Forrester, Jay W.: Correspondence, 1973-1979

Massachusetts Institute of Technology
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JAN 3 1979

January 2, 1979

Jay W. Forrester
Germeshausen Professor

Professor Carroll Wilson
E40-159
M.I.T.

Subject: February visit of David Sternlight

Dear Carroll:

I hope it can be arranged for Sternlight to visit with us again when he is here in February on your coal study.

The following times in February I have other commitments:

Friday, February 2 in the afternoon
February 5-7 (I could probably arrange to free up either the 5th or the 7th if necessary and if I know the proposed dates by the middle of January.)
Wednesday, February 14
Thursday, February 15 in the morning

Other times in February are now free. We can make a final check on dates when you see the probable time that is shaping up.

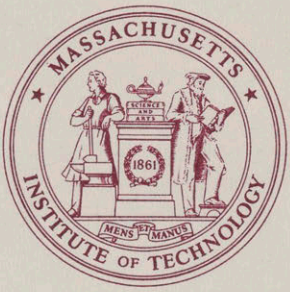
Sincerely yours,

Jay

1/25/79 Gave Sternlight Date & JWF

JWF/cdk

THE SYSTEM DYNAMICS NATIONAL MODEL



SYSTEM DYNAMICS GROUP

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Cambridge, Massachusetts 02139

SYSTEM DYNAMICS GROUP

Faculty

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Nathaniel J. Mass, Director of National Modeling Project
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Graduate Students

Homayoon Dabiri
Nathan Forrester
Mark Paich

Throughout the world economic behavior is baffling businessmen, politicians, the press, and the public. Economic difficulties are resisting conventional cures. The complexity of a national economy eludes explanation by traditional economic analysis. Because there is no unifying theory, each economic symptom is attacked separately: corrective actions frequently defeat one another. But in the last few years, methods have been developed that show how business and governmental policies interact to modify economic behavior.

THE SYSTEM DYNAMICS NATIONAL MODEL

System Dynamics is a method for organizing knowledge of economic structure and policies into a computer simulation model. Decision-makers in business and public affairs possess a vast amount of correct information about organizations and the reasons for particular decisions in the operating world of business and politics. Until recently, it has not been possible to use the wealth of practical information in an analysis of economic behavior. But it is now possible to show that readily available information about the parts does explain behavior of the whole.

The System Dynamics National Model, developed at M.I.T., brings the structure and decision-making processes of an economy into the laboratory where behavior can be studied and the effect of alternative policies evaluated. The National Model portrays movements of people, production of goods, consumption of materials and energy, setting of prices and wages, flows of money, management of inventories, and responses to available information.

STRUCTURE OF THE NATIONAL MODEL

The System Dynamics National Model replicates the ways sectors of an economy are interconnected and managed. The Model will include fifteen production sectors, each resembling the structure of a business firm with acquisition of labor and other factors of production, management of backlogs and inventories, handling of accounts payable and receivable, generation of balance sheet and profit and loss, borrowing and saving, and price setting.

Production sectors:

Consumer durables
Capital equipment
Housing
Resources
Services
Military operations
Government service
Knowledge (education and new technology)
Self-provided family services
Soft goods
Agriculture
Energy
Transportation
Construction

Each production sector will use twelve factors of production including labor, professionals, capital equipment, new technology, buildings, land, transportation, services, energy, and materials. People in the production sectors are divided into labor and professionals, and for each category a labor mobility network generates movement in response to differences in wages, labor supply, job openings and unemployment payments.

In addition to the fifteen production sectors, the National Model includes specialized sectors for other social and economic functions.

* Household consumption sectors are divided into economic categories, and each sector has income and savings, borrows money, and consumes goods and services.

* The financial sector of the Model represents commercial banking, long-term business loans, mortgage loans, savings, and the Federal Reserve.

* The government sector generates government services, tax rates, government expenditures, transfer payments, and bond sales.

* The foreign-trade sector represents external markets and sources of imported materials, resources, and energy.

* The demographic sector, by generating age distribution, permits evaluation of policies relating to private retirement plans and Social Security.

Several years have been devoted to the design and testing of sectors, both separately and in combination. The Model has now been sufficiently refined to begin policy analysis simultaneously with further evaluation and improvement of the Model.

POLICY ANALYSIS USING THE NATIONAL MODEL

The System Dynamics National Model has been developed for evaluating the impact of alternative policies on economic and social behavior. The results of policy analysis are often unexpected. Some policies that excite much political controversy can be shown to have little effect, while the most influential policies have often been overlooked.

Although the National Model is not yet fully assembled, the present partial model is suffi-

ciently comprehensive for study of important economic issues and for testing related policies.

The National Model now exhibits the several dynamic behavior patterns that have been studied and debated in the economic literature, including the ordinary business cycle of 3 to 7 years duration, the Kuznets cycle of 15 to 25 years, and the long wave or Kondratieff cycle spanning some 45 to 60 years. Analysis of the following issues lies within the scope of the National Model at the present time.

Major Depressions Deep economic depressions have occurred in the 1830s, 1890s, and 1930s, and are the low points in the long wave or Kondratieff cycle of economic activity. The National Model has already provided a theory of how the long wave can occur. It is a process involving buildup and collapse of capital-producing sectors in the economy with related disturbances in prices, interest rates, debt, and financial stability. Conditions in the 1970s are in some ways like those in the 1920s and correspond to behavior generated by the National Model at the peak of the long wave. The Model can now be used to evaluate policies for alleviating long-wave imbalances in liquidity, employment, and relative sizes of different sectors in the economy.

Energy Prices and Supply Energy as energy, energy prices, and energy availability all circulate separately in the Model. The Model handles both the supply and demand for energy, and allows energy to interact with other factors of production so that trade-offs among factors like energy, labor, and capital can take place. The Model permits evaluation of policies that affect price and supply of energy in terms of how they affect employment, prices, and standard of living.

Monetary Policy Preliminary investigations suggest that monetary policy may be less important in the business cycle and more important in the longer modes of fluctuation than has been previously believed. In the National Model it is possible to try alternative monetary policies to test their effect on unemployment and inflation.

Inflation No consistent theory exists to integrate the many economic interactions in the inflation process. By tying together the diverse forces related to inflation, the National Model can now be an effective tool for determining how different policies can contribute to the control of inflation.

Other important policy areas for which the National Model is designed include:

The effect of wage and price controls
Taxation
Productivity
Fiscal Policy

Energy imports
Shift between energy sources
Economic growth
Agriculture supports and acreage limits

Balance of payments and exchange rate
Retirement plans and Social Security

The National Model will make it possible to see for the first time how a change in any one economic or social policy produces responses throughout the system. Just as importantly, the Model will demonstrate which changes have a lasting effect and which induce self-defeating compensations.

SPONSORING THE NATIONAL MODEL

Over the years, corporations, government agencies, foundations, and individuals have contributed to support of the System Dynamics National Model. Sponsors have recognized in the Model a unique concept which could have a major impact on both private and public decision-making. The National Model Project needs continuing support to increase staff, begin analysis of alternative national policies, and continue assembly and refinement of the Model. In addition to financial assistance, Sponsors participate in the program in a number of ways:

Sponsors receive advance copies of papers and reports.

Sponsors attend semiannual meetings for presentation of reports on progress and results of the Project.

Sponsors participate in the research through a review of assumptions in the National Model, and make suggestions for improvement.

Sponsors may make special arrangements to place a representative with the System Dynamics Group for a period of training.

Sponsors are the first to acquire insights growing out of the National Model for their own guidance and to become a channel of communication to business, government, and the public.

Sponsors of the System Dynamics National Model contribute to a program which can substantially improve our society's prospects for the future. The challenge is to identify and emphasize those actions that enhance the prospects for the decades ahead.

AMONG THOSE WHO HAVE SUPPORTED THE SYSTEM DYNAMICS NATIONAL MODEL

Corporations:

American Telephone & Telegraph
Commercial Union Assurance Companies
Corning Glass Works
Digital Equipment Corporation
Equitable Life Assurance
Joy Manufacturing Company
Internationl Business Machines
Kollmorgen Corporation
MITRE Corporation
Monogram Industries
Motorola
Pratt & Whitney
Signode Corporation
SmithKline

Government

National Science Foundation
Michigan Department of Labor
with Michigan State University
National Center for Productivity and Quality of Working Life

Foundations

Cummins Engine Foundation
General Electric Foundation
General Motors Foundation
Garvey Kansas Foundation
Frederick Henry Prince Trust
Independence Foundation
Joseph & Helen Regenstein Foundation
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Rockefeller Brothers Fund
Ruth & Vernon Taylor Foundation
W.E. Upjohn Institute for Employment Research
Alex C. Walker Foundation
Zaffaroni Foundation

(Sponsors, continued)

Individuals

Mr. T.J. Coolidge, Jr.
Mr. Kenneth J. Germeshausen
Mr. John A. Harris IV
Dr. Alan F. Kay
Mr. Jean D. Lebel
Mr. Phillip H. Smith

RELATED READINGS

(Available from the System Dynamics Group)

Articles:

"The System Dynamics National Model: Understanding Socio-Economic Behavior and Policy Alternatives," Jay W. Forrester, Nathaniel J. Mass, and Charles J. Ryan, *Technological Forecasting and Social Change,* July 1976.

"Business Structures, Economic Cycles, and National Policy," Jay W. Forrester, *Futures,* June 1976.

"Changing Economic Patterns," Jay W. Forrester, *Technology Review,* Volume 80, Number 8, August/September 1978.

Interview with Jay W. Forrester, *Fortune,* January 16, 1978.

"Growth Cycles," Jay W. Forrester, *De Economist,* Nr. 4, 1977.

"Economic Perspective," Jay W. Forrester. Reprinted from "The Changing Environment for Industrial Enterprise" reporting A Symposium for the International Press Sponsored by Sperry Rand Corporation, March 1977.

Special Papers:

"Energy Policy," Jay W. Forrester, February 6, 1979, D-3017-2.

"The System Dynamics National Project Annual Report 1976," System Dynamics Group, M.I.T., December 1976.

"Capital Formation and the Long Wave in Economic Activity," Report on a Meeting of Corporate Sponsors of the System Dynamics National Project Held at M.I.T. on March 11, 1977.

Congressional Testimony

"An Alternative Energy Policy," Jay W. Forrester, Testimony before the Subcommittee on Energy and Power, U.S. House of Representatives Commerce Committee, June 1, 1977, D-2717.

"Understanding the Changing Basis for Economic Growth," Jay W. Forrester, Opening Statement for a Hearing of the Joint Economic Committee, U.S. Congress, November 10, 1976, D-2514-1.

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May 10, 1979

369-9372

Notes for Carroll Wilson
From: Jay W. Forrester
Date: December 28, 1978

RBF should consider participating again in supporting the System Dynamics National Model being developed by Professor Jay W. Forrester at M.I.T. The project was originally undertaken at the suggestion of RBF from which came initial funding of $800,000 to launch development of the National Model. Since that time, financial support has been diversified to a group of 25 sponsors that include corporations, foundations and private individuals. Among the corporate sponsors are AT&T, IBM, General Motors, Cummins Engine, Merrill Lynch and Motorola.

Until a year ago, staff of the Project were creating the basic computer model to show how corporate, consumer, and political activities combine to produce business cycles, depressions, and inflation. Now, enough of the National Model has been assembled to permit the Project to address important economic issues. Two areas of practical interest are already being investigated.

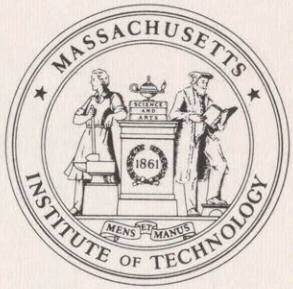
First, the National Model generates the economic long wave that appears to have caused recurring great depressions at 45-to-60-year intervals like those of the 1830s, 1890s, and 1930s. As shown in the Model, a peak in the long wave is a time of falling return on investment, declining new investment, rising prices, slowing of the rise in labor productivity, faltering of new technical innovation, and increasing severity of business cycles. Such are today's economic symptons. The National Model is clarifying the major economic issues that now dominate the press and politics.

Second, the National Model is being used to clarify the confusing issues surrounding inflation. At the last semiannual meeting of Sponsors of the National Model, recent work on inflation was presented. Many in the audience said it had provided the clearest picture yet available of the forces surrounding inflation. Uniqueness of the National Model lies in showing how pieces of the inflation puzzle fit together. The Model demonstrates how an increase in money supply beyond the rate of increase in real output is the only factor that can lead to sustained inflation. All other alleged causes of inflation, like upward pressure on wages by unions, rising oil price, and government deficit can produce internal distortions in the economy but, by themselves, cannot produce sustained inflation. What the other factors can do is to produce pressures like unemployment, tight liquidity, and a decline in production that are then interpreted by government as justification for increasing the money supply. But the Model also shows how increasing the money supply can accentuate the very conditions that were expected to have been relieved. For example, low liquidity becomes an argument for more money, but the resulting inflation can drive up prices somewhat more than the money supply has increased, with a consequent worsening of liquidity. Results from the National Model make clearer the reasons why wage and price controls fail to yield long-term control of inflation. Also, from work on the National Model, the presumed unfavorable trade-off between unemployment and inflation is seen to have very little foundation. It appears that a negligible social price need be paid to stop inflation.

