipments to the Goods Sector
1740 '
1750 'Termination Routine
1760 '
1770 IF C$="q" THEN 1800 ELSE 1780
1780 IF C$="Q" THEN 1800 ELSE NEXT T
1790 '
1800 CLS:PRINT USING "Your score was ####";S
1810 PRINT:PRINT
1820 '
1830 INPUT "<return> to plot results";P$
1840 IF P$="q" THEN 2380 ELSE 1850
1850 IF P$="Q" THEN 2380 ELSE 1870
1860 '
1870 'Plotting Subroutine
1880 '  for the NEC-PC8201A
1890 '
1900 PX=6
```

```
1910 SCREEN 0,0:CLS
1920 YM=2500   'maximum y value
1930 TM=70
1940 INPUT "NG"; X$
1950 FOR T=0 TO TM STEP 2
1960 IF R(1,T/2+1)*63/YM>63 THEN Y=2 ELSE Y=63-R(1,T/2+1)*63/YM
1970 PSET(20+T*36*PX/TM,Y)
1980 PSET(20+T*36*PX/TM,Y-1)
1990 PSET(20+T*36*PX/TM,Y-2)
2000 NEXT T
2010 INPUT "NC"; X$
2020 FOR T=0 TO TM STEP 2
2030 IF R(2,T/2+1)*63/YM>63 THEN Y=2 ELSE Y=63-R(2,T/2+1)*63/YM
2040 PSET(22+T*36*PX/TM,Y)
2050 PSET(23+T*36*PX/TM,Y)
2060 PSET(24+T*36*PX/TM,Y)
2070 PSET(22+T*36*PX/TM,Y-1)
2080 PSET(24+T*36*PX/TM,Y-1)
2090 PSET(22+T*36*PX/TM,Y-2)
2100 PSET(23+T*36*PX/TM,Y-2)
2110 PSET(24+T*36*PX/TM,Y-2)
2120 NEXT T
2130 INPUT X$
2140 SCREEN 0,0:CLS
2150 INPUT "PC"; X$
2160 FOR T=0 TO TM STEP 2
2170 IF R(4,T/2+1)*63/YM>63 THEN Y=2 ELSE Y=63-R(4,T/2+1)*63/YM
2180 PSET(20+T*36*PX/TM,Y)
2190 PSET(20+T*36*PX/TM,Y-1)
2200 PSET(20+T*36*PX/TM,Y-2)
2210 NEXT T
2220 INPUT "DP"; X$
2230 FOR T=0 TO TM STEP 2
2240 IF R(5,T/2+1)*63/YM>63 THEN Y=2 ELSE Y=63-R(5,T/2+1)*63/YM
2250 PSET(22+T*36*PX/TM,Y)
2260 PSET(23+T*36*PX/TM,Y)
2270 PSET(24+T*36*PX/TM,Y)
2280 PSET(22+T*36*PX/TM,Y-1)
2290 PSET(24+T*36*PX/TM,Y-1)
2300 PSET(22+T*36*PX/TM,Y-2)
2310 PSET(23+T*36*PX/TM,Y-2)
2320 PSET(24+T*36*PX/TM,Y-2)
2330 NEXT T
2340 INPUT X$
2350 SCREEN 0,0:CLS
2360 '
2370 CLS
2380 PRINT:PRINT:PRINT
2390 PRINT "Thank you for playing:
2400 PRINT
2410 PRINT "       STRATEGEM-2"
2420 PRINT:PRINT
2430 END
```

STEPS OF THE GAME

1. RECEIVE NEW ORDERS FROM THE CAPITAL SECTOR INTO THE BACKLOG
   Transfer the markers that represent NEW ORDERS from the Capital Sector into the left half of the box containing the BACKLOG OF UNFILLED ORDERS. Count the total BACKLOG OF UNFILLED ORDERS from Capital Sector and write this number in row 1 under the appropriate year of the Record Sheet.

2. RECEIVE NEW ORDERS FROM THE GOODS SECTOR INTO THE BACKLOG
   Turn over the top card on the deck that represents orders from the Goods Sector. From your supply off the Playing Board take the indicated number of markers and place them in the right half of the box containing the BACKLOG OF UNFILLED ORDERS. Count the total BACKLOG OF UNFILLED ORDERS from Goods Sector and write this number in row 2 under the appropriate year of the Record Sheet.

3. CALCULATE DESIRED PRODUCTION
   Desired production equals the total BACKLOG OF UNFILLED ORDERS from both the Capital Sector and the Goods Sector: (row 1 + row 2) on the Record Sheet. Calculate this number and write it in row 3 under the appropriate year of the Record Sheet.

4. COUNT THE CAPITAL STOCK
   Count the total number of markers in the CAPITAL STOCK box, and write this number in row 4 of the Record Sheet. This number equals production capacity for the current 2 year period.

5. PLACE ORDERS FOR NEW CAPITAL STOCK
   Evaluate your production capacity, estimate future depreciation of capital stock, and look at your desired production. Then decide how many new units of CAPITAL STOCK you wish to order. Take the markers that represent this number from your supply off the Playing Board and place them in the box for NEW ORDERS-Capital Sector. Write the amount of your order in row 5 of the Record Sheet.

6. CALCULATE PRODUCTION
   Production is the smaller of desired production (row 3) and production capacity (row 4). Write this number in row 6 of the Record Sheet.

7. CALCULATE DEPRECIATION
   Each period one-tenth of the markers in the box holding the CAPITAL STOCK, rounded to the nearest 10 units, are removed from the Playing Board to represent the effects of depreciation. Calculate and then write in row 7 the number of CAPITAL STOCK units that depreciate during this period. Then remove these markers from the CAPITAL STOCK box and place them in your marker supply off of the Playing Board. These markers should be recycled for use in placing new orders from the Goods Sector and the Capital Sector, Steps #2 & #5, in future periods of the game.

8. CALCULATE SHIPMENTS TO THE CAPITAL STOCK

Every period the CAPITAL STOCK and the Goods Sector both receive a share of the period's production that is proportional to each sector's respective fraction of orders in the box containing the BACKLOG OF UNFILLED ORDERS. Thus the shipments to increase the CAPITAL STOCK in each period equal:

$$\frac{\text{Backlog of the Capital Sector (row 1)} * \text{Production (row 6)}}{\text{Desired Production (row 3)}}$$

Calculate the number of units shipped to the CAPITAL STOCK this period. Then remove this number of markers from the left half of the box containing the BACKLOG OF UNFILLED ORDERS from the Capital Sector. Transfer these markers via the Production box to the box holding the CAPITAL STOCK. In row 8 of the Record Sheet write the number of goods in this shipment.

9. CALCULATE SHIPMENTS TO THE GOODS SECTOR

Every period the shipments to the Goods Sector equals:

Production (row 6) - Shipments to the Capital Stock (row 8)

Calculate the amount of these shipments this period and then write the appropriate number in row 9 of the Record Sheet. Remove this number of markers from the right half of the box holding the BACKLOG OF UNFILLED ORDERS from Goods Sector and transfer them off the Playing Board via the Production box. These markers should be recycled for use in placing new orders from the Goods Sector and the Capital Sector, Steps #2 & #5, in future periods of the game.

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To initialize the Playing Board before starting the game:

- color the four circles of the marker key different colors to indicate the denominations of the markers or place markers of different colors on each of the circles,
- place a marker representing 50 orders in the Playing Board rectangle representing New Orders - Capital Sector,
- place the deck with 70 orders face down in the Playing Board rectangle representing New Orders - Goods Sector.