Progress on understanding the economy through use of the National Model is being restricted by available funding. Furthermore, substantial

skilled staff time is being diverted to seek continuity of funding. RBF could have a major impact on understanding inflation and policies to control inflation, the effect of alternative energy policies on future evolution of the economy, and policies to alleviate unemployment by once again supporting the National Model.

NATIONAL DYNAMICS PROJECT
SPONSORSHIP PROGRAM



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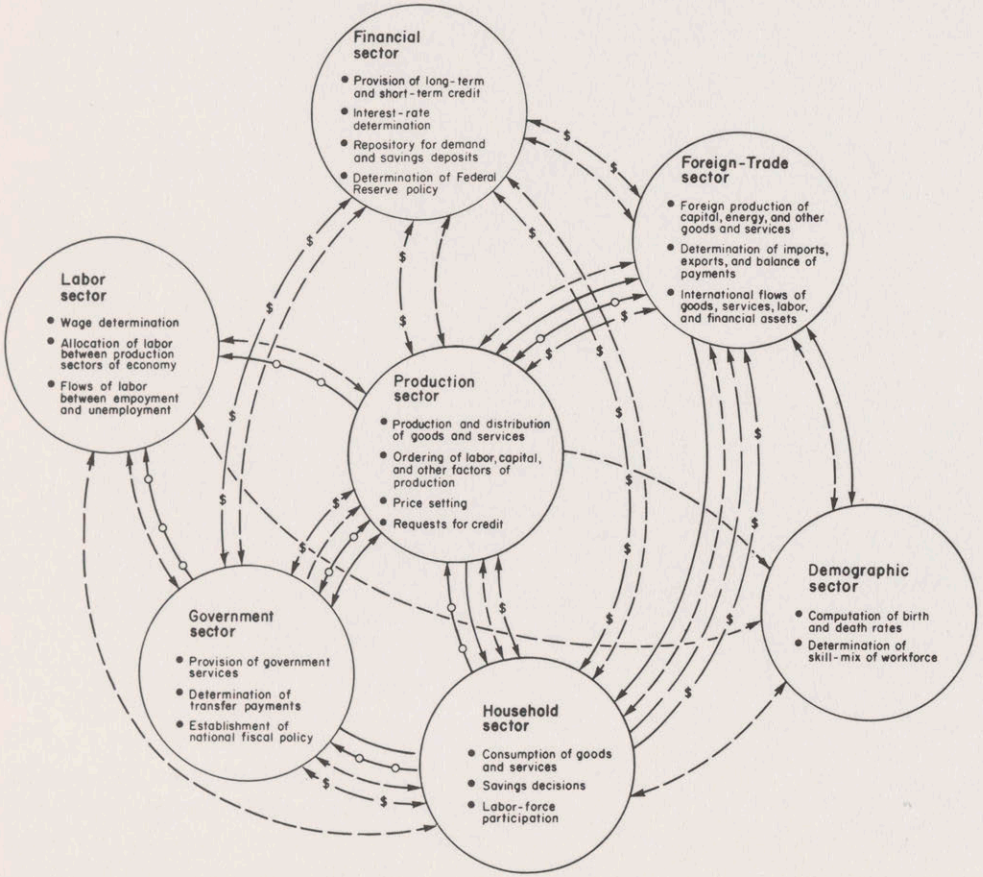
Financial sector
• Provision of long-term and short-term credit
• Interest-rate determination
• Repository for demand and savings deposits
• Determination of Federal Reserve policy
Foreign-Trade sector
• Foreign production of capital, energy, and other goods and services
• Determination of imports, exports, and balance of payments
• International flows of goods, services, labor, and financial assets
Labor sector
• Wage determination
• Allocation of labor between production sectors of economy
• Flows of labor between empoyment and unemployment
Production sector
• Production and distribution of goods and services
• Ordering of labor, capital, and other factors of production
• Price setting
• Requests for credit
Demographic sector
• Computation of birth and death rates
• Determination of skill-mix of workforce
Government sector
• Provision of government services
• Determination of transfer payments
• Establishment of national fiscal policy
Household sector
• Consumption of goods and services
• Savings decisions
• Labor-force participation
$

CONTENTS

THE NATIONAL DYNAMICS PROJECT

The national economy has reached a baffling degree of complexity. Business men, government officials, and economists lack agreement on social and economic policies. When unemployment and inflation became serious in the early 70's, they were considered short-term phenomena to be treated with policies that increased government spending and regulation. Although the economy has recently improved, many people expect inflation, unemployment, energy shortage, and environmental issues to endure as long-term difficulties. In the face of tightening interrelatedness in the economy, the public, business executives, and political leaders have become less able to perceive a future path for the nation.

The National Dynamics Project at M.I.T. is building a new kind of foundation for understanding the performance of the economy and creating a tool for testing the socio-economic impact of proposed policy alternatives. The Project is based on the system dynamics approach to problem solving which integrates the major elements that interact to produce social and economic change. The system dynamics methodology centers around feedback loop structures—circular chains of cause and effect—that govern behavior of systems over time. In addition to incorporating measured economic variables, more intangible variables such as social values and attitudes are also included. The National Dynamics Project is directed toward understanding the socio-economic system through assembling individual sectors, incorporating their dynamic interrelationships, revealing the way policies and laws affect behavior, and assessing short-term and long-term effects of alternate public and private policies.

By participating as a Sponsor of the National Dynamics Project, corporations and individuals can join with the System Dynamics Group at the Sloan School at M.I.T. to:

- improve understanding of economic behavior
- inform citizens regarding economic issues
- generate clearer economic insights for corporate decisions
- recommend more stable and effective government policies

Since 1972, the M.I.T. System Dynamics Group, under the leadership of Professor Jay W. Forrester, has been investigating social and economic change in the United States. Building on methods developed during the last two decades for analyzing social and industrial systems, the National Dynamics Project is working toward a better understanding of how the economy functions. The result should be an improved ability to assess desirability of alternative national policies and business decisions.

The National Dynamics Project is part of a broader program that includes:

- applying the methods of system dynamics to improving corporate policies
- educating students in system dynamics principles
- extending earlier system dynamics applications in urban behavior, population and food problems, and the criminal justice system
- introducing system dynamics as a unifying structure in the educational system, even as early as the elementary grades
- developing additional theory and concepts about behavior of complex social systems

The five-year first phase of the National Dynamics Project has been supported by grants from foundations, corporations, and individuals. To date, the Project has been planned, technical approaches have been established, skilled staff has been assembled, detailed structure of the System Dynamics National Model of the economy has been developed, most subsectors of the Model have been formulated, subsectors have been individually tested, and assembly of the Model is under way. Already, provocative new insights are emerging and the national press has begun to follow developments in the Project.

The National Dynamics Project is now being expanded to include:

- evaluation of policy alternatives
- continuing development of the National Model to broaden the scope of policy issues to which it can be applied
- assembling a group of participating individuals and organizations to provide advice on direction of the work, and to act as channels for dissemination of results
- making available to the public a series of paperback books on dynamic behavior of the economy and on the short-term and long-term effects of important policy choices
- suggesting directions for governmental action
- providing a framework and long-range view for private-sector decisions

THE NATIONAL MODEL

The National Dynamics Project is organized to create, interpret, and use the System Dynamics National Model of social and economic behavior in the United States. The National Model is entirely different from the econometric models commonly used in government and industry; it is built on a far more comprehensive information base; it combines short-term issues with long-term consequences; it spans from internal corporate structure to governmental policy; and it represents not just money equivalents in the economy but also the "real" flows of people, goods, information, capital equipment, land usage, resources, materials, and energy.

The National Model is a dynamic, disequilibrium, simulation model that integrates the activities of corporations, labor, financial institutions, government, foreign trade, and households. The model portrays flows of information, money, people, products, services, materials, energy, and orders. Production sectors represent:

- energy
- resources
- agriculture
- capital equipment
- military equipment
- secondary manufacturing
- consumer durable goods
- consumer soft goods
- consumer services
- governmental services
- technology
- construction
- transportation

Factors of production used by each production sector include:

- capital
- labor
- professionals
- services
- land
- materials
- technology
- energy
- transportation
- buildings

Each production sector generates price, inventory, order backlogs, and profitability out of conditions within the sector and between sectors. Each sector maintains profit-and-loss and balance-sheet information, saves and borrows money, and computes profitability. Market clearing depends not only on price but also on availability.

By reaching from the fine detail of industrial organization to national monetary and fiscal policy, the National Model encompasses the micro and macro elements which make up the structure of the economy. In addition to conventional economic variables, social variables (like expectations, values, affluence, technology, labor mobility, and social stress) permit a realistic analysis of issues such as employment, inflation, resource scarcity, capital accumulation, energy availability, population, and economic growth.

A demographic sector generates birth and death rates and age distribution of population to allow the Model to be used for examining questions that have been raised about future financial stability of Social Security and private pension plans. Environmental limits can be introduced in energy and resource sectors and in land availability to answer questions about how growth will interact with geographic restraints. New technology arises within a sector generating education and research. Price changes, wage setting, and money flows are included. Consumption sectors buy goods, food, services, housing, energy, and transportation.

METHODOLOGY

The National Project is based on the system dynamics approach to understanding social systems. System dynamics has been under development at M.I.T. since 1956. It has been applied to corporate policy, urban growth and stagnation, and world pressures arising from population, food shortage, pollution, and energy depletion.

In a system dynamics analysis, a computer simulation model is created from the rich store of human observations and descriptive information about structure and policies in a social system. Principles from the field of feedback systems theory are used to select and organize available information. The resulting "model" then allows a computer to play the roles of many parts of the system to show how parts interact in producing behavior seen in actual systems. Reasons for previously puzzling behavior are exposed. Proposed new laws, programs, and policies can be tried in the computer model as a preview of how the policies would affect the actual system.

OBJECTIVES

Because of its comprehensive structure, the National Model is a central vehicle through which the National Project can address a wide variety of issues. The number of areas and the rapidity of progress depends on financial support for an adequate staff.

Typical issues to be treated by the National Dynamics Project can be roughly divided between public policy and private sector decisions. The following are examples of major policy areas within the scope of the Project:

PUBLIC POLICY

Simultaneous inflation and unemployment have contradicted earlier economic theory. But explanations seem to lie in social changes, growing size of government, expanded public transfer payments, and the possibility of a major 50-year capital-sector cycle in the economy. The National Model contains structures for exploring these issues and identifying more effective policies.

Growth into environmental limits is exerting new social and economic pressures that are poorly understood. The National Model allows testing of various assumptions about capital investment, changing extraction costs, and improving technology to help resolve present controversies.

Business cycle fluctuations have been growing in amplitude since 1965. Preliminary work with the National Model suggests reasons for a worsening business cycle. Further studies should lead to policy recommendations for greater stability.

Viability of retirement plans and Social Security are open to doubt as age distribution changes along with inflation, government borrowing, and altered growth patterns. The National Dynamics Project can examine these interactions to help understand where present government policies are apt to lead, to revise those policies, and to establish a convergence between expectations and reality.

Energy policy remains unresolved because energy is so interwoven with every aspect of the economy that alternative proposals cannot be evaluated effectively by debate and compromise. The National Model has an energy-producing sector, generates energy price, and represents demand for energy in production and household sectors of the economy. The Model should show both short-term and long-term responses to proposed energy policies as a guide to national and corporate action.

Balance of payments and exchange rates can be related to inflation and domestic standard of living by adding foreign sectors to the National Model. Domestic and foreign policies can then be examined in the context of their effect on one another.

PRIVATE-SECTOR DECISIONS

Intensive use of capital plant to replace labor in production has increased for several decades. But continuation of such a trend may not be appropriate if unemployment persists, energy prices remain high, and if a decline in the long-term capital-investment cycle shifts relative costs in favor of more labor-intensive production. Some of the present social and economic crosscurrents seem to be arising from such changes, and the behavior can be clarified to give a better basis for corporate decisions.

Interest rates have been shifting rapidly in response to changing social and economic forces. Historically, interest rates have risen to sharp peaks some 45 to 60 years apart. A better understanding of the short-term and long-term influences on interest rate would assist in corporate investment decisions.

Accumulation of debt is becoming unmanageable in some states and municipalities. Growing consumer and corporate debt may likewise become depressive. Debt at all levels from the individual to the national government becomes increasingly important in private business decisions. The National Model can be used to examine dynamics of rise and fall in debt, defaults, and effects of debt on growth in the private sector.

The Kondratieff 50-year cycle is potentially of major significance to the capital sectors of the economy and to all investments in buildings and machinery. The long capital-investment cycle is a critical subject for immediate research because of its likely relevance to present behavior of inflation, unemployment, interest rates, and private sector investment.

Agricultural trends toward less farm labor, more capital equipment, and more energy consumption may reverse in the face of social, economic, and environmental changes. The consequences will be felt in all sectors of the economy and are important to long-range business planning.

STAFF AND BUDGET

The National Dynamics Project now has a staff of twelve professionals plus support personnel. The professional staff members have substantial experience in the system dynamics field and most have been working on the National Model for the last four years. The present staff is a solid core group around which to add the new activities necessary for evaluating policy and disseminating results.

Expenditure rate on the National Project is now about $600,000 per year. That level of funding must continue during the next three years to support completion and testing of the National Model. Beyond that time, a group of about the same size will be occupied on the National Model with changes, new ideas, and responses to outside suggestions for improvement. In addition, two staff groups are now needed, one for policy analysis, and another for lectures, writing, and meetings with individuals, public groups, and government representatives. Expansion of the budget for the Project from the present level will be required to support the activities of policy analysis and communication of results.

PARTICIPATION BY SPONSORS

By sharing in financial support of the National Dynamics Project, sponsors will be playing a major role in achieving a better understanding of social and economic behavior in the United States. They will be helping to insure that more effective governmental policies are followed in the future, that the public comes to a better understanding of economic behavior, and that a broader framework of economic insights is available as a basis for private-sector decisions.

In addition, sponsors will benefit to the extent that they choose to participate directly in the National Dynamics Program. Involvement will vary according to wishes of the sponsor and can include:

- receiving advance copies of papers ahead of the usual publication delays
- attending semi-annual meetings of sponsors for presentation of progress and findings
- participating intensively in the research through detailed review of assumptions in the National Model and suggestions for improvement
- arranging special opportunities for stationing a representative of the sponsor with the National Dynamics Project for training in and contribution to the program
- acting as a channel of communication to bring results of the Project to the attention of government officials and the public

A coalition of sponsors participating with the System Dynamics Group at M.I.T. should substantially improve prospects for the future. Every present action contributes to shaping that future – some actions exert influence toward a better future but some do the opposite. The challenge is to identify and emphasize those actions that enhance prospects for the decades ahead. By creating a means for better evaluation of policy choices and a basis for improved public understanding, we can work together for better guidance of national affairs.

For additional information contact:

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617-253-1577

Related readings available on request:

"Business Structure, Economic Cycles, and National Policy," by Jay W. Forrester, *Business Economics,* vol. 11, no. 1, January 1976, pp. 13-24.

"Modeling Cycles in the National Economy," by Nathaniel J. Mass, *Technology Review,* vol. 78, no. 5, March/April 1976.

"System Dynamics and the National Project," by Jay W. Forrester, Nathaniel J. Mass, and Charles J. Ryan, *Technological Forecasting and Social Change,* vol. 9, no. 1/2, July 1976.

"Counterintuitive Behavior of Social Systems," by Jay W. Forrester, *Technology Review,* vol. 73, no. 3, January 1971; also in *Collected Papers of Jay W. Forrester,* The MIT Press, Cambridge, Massachusetts, 1975.

Industrial Dynamics, by Jay W. Forrester, The MIT Press, Cambridge, Massachusetts, 1961.

Economic Cycles: An Analysis of Underlying Causes, by Nathaniel J. Mass, The MIT Press, Cambridge, Massachusetts, 1975.

May 1978

FORTUNE
January 16, 1978

A Difference of Opinion

We're Headed for Another Depression

"The long wave is a process in which the capital-goods sectors grow to a size that cannot be sustained and then collapse."

A Difference of Opinion

We're Headed for Another Depression

Back in the Twenties, the Russian economist Nikolai Kondratieff collected and published a set of statistics which seemed to indicate that all capitalist countries were subject to fifty-year cycles of growth and decline. He predicted the Great Depression, but because his long-wave theory suggested that capitalism would bounce back, it was heresy to Marxists, and Kondratieff ended up in Siberia. His theory was little better received in the West. Now, with the world economy recovering rather slowly from a severe recession, Kondratieff is gaining some converts.

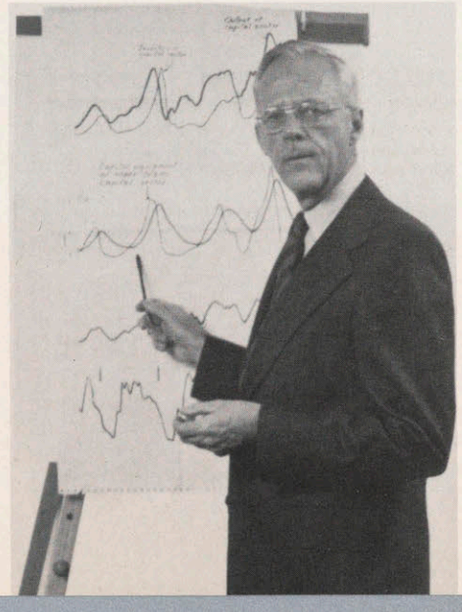
One believer is Jay W. Forrester, who invented the random-access magnetic memory for computers and who is into a second career, examining the dynamics of social and economic behavior. A professor of management at the Massachusetts Institute of Technology and a member of the Club of Rome, he developed the computer models used in that now-famous volume, *The Limits to Growth*, and in his own *Urban Dynamics*. More recently, Forrester and his associates have put together a new model of the U.S. economy which suggests, he says, that we have again passed the peak of a "Kondratieff wave" and, if current policies prevail, will probably face a prolonged period of economic doldrums.

It seems rather a big jump from designing computers to disinterring the theory of a defunct Russian economist. How did you happen upon the work of Nikolai Kondratieff?

For the past two decades we have been developing a field called system dynamics using computers to simulate the behavior of complex systems. We found that the interactions between consumer sectors and capital-goods sectors can produce a long fluctuation of economic activity spanning forty-five to sixty years. The behavior was much like that described in the literature for the Kondratieff cycle. The cycle tends to exhibit a long growth phase for some thirty years, a rapid decline in capital spending occurring in a few years, and a decade of stagnation before the next growth phase starts.

The dynamics of the long wave can be seen by starting with the industrial economies in 1945. After the Great Depression and World War II, every aspect of capital plant was inadequate. Consumer durables, housing, office buildings, factories, transportation systems, and schools were old and inadequate. To rebuild the depleted capital stock in a short time, like twenty years, construction rose to a rate higher than would be needed in the long run to compensate for physical depreciation. And when adequate capital plant had been created, a time that may have occurred in the 1960's, tremendous forces persisted to sustain the process of capital accumulation. The result has been an unbalancing of the system, with too much capital and too much debt. Eventually, momentum falters as capital plant becomes more and more excessive. It is probable that enough capital plant now exists to sustain output for at least a decade with little additional investment.

But many people think that we have not an excess of capital but rather a capital shortage right now. How does this square with your notion that we are well on the road to 1929?



Those who see a capital shortage are looking at a few special industries or are simply extrapolating attitudes of the last three decades about growth in capital plant. I don't share the widespread expectation that the resumption of business investment will solve the existing economic problems. The current slowdown in investment is attributed by many to a lack of confidence. But that lack of confidence is produced by the underlying facts. Return on gross investment has been declining for the past decade and there is no longer a significant risk premium for investment. And as you look around the economy, there is a strong tendency toward excess capacity; you see it in office buildings, in the steel industry, and in airline seats. New tankers have been coming out of the shipyards and going immediately into lay-up. College graduates, who represent investment in human capital, find it increasingly difficult to get jobs.

You are aware, of course, that most academic economists don't give much credence to Kondratieff's theory.

Most academic economists still think only in terms of the short-run business cycle, to which they attribute almost all variations in economic behavior. This is perhaps natural. Business cycles are familiar; most people have experienced several, and changes during the business cycle occur fast enough to be readily observed. But familiarity is not equivalent to importance. As the business community and governmental authorities become more interested in the long-wave phenomena and as the evidence becomes more clear, I think economists will take the existence of a Kondratieff wave more seriously. Also, as we develop a theory of how the long wave is generated, evidence from real life becomes

more understandable and persuasive.

Are you predicting then that the world is about to tumble into a 1930's-style depression?

Not necessarily. As we see it, the most basic characteristic of the long wave is a process in which the capital-goods sectors grow to a size that cannot be sustained and then collapse. But collapse does not always take the same form.

What actually happens depends on how the country reacts. I don't see the outcome as necessarily disastrous. It need not even reduce our standard of living if we understand the process and learn to encourage necessary changes rather than stand against them until the economy develops great internal stress. But if government actions are counterproductive, as I think has often been the case in the past, then the down phase will be one much like the Thirties—a time of great economic and social distress.

I think it is likely that the classical levers of monetary and fiscal policy are unable to deal with the kind of unemployment that comes from long-wave behavior. One might be able to sustain a peak period of production for two or three additional years by forceful use of monetary and fiscal mechanisms, but the result will only be a steeper drop when the inherent pressures accumulate. So the real trade-off of activist policies will not be between unemployment and inflation but between temporary and long-range solutions.

If you can't reduce unemployment by conventional economic policies, what can you do?

The most fruitful policies would probably be in the area of manpower allocation. We are beginning to examine alternative policies with respect to how people can be encouraged rather than inhibited in moving to sectors where there can be economic opportunity. People who are becoming unemployed in the capital-goods sectors probably cannot remain effectively employed in those sectors. If the country tries to solve such long-term unemployment through unemployment compensation and welfare, it will trap a whole generation of people as wards of the state.

The long wave is clearly coupled with major changes in technology. A unique technological infrastructure goes with each succeeding wave. For example, the infrastructure that supported railroads was incompatible with the one that grew up around airplanes. It is not possible to change that social and economic infrastructure quickly.

Historically, the down-slope of a Kondratieff wave has been a period in which the economy extracts itself from the old technology by using up the old capital plant, while the up-slope has been a period of rebuilding along new technological lines. The social and economic policies that will help alleviate the distress of the downturn might be ones that start the rebuilding earlier than would happen naturally.

For example, the kind of issue that now arises can be seen in the debate on energy. For several years there has been a controversy about whether or not a new energy system could be built without robbing capital-creating capacity needed by industry. One of the arguments against aggressive construction of a new kind of energy-producing system was that the economy cannot produce the necessary capital plant. But the concern is groundless if the capital sectors are no longer needed for the present industrial infrastructure.

So we face a major policy dichotomy: Does the government support those who are becoming unemployed in the capital sectors with welfare and unemployment compensation, or does it do what is done in wartime and redirect that capital-producing capability into an area that we are going to need in the future?

Does your theory have any message for corporate managers?

Those managers that still have room to maneuver should be reducing indebtedness and putting themselves in a position where they have future flexibility. Capital-goods producers in particular have a problem of deciding where they are going to go in the near future. Simply trying to hold on to a situation that is no longer viable may well be a losing battle. Rather than trying to simply perpetuate the past, they should look twenty years ahead and see the kind of economic activity into which they could fit; they should try to lay the groundwork for a future compatible with the next long wave of capital creation and the new technological infrastructure that replaces the present one.

For example, General Motors went into the development of diesel locomotives around 1930, an investment that did not begin to pay off until after the Depression. One must look for a degree of innovation comparable to the development of television when radio was the major source of entertainment, or the development of the airplane when railroads were still the most important means of transportation. Those who correctly look across into the next technological upswing will be the ones who lay the foundations for success. Those who look across incorrectly and back the wrong vision of the future will be in difficulty.

The pressures are going to make people feel that they have short-range problems that must be solved immediately, when the real message is that they should take a long-range view.

Do you have any idea of the technological basis for the next major wave?

I am no more sure of the shape of the next technological wave than other people. I expect that energy will move toward renewable and more decentralized sources, not only because of the nature of new energy sources, but because of changes in our social system. If our society goes to still bigger and more centralized energy sources, as we have been doing in the past, we will produce a more and more vulnerable socioeconomic system. I expect that declining worldwide political stability with in-

creasing unrest and sabotage will combine with the persuasiveness of decentralized energy sources—like solar and wind power and alcohol from farm products—to encourage decentralization. Energy networks with larger and larger power plants are not, I think, the wave of the future.

Likewise, I believe we are at the end of the pendulum swing toward a tightly integrated world economy. Many stresses are now arising from excessive international coupling. Countries will realize that they can't solve all their problems outside their borders. Hence, the natural drift of political forces will be toward more economic nationalism. Now that is not necessarily bad. It will bring problems down to a more manageable scale. If individual countries can't understand and manage their economies, I doubt the likelihood of managing all countries simultaneously.

If the industrialized countries enter a decade of economic weakness, what will be the political effects? The Thirties, after all, were a period of great instability.

If the country moves into a major economic dislocation without public understanding of why problems are occurring, there may well follow a breakdown of political stability. A succession of progressively deeper recessions could lead to even greater mutual accusations between government, business, and the public. Actually, no one group is causing the problems. The stresses arise from how the socioeconomic system has been functioning. Every segment of society has had a hand in creating that system. The group here at M.I.T. working on the System Dynamics National Model hopes to contribute thoughts and suggested alternative policies.

In reality, much conflict between the interests of different groups arises from misunderstanding. There is every reason for government, corporations, and labor to move in the same direction. But this requires a public grasp of the real nature of our economic distress. Rather than battles over ideologies and interests, what we need is a constituency for the future. F

January 2, 1979

PERSONAL

Mr. William M. Dietel
President, Rockefeller Brothers Fund
1290 Avenue of the Americas - 34th floor
New York, New York 10020

Dear Bill:

Enclosed is my letter to Nelson. I've omitted the SCEP, SMIC and WAES reports because these are on the shelves at RBF. I have included with your copy the report of the first WOCO meeting in Aspen including the list of participants and purposes as well as the Shell Briefing Service Summary of the WAES report.

It took most of the letter to lay out my estimate of the importance and relevance today the SCEP, SMIC, WAES, WOCO style process for dealing with important national or global issues. I did have my first experience in this process in the special studies project of the Rockefeller Brothers Fund twenty years ago.

I decided that the most effective thing I could do would be what I have said towards the conclusion about Jay's work. Enclosed is a memo Jay gave me plus the current packet of information about the national model and its sponsors.

I am off to Europe to visit WOCO teams in Denmark, the Netherlands, Germany, France and the U.K. returning on the 18th. I hope there may be a future opportunity to explore further my suggestion that the Fund sponsor and provide seed money for such enterprises applied to other subjects and also in order to develop successful entrepreneurs who can succeed in organizing and directing such projects. WOCO may be the last one for which I take central responsibility.

With best regards.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosures

Notes for Carroll Wilson
From: Jay W. Forrester
Date: December 28, 1978

RBF should consider participating again in supporting the System Dynamics National Model being developed by Professor Jay W. Forrester at M.I.T. The project was originally undertaken at the suggestion of RBF from which came initial funding of $800,000 to launch development of the National Model. Since that time, financial support has been diversified to a group of 25 sponsors that include corporations, foundations and private individuals. Among the corporate sponsors are AT&T, IBM, General Motors, Cummins Engine, Merrill Lynch and Motorola.

Until a year ago, staff of the Project were creating the basic computer model to show how corporate, consumer, and political activities combine to produce business cycles, depressions, and inflation. Now, enough of the National Model has been assembled to permit the Project to address important economic issues. Two areas of practical interest are already being investigated.

First, the National Model generates the economic long wave that appears to have caused recurring great depressions at 45-to-60-year intervals like those of the 1830s, 1890s, and 1930s. As shown in the Model, a peak in the long wave is a time of falling return on investment, declining new investment, rising prices, slowing of the rise in labor productivity, faltering of new technical innovation, and increasing severity of business cycles. Such are today's economic symptons. The National Model is clarifying the major economic issues that now dominate the press and politics.

Second, the National Model is being used to clarify the confusing issues surrounding inflation. At the last semiannual meeting of Sponsors of the National Model, recent work on inflation was presented. Many in the audience said it had provided the clearest picture yet available of the forces surrounding inflation. Uniqueness of the National Model lies in showing how pieces of the inflation puzzle fit together. The Model demonstrates how an increase in money supply beyond the rate of increase in real output is the only factor that can lead to sustained inflation. All other alleged causes of inflation, like upward pressure on wages by unions, rising oil price, and government deficit can produce internal distortions in the economy but, by themselves, cannot produce sustained inflation. What the other factors can do is to produce pressures like unemployment, tight liquidity, and a decline in production that are then interpreted by government as justification for increasing the money supply. But the Model also shows how increasing the money supply can accentuate the very conditions that were expected to have been relieved. For example, low liquidity becomes an argument for more money, but the resulting inflation can drive up prices somewhat more than the money supply has increased, with a consequent worsening of liquidity. Results from the National Model make clearer the reasons why wage and price controls fail to yield long-term control of inflation. Also, from work on the National Model, the presumed unfavorable trade-off between unemployment and inflation is seen to have very little foundation. It appears that a negligible social price need be paid to stop inflation.

Progress on understanding the economy through use of the National Model is being restricted by available funding. Furthermore, substantial

skilled staff time is being diverted to seek continuity of funding. RBF could have a major impact on understanding inflation and policies to control inflation, the effect of alternative energy policies on future evolution of the economy, and policies to alleviate unemployment by once again supporting the National Model.

January 2, 1979

Professor Jay W. Forrester
Room E40-253
M.I.T.

Dear Jay:

Enclosed is my letter to Nelson Rockefeller in response to his request to me of December 1. I wished to use this opportunity not only to put forward the merits of RBF support of WOCO but also to urge the consideration of initiatives in sponsoring SCEP, SMIC, WAES, WOCO style enterprises.

It then seemed best to call his attention to the maturity of your project in the last few paragraphs.

I have sent a copy of this to Bill Dietel plus your memo to me and the material you sent to me.

I hope this will open the door again.

As you know, Nelson's general attitude is one of belief in our surmounting any obstacle if we work hard enough at it. Thus he didn't like "Limits to Growth" at all and he may not like the long wave either.

In view of Bill Dietel's strong interest and support of your work I am confident that he will make a good case for it.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

WOCO WORLD COAL STUDY

Carroll L. Wilson, Director
MIT, E40-159
Cambridge
Massachusetts 02139

Telephone: (617) 253-3418
Telex: 92-1473

January 2, 1979

Dr. David Sternlight
Chief Economist
Atlantic Richfield Company
515 South Flower Street
Los Angeles, CA 90071

Dear David:

A couple of weeks ago I spent an afternoon with Jay Forrester getting up to date on the progress in his national model and the policy exploration which is now possible with its present state of maturity. In particular we talked about the diagnosis of the behavior of the system in relation to inflation.

He has resubmitted a proposal to the Atlantic Richfield Foundation which I enclose and you may already have seen.

I think that it would be very interesting to you to plan to spend a couple of hours with Jay on your next visit in this neighborhood.

As you know, I'm off to Europe to visit our WOCO teams in Denmark, the Netherlands, Germany, Paris and London January 6-18. I expect we should have a meeting of U.S. Associates early in February. I would like to combine this with a time when you could come, when Jay would be here, and when it is otherwise propitious.

Do let me know what your general schedule is so we can build around it.

With best regards.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

January 2, 1979

Professor Jay W. Forrester
Room E40-253
M.I.T.

Dear Jay:

It seemed to me best to take this up through David Sternlight who will be a critical factor in Bradshaw's assessment.

Enclosed is my letter to David. Please also let me know your schedule in February so we can combine these times if possible so that you will be here when we hold the Associates meeting at which David will be present.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

WOCO WORLD COAL STUDY

Carroll L. Wilson, Director
MIT, E40-159
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Massachusetts 02139

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Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

December 21, 1978

Jay W. Forrester
Germeshausen Professor

Dr. David Sternlight
Chief Economist
Atlantic Richfield Foundation
515 South Flower Street
Room 4039
Los Angeles, California 90071

Dear Dr. David Sternlight:

Enclosed are copies of letters and the revised proposal as being submitted to the Atlantic Richfield Foundation.

I hope you continue to feel that this is a significant and worthwhile effort and that you will encourage acceptance.

Please let me know if we can supply additional information. I would like to encourage your visiting us here if you would like to be brought up to date on our work.

Sincerely yours,

Jay

JWF/cdk

enc: copy letter to Mr. Walter Eichner--12/21/78
copy letter to Mr. Robert Anderdon--12/21/78
"Proposal to the Atlantic Richfield Foundation for Policy Analysis Using the System Dynamics National Model," Jay W. Forrester, System Dynamics Group, M.I.T., December 15, 1978, D-2872-2.
"Changing Economic Patterns," Jay W. Forrester, Technology Review, August/September 1978.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

December 21, 1978

Jay W. Forrester
Germeshausen Professor

Professor Carroll L. Wilson
E40-159
M.I.T.
Cambridge, Massachusetts 02139

Dear Carroll:

A few months ago you suggested your willingness to encourage Atlantic Richfield in supporting the System Dynamics National Model. Enclosed is a revised proposal that we are resubmitting after they declined our proposal last spring because of lack of funds in the 1978 budget. At that time David Sternlight encouraged us to resubmit for consideration in 1979. I have written the enclosed letters to Anderson, Eichner and Sternlight.

I do not personally know Thornton Bradshaw. Perhaps it would be appropriate for you to write to him with your own recommendations. The inflation work I discussed with you indicates how the National Model is now making contact with important national issues.

Sincerely yours,

Jay

enc: copy letter to Mr. Walter Eichner--12/21/78
copy letter to Mr. Robert Anderson--12/21/78
copy letter to Dr. David Sternlight--12/21/78
"Proposal to the Atlantic Richfield Foundation for Policy Analysis Using the System Dynamics National Model," Jay W. Forrester, December 15, 1978

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

December 21, 1978

Jay W. Forrester
Germeshausen Professor

Mr. Walter D. Eichner
Executive Director
Atlantic Richfield Foundation
515 South Flower Street
Room 2324
Los Angeles, California 90071

Dear Mr. Eichner:

As I discussed with you by telephone, we are resubmitting our proposal for partial support of the System Dynamics National Model, as suggested to us by Dr. Sternlight after his discussion with you last spring. Enclosed is an informal, original of the proposal from which you can make extra copies. You should be receiving the official copy from our Office of Sponsored Programs.

As you will note, we have reduced the request from $100,000 to $50,000 per year for three years. This reduced amount brings the request into line with the annual amount we are receiving from AT&T, IBM, Cummins Engine Company, and one private individual sponsor.

We would be very pleased if you are able to visit us here so that you may learn more about the work and become better acquainted with our staff. Please let me know if we can provide any additional information that would be helpful.

I am not enclosing this time the appendices mentioned in the proposal. If the earlier copies have escaped, or if you would like additional copies, please let me know, and we will provide what you need.

Sincerely yours,

Jay W Forrester

JWF/cdk

enc: "Proposal to the Atlantic Richfield Foundation for Policy Analysis Using the System Dynamics National Model Project," Jay W. Forrester, December 15, 1978, D-2872-2.
"Changing Economic Patterns," Jay W. Forrester, Technology Review, August/September 1978.
copy letter to Mr. Robert Anderson--12/21/78.

cc: Dr. David Sternlight

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

December 21, 1978

Jay W. Forrester
Germeshausen Professor

Mr. Robert Anderson
Chairman and Chief Executive Officer
Atlantic Richfield Company
515 South Flower Street
Los Angeles, California 90071

Dear Mr. Anderson:

As you will recall, I have spoken with you on several occasions about our work toward a better understanding of economic behavior. The System Dynamics National Model has now reached a point in its development where it is shedding useful light on economic behavior. The future program will be a combination of extending the Model and making progressively more comprehensive use in policy evaluation.

Thus far the National Model has been effective in exploring two important areas. First is the long wave in the economy that we believe accounts for the great depressions of the 1830s, 1890s and 1930s, and shows the underlying reason why these recur at intervals of about 50 years. The second more recent area is in showing how various issues are interrelated in the process of inflation. Inflation was the focal point of discussion at our last semiannual meeting of Sponsors held November 1 and 2. We had about 40 people attending. Many of them said it was the clearest picture of inflation and avenues for control of inflation that they had yet encountered.

Last spring we submitted a proposal to the Atlantic Richfield Foundation for partial support of the work. No action was taken by the Foundation because funds for 1978 had been fully committed. We were encouraged to resubmit.

We are sending a revised proposal to Walter Eichner, a copy of which is enclosed. We have reduced the amount requested from $100,000 per year to $50,000 per year, which brings the amount into line with the level of support we are receiving from several other corporations and from one man who is a Sponsor as a private individual.

We would be greatly encouraged if Atlantic Richfield would join in this effort. I believe that the National Model stands a good chance of explaining many puzzling things now happening in the industrial economies and that the Model is a vehicle for evaluating alternative policies in a persuasive way.

Sincerely yours,

Jay

JWF/cdk

enc: "Proposal to the Atlantic Richfield Foundation for Policy Analysis Using the System Dynamics National Model," Jay W. Forrester, System Dynamics Group, M.I.T., December 15, 1978, D-2872-2.
"Changing Economic Patterns," Jay W. Forrester, Technology Review, August/September 1978.

cc: Mr. T.E. Bradshaw (with enclosures)
Mr. Walter D. Eichner (with enclosures)
Dr. David Sternlight (with enclosures)

8/29/78

file

TEXTRON

Erskine N. White, Jr.
Executive Vice President

Textron Inc.

40 Westminster Street
Providence, R.I. 02903
401/421-2800

August 24, 1978

Dr. Jay W. Forrester
Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts 02139

Dear Dr. Forrester:

This is merely to record, with apologies, receipt of your letter of July 19, and to assure you that it hasn't been thrown into the circular file.

In fact, one of the problems is that I became so intrigued with some of the material you sent along that I neglected even to acknowledge receipt thereof.

We will be back to you again before too long.

Sincerely,

Erskine White

W:d

bcc: Mike Zuck

July 19, 1978

Mr. E. N. White
Executive Vice President
Textron, Incorporated
40 Westminster Street
Providence, R.I. 02903

Dear Mr. White:

I am writing to you as a follow-up to the talk I gave a year ago at the Textron Research Briefing held here at M.I.T. We have not been in touch since the briefing, but perhaps this is an appropriate time to begin a discussion regarding a possible closer association between Textron and the M.I.T. System Dynamics Group.

As you may already know, we have been working during the past six years on the National Dynamics Project. The objective is to interrelate corporate and governmental structure and policies, through the use of a computer model of the national economy, to achieve a better understanding of socio-economic behavior. The system dynamics method we are following is new to economic analysis. It has been developed over the last 20 years for showing how corporate structure and policies produce growth, stability, and changes in market share. The National Model based on the same system dynamics approach is becoming a framework both for a more perceptive choice of national policies and for more effective decisions in the private sector.

As the National Dynamics Project begins to produce early results, the tasks involved in interpreting and communicating our findings place an increasing burden on our limited staff. For this reason, we have recently been augmenting our efforts through a group of corporations and individuals participating as advisors, assisting in financial support, and acting as channels of dissemination for new insights as they evolve. In order to maintain closer contact with the business community, we have initiated a special Sponsors Program for the National Dynamics Project. We would like to invite you to join with us and other Sponsors in working toward improved national policies and a better understanding of the economy as a foundation

for corporate decisions.

The purpose of the Sponsors Program is to:

** Serve as a two-way channel of communication with the business community,

** Help in developing a better public understanding of central economic issues,

** Provide financial support.

Events in the national economy in the last few years have been disquieting to many business and national leaders. Sponsors are finding that participation in the program is helping them to generate clearer economic insights for corporate and business decision-making. Among Sponsors are Cummins Engine Company, IBM, Rockefeller Brothers Fund, Digital Equipment Corporation, Pratt & Whitney, Corning Glass, Commercial Union Assurance Companies, Motorola, and AT&T.

The enclosed brochure gives details of the Sponsorship Program. I am also including some papers that you may have not seen. They describe the scope of our work and may be helpful in your consideration.

As a member of the M.I.T. Industrial Liaison Program, you already have access to the papers and symposia from our work that are made available through that program. Through the System Dynamics Project Sponsorship Program we are suggesting an additional involvement that will include, under the first two items on page 12 of the brochure, more intensive contact through more deta tailed publications and special meetings. The last three items on page 12 are specific to the System Dynamics Sponsorship Program.

My colleagues and I will be pleased to have you join in this effort that we believe is of great importance to the future of this country. Please let me know if we can supply additional information. You may want to come here for more extensive discussion. I await your suggestion for the next step that will help you reach a decision to join with our other sponsors in this undertaking.

Sincerely yours,

JWF/jw

Encls: listed on page 3.

Enclosures:

"Policy Analysis Using the System Dynamics National Model," Jay W. Forrester, Spril 6, 1978, D-2881-1.

Interview with Jay W. Forrester, Fortune, January 16, 1978.

"The System Dynamics National Project Annual Report 1976," System Dynamics Group, M.I.T., December 1976.

"Capital Formation and the Long Wave in Economic Activitiy," Report on a Meeting of Corporate Sponsors of the System Dynamics National Project held at MIT on March 11, 1977.

"Business Structures, Economic Cycles, and National Policy," Jay W. Forrester, Futures, June 1976.

"The System Dynamics National Model: Understanding Socio-Economic Behavior and Policy Alternatives," Jay W. Forrester, Nathaniel J. Mass, and Charles J. Ryan, Technological Forecasting and Social Change, July 1976.

"Understanding the Changing Basis for Economic Growth," Jay W. Forrester, Opening Statement for a Hearing of the Joint Economic Committee, U.S. Congress, November 10, 1976, D-2514-1.

"Economic Perspective," Jay W. Forrester, March 22, 1977, D-2267-1.

"National Dynamics Project Sponsorship Program," System Dynamics Group, MII.T., May 1976.

"Changing Economic Patterns," Jay W. Forrester, May 4, 1978, D-2891-1.

Notes re lunch on the day
of the Textron Research Briefing

June 23 '77

At lunch today I sat between

J. B. Collinson Pres., my left.
E. N. White, Exec. V.P., my right.

of Textron

before my talk to them

JF

Both seem interested in the Nat. Mod. and had read Futures article before my talk.

FORTUNE
January 16, 1978

A Difference of Opinion

We're Headed for Another Depression

"The long wave is a process in which the capital-goods sectors grow to a size that cannot be sustained and then collapse."

A Difference of Opinion

We're Headed for Another Depression

Back in the Twenties, the Russian economist Nikolai Kondratieff collected and published a set of statistics which seemed to indicate that all capitalist countries were subject to fifty-year cycles of growth and decline. He predicted the Great Depression, but because his long-wave theory suggested that capitalism would bounce back, it was heresy to Marxists, and Kondratieff ended up in Siberia. His theory was little better received in the West. Now, with the world economy recovering rather slowly from a severe recession, Kondratieff is gaining some converts.

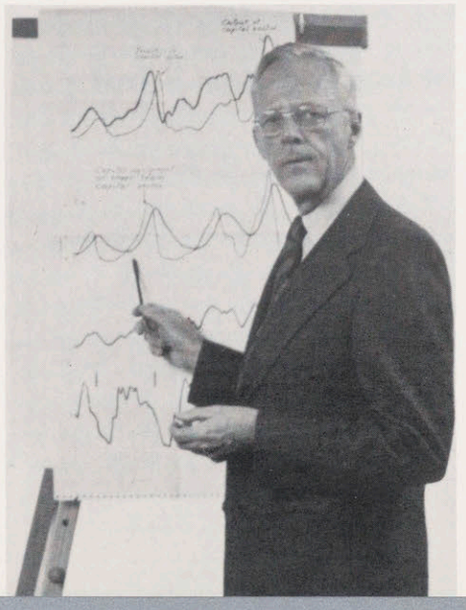
One believer is Jay W. Forrester, who invented the random-access magnetic memory for computers and who is into a second career, examining the dynamics of social and economic behavior. A professor of management at the Massachusetts Institute of Technology and a member of the Club of Rome, he developed the computer models used in that now-famous volume, *The Limits to Growth*, and in his own *Urban Dynamics*. More recently, Forrester and his associates have put together a new model of the U.S. economy which suggests, he says, that we have again passed the peak of a "Kondratieff wave" and, if current policies prevail, will probably face a prolonged period of economic doldrums.

It seems rather a big jump from designing computers to disinterring the theory of a defunct Russian economist. How did you happen upon the work of Nikolai Kondratieff?

For the past two decades we have been developing a field called system dynamics using computers to simulate the behavior of complex systems. We found that the interactions between consumer sectors and capital-goods sectors can produce a long fluctuation of economic activity spanning forty-five to sixty years. The behavior was much like that described in the literature for the Kondratieff cycle. The cycle tends to exhibit a long growth phase for some thirty years, a rapid decline in capital spending occurring in a few years, and a decade of stagnation before the next growth phase starts.

The dynamics of the long wave can be seen by starting with the industrial economies in 1945. After the Great Depression and World War II, every aspect of capital plant was inadequate. Consumer durables, housing, office buildings, factories, transportation systems, and schools were old and inadequate. To rebuild the depleted capital stock in a short time, like twenty years, construction rose to a rate higher than would be needed in the long run to compensate for physical depreciation. And when adequate capital plant had been created, a time that may have occurred in the 1960's, tremendous forces persisted to sustain the process of capital accumulation. The result has been an unbalancing of the system, with too much capital and too much debt. Eventually, momentum falters as capital plant becomes more and more excessive. It is probable that enough capital plant now exists to sustain output for at least a decade with little additional investment.

But many people think that we have not an excess of capital but rather a capital shortage right now. How does this square with your notion that we are well on the road to 1929?



Those who see a capital shortage are looking at a few special industries or are simply extrapolating attitudes of the last three decades about growth in capital plant. I don't share the widespread expectation that the resumption of business investment will solve the existing economic problems. The current slowdown in investment is attributed by many to a lack of confidence. But that lack of confidence is produced by the underlying facts. Return on gross investment has been declining for the past decade and there is no longer a significant risk premium for investment. And as you look around the economy, there is a strong tendency toward excess capacity; you see it in office buildings, in the steel industry, and in airline seats. New tankers have been coming out of the shipyards and going immediately into lay-up. College graduates, who represent investment in human capital, find it increasingly difficult to get jobs.

You are aware, of course, that most academic economists don't give much credence to Kondratieff's theory.

Most academic economists still think only in terms of the short-run business cycle, to which they attribute almost all variations in economic behavior. This is perhaps natural. Business cycles are familiar; most people have experienced several, and changes during the business cycle occur fast enough to be readily observed. But familiarity is not equivalent to importance. As the business community and governmental authorities become more interested in the long-wave phenomena and as the evidence becomes more clear, I think economists will take the existence of a Kondratieff wave more seriously. Also, as we develop a theory of how the long wave is generated, evidence from real life becomes

more understandable and persuasive.

Are you predicting then that the world is about to tumble into a 1930's-style depression?

Not necessarily. As we see it, the most basic characteristic of the long wave is a process in which the capital-goods sectors grow to a size that cannot be sustained and then collapse. But collapse does not always take the same form.

What actually happens depends on how the country reacts. I don't see the outcome as necessarily disastrous. It need not even reduce our standard of living if we understand the process and learn to encourage necessary changes rather than stand against them until the economy develops great internal stress. But if government actions are counterproductive, as I think has often been the case in the past, then the down phase will be one much like the Thirties—a time of great economic and social distress.

I think it is likely that the classical levers of monetary and fiscal policy are unable to deal with the kind of unemployment that comes from long-wave behavior. One might be able to sustain a peak period of production for two or three additional years by forceful use of monetary and fiscal mechanisms, but the result will only be a steeper drop when the inherent pressures accumulate. So the real trade-off of activist policies will not be between unemployment and inflation but between temporary and long-range solutions.

If you can't reduce unemployment by conventional economic policies, what can you do?

The most fruitful policies would probably be in the area of manpower allocation. We are beginning to examine alternative policies with respect to how people can be encouraged rather than inhibited in moving to sectors where there can be economic opportunity. People who are becoming unemployed in the capital-goods sectors probably cannot remain effectively employed in those sectors. If the country tries to solve such long-term unemployment through unemployment compensation and welfare, it will trap a whole generation of people as wards of the state.

The long wave is clearly coupled with major changes in technology. A unique technological infrastructure goes with each succeeding wave. For example, the infrastructure that supported railroads was incompatible with the one that grew up around airplanes. It is not possible to change that social and economic infrastructure quickly.

Historically, the down-slope of a Kondratieff wave has been a period in which the economy extracts itself from the old technology by using up the old capital plant, while the up-slope has been a period of rebuilding along new technological lines. The social and economic policies that will help alleviate the distress of the downturn might be ones that start the rebuilding earlier than would happen naturally.

For example, the kind of issue that now arises can be seen in the debate on energy. For several years there has been a controversy about whether or not a new energy system could be built without robbing capital-creating capacity needed by industry. One of the arguments against aggressive construction of a new kind of energy-producing system was that the economy cannot produce the necessary capital plant. But the concern is groundless if the capital sectors are no longer needed for the present industrial infrastructure.

So we face a major policy dichotomy: Does the government support those who are becoming unemployed in the capital sectors with welfare and unemployment compensation, or does it do what is done in wartime and redirect that capital-producing capability into an area that we are going to need in the future?

Does your theory have any message for corporate managers?

Those managers that still have room to maneuver should be reducing indebtedness and putting themselves in a position where they have future flexibility. Capital-goods producers in particular have a problem of deciding where they are going to go in the near future. Simply trying to hold on to a situation that is no longer viable may well be a losing battle. Rather than trying to simply perpetuate the past, they should look twenty years ahead and see the kind of economic activity into which they could fit; they should try to lay the groundwork for a future compatible with the next long wave of capital creation and the new technological infrastructure that replaces the present one.

For example, General Motors went into the development of diesel locomotives around 1930, an investment that did not begin to pay off until after the Depression. One must look for a degree of innovation comparable to the development of television when radio was the major source of entertainment, or the development of the airplane when railroads were still the most important means of transportation. Those who correctly look across into the next technological upswing will be the ones who lay the foundations for success. Those who look across incorrectly and back the wrong vision of the future will be in difficulty.

The pressures are going to make people feel that they have short-range problems that must be solved immediately, when the real message is that they should take a long-range view.

Do you have any idea of the technological basis for the next major wave?

I am no more sure of the shape of the next technological wave than other people. I expect that energy will move toward renewable and more decentralized sources, not only because of the nature of new energy sources, but because of changes in our social system. If our society goes to still bigger and more centralized energy sources, as we have been doing in the past, we will produce a more and more vulnerable socioeconomic system. I expect that declining worldwide political stability with in-

creasing unrest and sabotage will combine with the persuasiveness of decentralized energy sources—like solar and wind power and alcohol from farm products—to encourage decentralization. Energy networks with larger and larger power plants are not, I think, the wave of the future.

Likewise, I believe we are at the end of the pendulum swing toward a tightly integrated world economy. Many stresses are now arising from excessive international coupling. Countries will realize that they can't solve all their problems outside their borders. Hence, the natural drift of political forces will be toward more economic nationalism. Now that is not necessarily bad. It will bring problems down to a more manageable scale. If individual countries can't understand and manage their economies, I doubt the likelihood of managing all countries simultaneously.

If the industrialized countries enter a decade of economic weakness, what will be the political effects? The Thirties, after all, were a period of great instability.

If the country moves into a major economic dislocation without public understanding of why problems are occurring, there may well follow a breakdown of political stability. A succession of progressively deeper recessions could lead to even greater mutual accusations between government, business, and the public. Actually, no one group is causing the problems. The stresses arise from how the socioeconomic system has been functioning. Every segment of society has had a hand in creating that system. The group here at M.I.T. working on the System Dynamics National Model hopes to contribute thoughts and suggested alternative policies.

In reality, much conflict between the interests of different groups arises from misunderstanding. There is every reason for government, corporations, and labor to move in the same direction. But this requires a public grasp of the real nature of our economic distress. Rather than battles over ideologies and interests, what we need is a constituency for the future. F

12/8/78

Carroll Wilson.

Carroll:

You may be interested in this correspondence with White of Textron before we meet at 2:00 on Tues Dec. 12.

Jay. F.

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

September 14, 1976

Jay W. Forrester
Germeshausen Professor

Professor Carroll Wilson
E40-159

Dear Carroll:

The practice of making presentations to outside groups tends to make us overlook the interests of our colleagues on campus. I would, therefore, like to invite you to the System Dynamics Group's presentation for the Industrial Liaison Program September 22. A copy of the program is enclosed. If you cannot make it for the whole day, you may want to attend the two o'clock talk which discusses the latest work to come out of our National Dynamics Program.

Sincerely yours,

Jay

JWF*eac
Encl: Industrial Liaison Program Symposium: "Socio-Economic Change in Industry and in the Nation"

SOCIO-ECONOMIC CHANGE IN INDUSTRY AND IN THE NATION

Chairman
Professor Jay W. Forrester
Germeshausen Professor
Alfred P. Sloan School of Management

Wednesday
September 22, 1976
Kresge Auditorium
M.I.T.

INDUSTRIAL LIAISON PROGRAM SYMPOSIUM
Massachusetts Institute of Technology

SOCIO-ECONOMIC CHANGE IN INDUSTRY AND IN THE NATION

Businessmen, government officials, and economists all agree that the national economy has reached a baffling degree of complexity. As a consequence of this complexity, we see little agreement on policies to alleviate problems such as inflation and unemployment. This presentation will focus on the National Dynamics Project. The Project is centered around a computer simulation model of the United States economy and is designed to better understand socio-economic behavior and to test the effectiveness of current and future alternative policies. System Dynamics has been used to analyze the behavior of a number of complex social systems and their problems. The Group is best known for its work on industrial, urban, and global dynamic problems. The presentation will include a discussion of the characteristics of complex social systems and the principles by which they are governed. The presentation will also touch on a number of current issues of interest to the public and private sectors, such as inflation, unemployment, recession, long- and short-term economic fluctuations, energy, and capital formation. The objective of the presentation is to show how a better understanding of national socio-economic behavior can be the basis for a more perceptive choice of national policies and form the framework for more effective decisions in the private sector.

Symposium attendance is limited to representatives from member companies of the Industrial Liaison Program. There are no fees associated with this meeting, and lunch is provided.

Notice of plans to attend this symposium should be sent by September 13, 1976, to the Conference Coordinator, Industrial Liaison Office, Room 39-657, M.I.T., Cambridge, MA 02139.

Registration will also be accepted by phone at (617) 253-6190, 6197, and 2691.

AGENDA

SEPTEMBER 22, 1976

8:30	Registration, Kresge Auditorium
9:00	INTRODUCTION
9:15	THE DYNAMIC STRUCTURE OF NATIONAL PROBLEMS Professor Jay W. Forrester
10:00	SYSTEM DYNAMICS IN ELEMENTARY EDUCATION Professor Nancy Roberts
10:30	Coffee Break
11:00	INDUSTRIAL DYNAMICS Professor James M. Lyneis
11:30	THE SYSTEM DYNAMICS NATIONAL MODEL Professor Nathaniel Mass
12:30	Lunch: Mezzanine Lounge, Student Center
2:00	BUSINESS STRUCTURE AND ECONOMIC CYCLES Professor Jay W. Forrester
3:15	SYSTEM DYNAMICS IN GOVERNMENT Professor John F. Collins
4:00	Sherry Hour

9:15
THE DYNAMIC STRUCTURE OF NATIONAL PROBLEMS

Professor Jay W. Forrester
Germeshausen Professor
Alfred P. Sloan School of Management

National problems like inflation and unemployment arise from complex interactions within the socio-economic system. Linear thinking of simple cause and effect must be replaced by recognition of the circular feedback loop structures in which each decision alters the surrounding system that in turn affects future decisions. Such changes in viewpoint underlie the system dynamics methodology that arise from the confluence of traditional management practice, cybernetics, and computer simulation.

10:00
SYSTEM DYNAMICS IN ELEMENTARY EDUCATION

Professor Nancy Roberts
Graduate School of Education, Lesley College

System dynamics is being used in kindergarten and elementary school to integrate levels of learning skills: Knowledge, Comprehension, Application, Analysis, and Synthesis. The system dynamics methodology is simple enough for the children to adopt rapidly. However, it has proven to be powerful enough to greatly facilitate the learning process, while increasing the children's confidence in their ability to understand and influence the world around them.

FUTURE INDUSTRIAL LIAISON SYMPOSIA

Advances in Modern Control Theory. . . . . November 17, 1976

Computer Graphics. . . . . November 23, 1976

Research in Electric Power . . . . . .December 1, 1976

Management of Human Resources:
New Issues and Challenges. . . . . .January 21, 1977
Los Angeles, California

INDUSTRIAL LIAISON PROGRAM STAFF

Professor Samuel A. Goldblith, Director

Mr. Henry B. Barg

Mr. J. Peter Bartl

Ms. Cynthia C. Bloomquist

Mr. Alfred R. Doig, Jr.

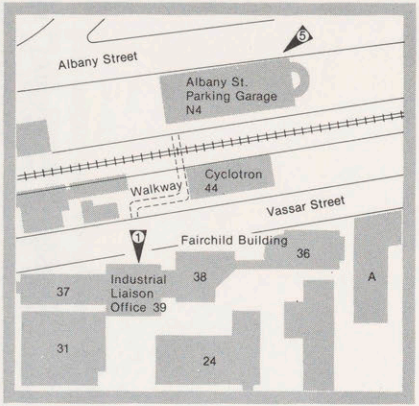
Mr. Eric C. Johnson

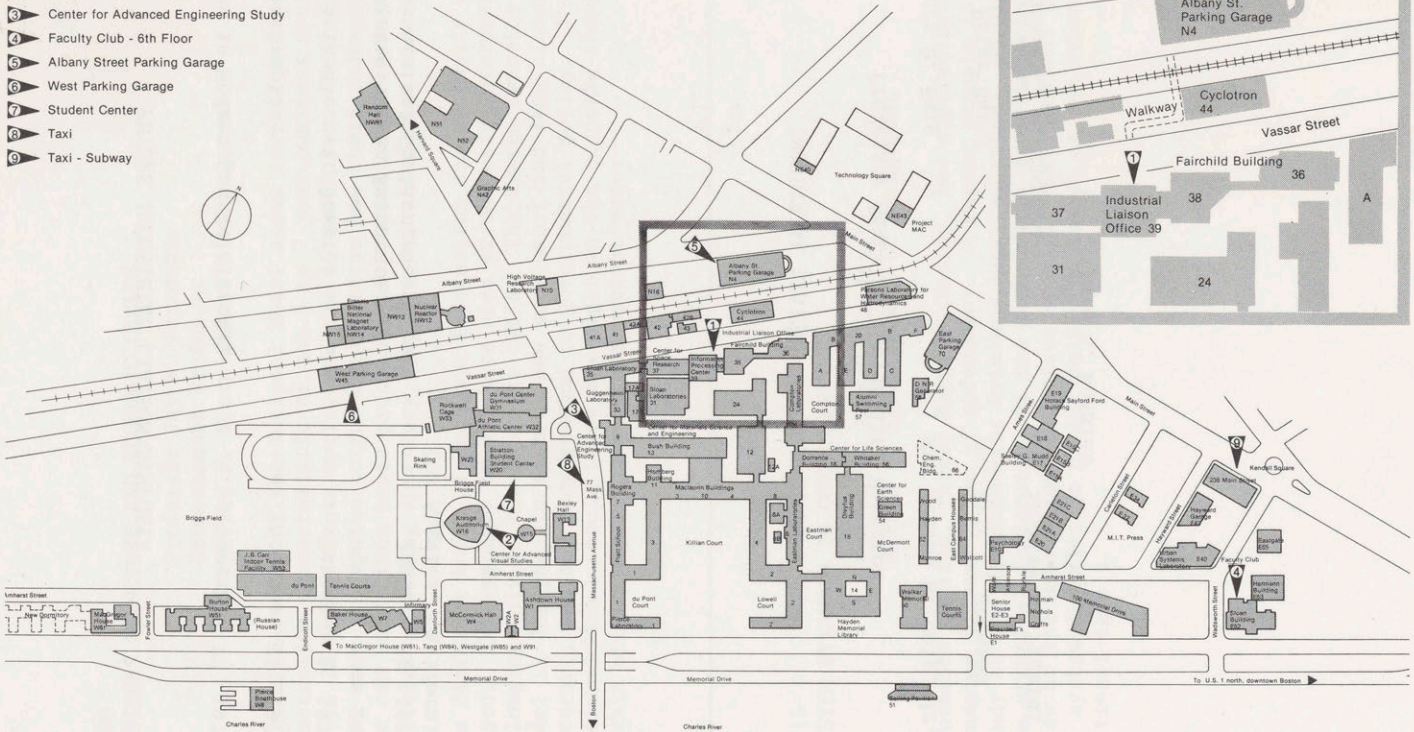
Dr. Shirley M. Picardi

Mr. Arturo A. Rosales

LEGEND

1. Industrial Liaison Office (Room 39-600)
2. Kresge Auditorium
3. Center for Advanced Engineering Study
4. Faculty Club - 6th Floor
5. Albany Street Parking Garage
6. West Parking Garage
7. Student Center
8. Taxi
9. Taxi - Subway





E40-159

October 5, 1975

Professor Jay W. Forrester
E52-454C
M.I.T.

Dear Jay:

Enclosed is a copy of my letter of resignation to Aurelio. I have handled this on a confidential basis because I don't want to cause undue rocking of the boat.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

DEPARTMENT OF ELECTRICAL ENGINEERING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS 02139
36-825

May 23, 1975

C.L. Wilson
Room E40-253

Dear Carroll:

On behalf of the Killian Award Selection Committee, please accept my thanks for your letter seconding the nomination of Jay Forrester for the Award. We considered some fifty nominations; regrettably, there can be only one winner each year! However, the list of nominees we considered, together with the documentation submitted in their behalf, will be transmitted to next year's Selection Committee. Although I have no way of predicting the procedures they will adopt, perhaps a short note from you and David Rose updating the material you have already submitted would be sufficient for renomination.

Again, may we express our appreciation for your thoughtful efforts.

Yours sincerely,

Bill

William M. Siebert
Chm., Selection Committee

WMS:san

Room E40-159

April
~~August~~ 27, 1975

Professor William M. Siefert
Room 36-825
M.I.T.

Dear Bill:

I understand that David Rose has proposed Jay Forrester for the Killian Award.

I regard Jay as one of the real pioneers at M.I.T. who has had the ability and the courage and the persistence to develop wholly new things. First these were in the field of computers and memory units and other things and for the last fifteen years he has been applying systems methodology of a particular kind to social and industrial and management problems.

His current work on the national model of the United States is a major pioneering venture. As such it is criticized by various groups, especially the economists, who have generally not regarded with favor the systems dynamics methodology. Nonetheless I think he is a person of outstanding distinction and in today's world represents a special kind of awareness of the need for applying the best methods arising in the field of engineering to social and economic and political problems.

I am pleased to second the nomination David Rose has made and Gordon Brown has seconded that Forrester be awarded the Killian award.

Sincerely,

CLW:F

Carroll L. Wilson

cc: Dean Gordon Brown
Professor David Rose

INTERDEPARTMENTAL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY *CAMBRIDGE, MASS. 02139*

from the office of Room 4-234

20. March 1975

MEMO TO: Prof. Carroll L. Wilson
Room E40-159

FROM: Gordon S. Brown

Dear Carroll,

Would you care to join the party??

Sincerely,

Barbara

Gordon S. Brown

GSB/bcw

Encl.

Dear File

YPS

DEPARTMENT OF NUCLEAR ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 Massachusetts Avenue Cambridge, Massachusetts 02139

Room: 24-210 (617)253-3807

GORDON S. BROWN

MAR 18 1975

Ref. to_____
File_____

March 17, 1975

Professor William M. Siebert
M. I. T., 36-825
Cambridge, Massachusetts

Dear Bill:

I nominate Professor Jay Forrester for the Killian Award. His contributions in many fields over many years qualify him amply for it.

My association with Jay came in two periods. As you know, he made the first large all-electronic computer, "Whirlwind", here at MIT; it had 50,000 vacuum tubes. In 1949-50, Professor W. P. Allis and I were among the very first users of that computer, and gained valuable insight thereby, on the behavior of plasmas in the presence of space charge.

Visualizing and constructing "Whirlwind" was remarkable enough in itself; but his later switch to global management issues has produced even more remarkable results. Some have held his "World Dynamics" and his protege's "Limit to Growth" in derision, particularly some U. S. economists. The critics are wrong. These works are valued not for the specific mathematical formulations or numbers, but for the concept of limits, the concept that many scenarios go wrong and few go right, and so forth. The energy, food and other resource difficulties we presently witness are evidence that Forrester is basically correct: society thinks it knows how the system works, but in fact it doesn't.

I recognize that Jay's nomination could be controversial, because he is a controversial man. I do not agree with some of his views myself, but that is irrelevant to what we are discussing.

I am sure you could get much more supporting material, such as the circumstances relating to his invention of the magnetic core memory, from Dean Gordon S. Brown, Emeritus, to whom I send a copy of this letter.

Please accept my kindest regards.

Yours sincerely,

David J. Rose
Professor

DJR/p
cc/Dean Gordon S. Brown, Emeritus

Carroll

INTERDEPARTMENTAL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY *CAMBRIDGE, MASS. 02139*

from the office of

Room 4-234

20. March 1975

MEMO TO: Prof. William Seifert
Room 20B-225

FROM: Gordon S. Brown

Dear Bill,

I have just read my copy of Prof. David Rose's letter to you dated March 17th, nominating Jay Forrester for the Killian Award. I consider this nomination very appropriate and wish formally to endorse Professor Rose's action.

I probably know Jay Forrester better than anybody else at M.I.T. I have worked with him since the 1930's. I have in my files a very considerable amount of information about his career, because in varying degree I have been involved in his nominations that led to his receiving the Valdemor Poulsen Gold Medal from the Danish Academy of Technical Sciences, the Medal of Honor from the Institute of Electronics and Electrical Engineers and the Howard N. Potts Medal from the Franklin Institute.

I will furnish your office with alot of relevant information, if you believe that now is the time to document fully the nomination. I am writing you today to endorse Professor Rose's action because it will take me at least several days to extract the other material from my files and send it to you.

Sincerely yours,

Gordon

Gordon S. Brown
Institute Professor
Emeritus

GSB/bcw

c.c. Carroll L. Wilson

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Jay W. Forrester
Germeshausen Professor

June 9, 1975

Mr. Leo Steg
General Electric Company
Valley Forge Space Center
P.O. Box 8555
Philadelphia, Pennsylvania 19101

Dear Mr. Steg:

Thank you for your letter of May 20 letting me know that the Franklin conference publication is on the way.

Regarding the meeting of the Club of Rome in Philadelphia, I have no information about it, nor am I involved in the planning. I am sending your letter and its enclosures along to Professor Carroll Wilson who is a member of the Executive Committee of the Club of Rome. I am sure he will be in touch with you if there is any opportunity to be of assistance. Ordinarily, the Club of Rome meetings have been for members and for certain invited officials. I believe they have not been meetings for presentation of papers that were not a part of the Club of Rome program.

Sincerely yours,

JWF:mu
cc: Professor Carroll L. Wilson

5/22/75

GENERAL ELECTRIC

SPACE DIVISION

SPACE SCIENCES
LABORATORY

GENERAL ELECTRIC COMPANY . . . . . VALLEY FORGE SPACE CENTER
(MAIL: P. O. BOX 8555, PHILADELPHIA, PENNSYLVANIA 19101), Phone (215) 962-2000

May 20, 1975

Dr. Jay Forrester
Professor of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Dr. Forrester:

I want again to express my appreciation for your participation at The Franklin Conference and for preparing the manuscript. I am pleased to say that all the papers are now at the printers and the issue should appear in due course.

I understand from The Franklin Institute that the Club of Rome is planning to hold one of its meetings next year at The Franklin Institute in Philadelphia. My wife, whose field is Philosophy, and some of her associates at Drexel University have followed the work of the Club of Rome with interest over the past few years. Her work in cybernetics and the applications some of her associates have made of it in the field of economics, which have been reported on in her own community, have now reached a phase where I think dialogue with the Club of Rome participants would be mutually beneficial.

I am asking for your help in having an invitation extended to her to participate in the Philadelphia meeting of the Club of Rome, and I am enclosing a resume of her and one of her associates who could also contribute.

Sincerely yours,

Leo Steg

LS:cgl
encl.

PROFESSIONAL RECORD

Doreen R. Steg

Education:

1948	New York University, New York City	B.A., Biology and Chemistry
1951	Cornell University, Ithaca, N.Y.	M.A., Comparative Literature
1955	Albany State Teachers College	Graduate Study (Albany, N.Y.)
1956	University of Pennsylvania,	Graduate Study
1957-59	Philadelphia, Pennsylvania	Frances Sergeant Pepper Fellowship
1959-60	" "	University Fellowship
1962	" "	Ph.D. , Philosophy and Education
1963-64	" "	National Science Foundation Postdoctoral Fellowship

Languages:

French, Russian, German

Professional Experience:

1948-51	Cornell University, Department of Modern Languages	Teaching Fellow, French Language and Literature
1952-54	Cayuga Heights Elementary School, Ithaca, New York	Part-time Faculty, French Teacher
1956-59	Miquon School, Miquon, Pennsylvania	Faculty, French Teacher
1961-62	Cheltenham Senior High School, Wyncote, Penna.	Faculty, French Teacher
1962-63	Temple University, Department: Foundation of Education	Lecturer, Philosophy and History
1963-64	University of Pennsylvania, Department: Philosophy of Education	Lecturer, National Science Foundation Fellow, Philosophy of Education
1964-66	Glassboro State College, N.J. Departments: Philosophy, Human Behavior and Development	Associate Professor (joint appointment) Human Behavior and Development, Philosophy of Education, Philosophy
1966-present	Drexel University, Department of Human Behavior and Development	Associate Professor, Human Behavior and Development
1966-73	" "	Department Chairman
1975	" "	Professor, Human Behavior & Development

Advisory Positions:

1964-68	Advisor	Elsemere Project, Glassboro, N.J.
1971	Advisor	Multi-Media Model High School, School District #1, Philadelphia
1971-Present	Advisor	Remedial Teaching School, 13 Rehov Hess, Tel-Aviv, Israel
1973-75	Board of Directors	MASPES (Middle Atlantic States Philosophy of Education Society)

Editorial Boards:

1971-Present	Editorial Board	"Kubernetes," International Journal of Cybernetics and General Systems, London
1974 - Present	Associate Editor	"Forum," Quarterly Journal, American Society for Cybernetics, Washington, D.C.

Consultantships:

1966-68	Consultant	Philadelphia Board of Education
1967-68	"	Program Development, Philadelphia, Drew and Powel Public Schools (Demonstration and Magnet Schools)
1969-71	"	Federal Design Engineering Company College Point, New York
1971	"	Van Leer Foundation, Special Projects, Jerusalem
1971	"	Evaluation Team of the Vineland Micro Social Learning Center, Vineland, New Jersey, New Jersey State Department of Education
1972-Present	Steering Committee	Kibbutz Project, Van Leer Foundation and Kibbutz Industries
1974	Advisory Board	New Jersey Center for Learning Disabilities, St. Elizabeth College, Convent Station, New Jersey

Department of Human Behavior and Development

Faculty: Six full-time, eight part-time, including two adjunct professors.

Student Body:
200 in departmental majors
700 in college (service courses)
50 in Humanities and Social Sciences (service courses)

Degree Programs Offered by Department:
Bachelor of Science
Master of Science

Majors:

Undergraduate:
Human Behavior and Development
Early Childhood Education
Home Economics Education
Special Education (under consideration)

Graduate:
Human Behavior and Development
Human Behavior and Development for Early Childhood Teachers
Human Behavior and Development for Home Economics Teachers

Special Facility:
Early Childhood Center
An Educational Day Care Program
7:30 A.M. - 5:30 P.M., 12 months/year
(Population 44, ages 2-1/2 to 6 years)
Racially and socio-economically integrated
Half Get Set, half tuition paying
10% severe exceptionalities

Accreditation:
General Program
Middle States Accreditation, 1971
Home Economics Education
Renewed State approval for Teacher Certification Program Certification, 1970 (received maximum renewal--5 years)
Early Childhood Education
Applied for state approval for Teacher Certification Program in 1971. As this is a new certification program for the state, the state is giving no program more than one year provisional approval for first five years. Provisional approval obtained 1971, 1972, 1973 (First Early Childhood Education Program in state with fundamental work in human behavior and development within a Department of Human Behavior and Development).

Curriculum Development:

1953-60		Development of substantive subject matter and methodology in French for ages 3 to 12 years. Program essentially oral-aural.
1966-73	Drexel University	Curriculum development for a new program in Human Behavior and Development. This included planning sequences and syllabi in both theoretical and more applied courses. Both graduate and undergraduate.
1969-70	" "	Curriculum Development Committee
1969-70	" "	Co-operative Education Committee
1970	" "	Committee for the Enhancement of Teaching
1970	" "	Ad Hoc Committee on Hiring, Retention and Tenure
1972	" "	Ad Hoc Committee on Physical Education

Courses Taught 1962-Present:

(Arranged from earliest to most recent)

Graduate	Contemporary Problems in Philosophy of Education
"	Recent Trends in American Education
"	History of American Education
"	Comparative History of Education (France, England, U.S.S.R., Germany and U.S.)
Undergraduate	Ethics
"	Introduction to Philosophy
"	Philosophy and Society
Graduate and Undergraduate	Human Behavior and Development
Undergraduate	Philosophy of Education
"	Psychological Foundation of Education
"	Development of Educational Thought
Graduate	Contemporary Theories of Cognitive Processes
Undergraduate	Concept Formation
Graduate	Value Inquiry
"	Systems Theory
Graduate and Undergraduate	Interdisciplinary Seminar
Undergraduate	Models of Teaching

Papers Presented:

"Directing Educational Leadership Toward Greater Child Orientation," Tri-County Workshop for Principals and Superintendents, Atlantic City, New Jersey, May 1965.

"Cybernetics and Education," Haifa Insitute of Technology (Technion), Haifa, Israel, May 1966.

"Spencer: Science and Ethics," Philosophy and Philosophy of Education Society (Northeastern Division), Philadelphia, Pennsylvania, October 1966.

"On the Use of Cybernetics in Education," American Association of University Professors, New Jersey, 1966.

"On Your Mark, Get Set," Pennsylvania State Teachers Conference, Harrisburg, Pennsylvania, October 1966.

"Education and Training in Early Childhood," Haifa Insitute of Technology (Technion), Haifa, Israel, March 1967.

"Recent Developments in Theories of Cognitive Processes," Workshop for Supervisors, Philadelphia Board of Education, Philadelphia, March 1967.

"On the Place of Reason in Education," Middle Atlantic Society of Philosophy and Education, New York, May 1967.

"The Concept Generation - Will We Be Ready For It?" ABWA, May 1967.

"Philosophy, Cybernetics and Education," University of Tokyo, Japan, May 1967.

"Programmed Instruction," University of Tokyo, Japan, May 1967.

"Some Recent Research in Early Childhood Education," Japan National Institute of Educational Research, Tokyo, Japan, 1967.

"Contemporary Problems in Education," University of Jammu and Kashmir, India, May 1967.

"Responsive Environments and an Early Childhood Center," Delaware Valley Association for Nursery and Kindergarten Education, January 1968.

"Responsive Environment, Learning and the Educational Profession," Responsive Environments Corporation Seminar, February 1968.

"Teleology, Philosophy and Technology," American Association for Mental Disabilities, Baltimore, Maryland, November 1968.

"Learning Disabilities and the Role of Institutions of Higher Education," The Delaware Valley Association for Children with Learning Disabilities, Philadelphia, Pennsylvania, September 1968.

"New Technology in Early Childhood Education," University of Pennsylvania, Philadelphia, Pennsylvania, December 1968.

Papers Presented: (Continued)

"Cybernetics, Responsive Environments and Learning," University of Maryland, December 1968.

"Programmed Instruction," Oranim Institute, Israel, 1969.

"Learning Disabilities and a Responsive Environments," St. Christopher's Hospital, Philadelphia, Pennsylvania, December 1970.

"Research, Development, Dissemination, Evaluation and Social Engineering," American Educational Research Association, Hilton, New York, February 1971.

"Responsive Environment - Current Research," Delaware Valley Association for the Education of Young Children, February 19, 1971.

"Systems Analysis and Child Growth and Development," Van Leer Foundation, Jerusalem, Israel, November 1971.

"Experiments in Responsive Environment at Drexel University," Philadelphia Regional Association for Childhood Education International, Drexel University, Philadelphia, Pennsylvania, November 20, 1971.

"Developments in Home Economics Education," National Association of Teacher Educators for Home Economics Session, American Vocational Association Convention, Portland, Oregon, December 7, 1971 (with L. Pearson).

"Helping Problem Learners During the Early Childhood Years," Presented at the Early Childhood Education II session (C-14), 1972 American Educational Research Association, Palmer House, Chicago, Illinois, April 6, 1972 (with A. D'Annunzio).

"Remarks on the Possible Economic Significance of 'Pre-School' Educational Technology," Conference, April 8, 1972, Drexel University (with R. Schulman).

"Cognitive Development of Young Children," at the Philadelphia Resources for Young Children Workshop, Drexel University Early Childhood Center, The School District of Philadelphia Board of Education and Temple University, Philadelphia, Penna., May 15, 1973.

"System Rules and Ethics, Or On Ethical Choice," (Part I), Technion-Israel Institute of Technology International Symposium, Ethics in an Age of Pervasive Technology, Haifa, Israel, December 20-25, 1974.

"Towards a Modest Empiricism in Human Transaction, Derived From A General Theory of Adapting Behavior," (Part II), Technion-Israel Institute of Technology International Symposium, Ethics in an Age of Pervasive Technology, Haifa, Israel, December 20-25, 1974 (with R. Schulman).

Invitational Seminars:

Departments: Special Education, University of Maryland, 1968.
Bio-Medical Engineering, Drexel University, 1969.
Environmental Sciences, University of Pennsylvania 1970.
Operations Research, University of Pennsylvania, 1971.

"Programmed Instruction," Oranim Institute, Israel, 1969.

"Modeling in the Behavioral Sciences," Eastern State School and Psychiatric Hospital, Trevose, Pennsylvania, January 1970.

"A Cybernetic Model of Thinking: Relevance to Behavior Modification, Teaching Machines and Talking Typewriters," Merck, Sharpe and Dohme Research Seminar, Eastern Pennsylvania Psychiatric Institute, October 1, 1971.

"Cybernetic Model of Learning and Its Use in Learning Disorders," Learning Disorder Workshop of the Regional Council of Child Psychiatry, Narberth, Pennsylvania, February 2, 1972.

"New Perspectives in Education," Departmental Presentation to the 19th Annual Conference of the Pennsylvania Association of Teacher Educators, Seven Springs, Champion, Pennsylvania, 15622, April 25-27, 1972.

"Models in Infant Learning," Week of the Young Child Conference, April 3, 1974, Drexel University.

"New Perspectives in a Responsive Environment," District 1, Staff Development, Philadelphia Public Schools, May 29, 1974.

"The Brain Changers," Board of Education, Philadelphia, Staff Development for Pre-Head Start Program, August 6-7, 1974.

Publications:

D'Annunzio, A. and Steg, D., "Effects of Individualized Learning Procedures on Children with Specific Learning Disabilities," Journal of Developmental Medicine, 16, p.507-512, 1974.

_____, "Effects of Two Programs on Perception and Reading in Kindergarten," International Reading Association, New Orleans, May 1974. Publication due 1975, "A Learning Print Approach Toward Perceptual Training and Reading in Kindergarten."

Schulman, R. and Steg, D., An Interdisciplinary Theory of Adapting Behavior," The Structural Learning Society, April 21, 1974. M. Scandura and H. Durnin, (eds.), Office of Naval Research Technical Report, NR 151-356X, September 1974.

Steg, D. and D'Annunzio, A., "Some Theoretical and Experimental Considerations of Responsive Environments, Learning, and Social Development,"(Proceedings, First International Congress of Cybernetics, London, 1969), J. Rose (ed.), Progress of Cybernetics, New York: Gordon and Breach Science Publishers, 1970.

Steg, D., D'Annunzio, A. and Fox, C., "Deviation-Amplifying Processes and Individual Human Growth and Behavior," World Organization of General Systems and Cybernetics, Blackburn College of Technology and Design, Feilden Street, Blackburn, BB2, 1LH Lancashire, England, August 1972, (Published 1974).

Steg, D., D'Annunzio, A., Moore, O.K. and Schulman, R., "Responsive Environments: Social and Emotional Growth," The American Orthopsychiatric Association, New York, N.Y., May 31, 1973, (Proceedings, 1973).

Steg, D., Mattleman, M. and Hammill, D., "Effects of Individual Programmed Instruction on Initial Reading Skills and Language Behavior in Early Childhood," International Reading Association, 6 Tyre Avenue, Newark, Delaware, April 1969.

Steg, D. and Schulman, R., "A General Theory of Adapting Behavior," Proceedings, 7th International Congress of Cybernetics, Namur, Belgium, 1974, (Publication due 1976).

_____, "Towards a Modest Empiricism in Human Transactions," American Society for Cybernetics, Annenberg School of Communications, University of Pennsylvania, October 31, 1974, (Publication due 1976).

Steg, Doreen R., "Life and Works of Madame de Lafayette," M.A. Thesis, Cornell University, Ithaca, New York, 1951.

_____, "A Philosophical and Cybernetic Model of Thinking," Ph.D. Dissertation, University of Pennsylvania, Philadelphia, Pennsylvania, 1962.

_____, "Some Aspects of Teaching and Learning," Proceedings, Philosophy of Education Society, Southern Illinois University, Edwardsville, Illinois, 1964.

_____, "Systems Rules and Ethics," Philosophy of Education Society, Southern Illinois University, Edwardsville, Illinois, pp.20-25, 1966.

Publications: (Continued)

Steg, Doreen R., "Human Behavior and Development," Laboratory Manual, Drexel Institute of Technology, Philadelphia, Pennsylvania, December 1966, Revised 1971.

_____, "Cognitive Development of Early Childhood," Delaware Valley Association for Nursery and Kindergarten Education, February 1967.

_____, "Experimental Program at Drexel," Delaware Valley Association for Nursery and Kindergarten Education, February 1968.

_____, "A Philosophical and Cybernetic Model of Thinking," International Association of Cybernetics, Palais des Expositions, Place Andre Ryckmans, Namur, Belgium, pp.846-854, 1970.

_____, "The Limitations of Learning Machines and Some Aspects of Learning," Focus on Learning, Volume 1, No.1, Davis Hall, Indiana University of Pennsylvania, Indiana, Pennsylvania 15701, Spring 1971.

_____, "Control Theory, Human Activity and Social Development," International Association of Cybernetics, Palais des Expositions, Place André Ryckmans, Namur, Belgium, 6th International Congress on Cybernetics, Namur, Belgium, 1970, Published 1972.

_____, "Some Thoughts on Thinking in Competency-Based Education," Workshop on Competency Based Teacher Certification, May 4, 1973, Cortland State University of the State of New York Monograph, The State Education Department, Albany, New York.

_____, "Some System Concepts in the Human System and a Review of Some Recent Experiments in Infant Behavior," Proceedings, 7th International Congress of Cybernetics, Namur, Belgium, 1974, (Publication due 1976).

_____, "A Philosophical and Cybernetic Model of Thinking, or A Feedback Analog to Thinking and Some Consequences," Society for Structural Learning, University of Pennsylvania, Philadelphia, Pennsylvania, 1974.

Projects:		Budget:
1966-67 1967-68	Sophistication of Syntactical Structure in Young Children, Co-operative study with D. Hammill (Temple University)and M. Mattleman (Temple University).	
1966 - Present	Responsive Environments Research, Pilot Program, Drexel University (In-House Funding).	
1966 - Present	Director, Responsive Environments Project, Drexel University	
1966-71 1971 - Present	On the Acquisition of Skills Leading to Reading and Concepts in Mathematics in Young Children, Office of Economic Opportunity Department of Health, Education and Welfare, Program support, Drexel University Early Childhood Center	averages $100,000/year
1967	"Operation Alphabet," Home Economics Training Course, Philadelphia County Board of Assistance, Economic Opportunity Act of 1964, Under Title V Project.	
1967 - Present	Development of Training Center for the Early Childhood Center at Drexel University	
1969	Director, Work-Study Pilot Project on "Communal Systems," on location, Kibbutz Maanit, Israel.	
1970	State Interagency 4-C Manpower Training Project, Pennsylvania Department of Education (not funded).	
1970-71	"Research, Development, Dissemination and Evaluation in Education," Department of Health, Education and Welfare.	$38,500
1971	Proposal:Development of Comprehensive Condensed Intercultural Patterns by Training Adult Impoverished Housewives, with R. Schulman (not funded).	
April 8, 1972	Conference: "The Effects of Individual Programmed Instruction and Related Procedures on Psycholinguistic and Perceptual Behavior in Early Childhood Using the Edison Responsive Environment," Responsive Environment Corporation matched funding. (Project Manager)	$3,500
1972	Proposal for Language Arts Center Experimental Model High School (developed at the request of Dr. Marechal-Neil Young, Superintendent, Special Education, Board of Education, Philadelphia).	
1972-74	Monitoring of Head Start Centers, Region III, Office of Child Development. (Project Manager)	$75,000/year
1974	Effects of Oralographic Software and the Edison Responsive Environment on Initial Reading Skills and Language Behavior With a Racially and Socio-Economically Integrated Group of 44 Children, Ages 2.5 to 6, Prentice Hall, Funded July 1974. Software and New Hardware, Responsive Environment: Oralographic Software, ERE_4 (Talking Typewriter), 2 Voice Mirrors, Talking Page (3 New Booths). (Project Director)	$60,000
1975-78	Replication and Extension of an Action Research Project Gauging the Effects of a Technologically Based System on Reading Skills and Language Behavior of a Racially and Socio-Economically Integrated Early Childhood Population. Bernard Van Leer Foundation. (Project Director)	$166,000

Projects: (Continued)

In Progress:

Proposal for Cost-Benefit Analysis of Educational Technology (Technological Assessment and Its Use in Reading), with R. Schulman and A. D'Annunzio. (funded 1977-78)

In Progress:

Effects of Oralographic Software and the Edison Responsive Environment on the Acquisition of Skills Leading to Independent Reading (Fourth Grade Level), and Language Behavior With a Group of Functionally Illiterate Members of the U.S. Armed Forces

Professional Memberships:

Member	National Honorary Society of Biology
"	National Society for the Study of Education
"	Middle Atlantic States Philosophy of Education Society
"	Comparative Education Society
"	John Dewey Society
Fellow	Philosophy of Education Society
Member	American Association for the Advancement of Science
Co-Founder	Society of Philosophy and Philosophy of Education (Eastern Division)
Member	American Association of University Professors
"	New York Academy of Sciences
"	Association Internationale de Cybernetique (president section 1969, chairman U.S. delegation 1975)
"	American Philosophical Association
"	American Society for Cybernetics (Associate Editor, "Forum")
"	NAEYC (National Association for the Education of Young Children)
"	DVAEYC (Delaware Valley Association for the Education of Young Children)
"	OMEP (United States National Committee for Early Childhood Education)
"	SRCD (Society for Research in Child Development)
"	PSEA (Pennsylvania State Education Association)
"	ATE (Association of Teacher Educators)

Professional Listings:

"Who's Who, American Women," since 1970.

"Who's Who in the East," since 1972.

"Who's Who Among Authors and Journalists," 1973.

"American Men and Women of Science," 1973.

International Scholars Directory, 1973.

The National Register of Prominent Americans and International Notables since 1974.

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Philadelphia, Pennsylvania 19130
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Address (Office): 11-507-A Drexel University
Philadelphia, Pa. 19104
Telephone: (215) 895-2125

Education

1934 -- B.A.: Smith College, Northampton, Mass.

1938 -- M.A.: Columbia University, New York, N.Y.

1964 -- Ph.D.: University of Pennsylvania, Philadelphia, Pa.

Positions

1965 -- to Present: Professor of Economics, Drexel University Philadelphia, Pa., College of Business and Administration.

June 1964-1969: Economic Consultant, Joint State Government Commission, General Assembly of the Commonwealth of Pennsylvania.

June 1943-May 1964: National Research Director, Industrail Union of Marine and Shipbuilding Workers of America, AFL-CIO.

October 1943-May 1943: Associate Economist, Shipbuilding Stabilization Committe, War Production Board.

1937-1941: Assisted in preparation of Encyclopedia Britannica-14th Edition.

Publications (Partial Listings)

1943 War Production Board, Shipbuilding Stabilization Committee: Editor: Preliminary Job Descriptions for the Ship and Boat Building and Repair Industry. (Washington, D.C.:G.P.O.)

1943 War Production Board, Shipbuilding Stabilization Committee: The History of the Shipbuilding Stabilization Committee. (Washington, D.C.:G.P.O.)

1943-1946 Revised, 1947 Revised, 1948 Revised, 1949-1963: The Financial Status of the Shipbuilding and Repair Industry. (Camden, N.J.:IUMSWA)

1946 The Story of Shipbuildings Stabilization - a tri partite agreement. (Camden, N.J.:IUMSWA)

--continued--

1946 "The Problem of Productivety Measurement in the Shipbuilding and Ship Repair Industry." Productivity Conference: Proceedings. (Washington, D.C.:G.P.O. October).

1946 "The Use of Corporate Financial Data in Collective Bargaining." Bureau of National Affairs: CBNC 12: 401-408. (Washington, D.C.: BNA, 9/23/46.)

1947 The Nation That Invented the Steamship. (New York and Washington, D.C.: Ratner).

1950 "Technical Memorandum Concerning Computation of the Construction Differential Subsidy" in U.S. Senate, 81st Congress, 1st Session, Committee on Interstate and Foreign Commerce, Sub-committee on Maritime Affairs: Proceedings. (Washington, D.C.: G.P.O. April).

1954 Historical Summary of U.S. Governmental Assistance to the Merchant Marine. (Camden, N.J.: IUMSWA).

1955 "M-Day Requirements for Vessel Construction and Repair," in U.S. Senate, 84th Congress, 1st Session, Committee on Interstate and Foreign Commerce; Proceedings. (Washington, D.C.: G.P.O. April).

1961 Some Observations on Present and Future Business Cycles in the U.S. (Camden, N.J.: IUMSWA).

1962 " 'Absentee ownership' reread," in American Journal of Economies and Sociology. (21:3, 319-330, July).

1968 Economic Growth, for what? (Philadelphia: I-in-A).

1968 New Dimensions in Consumer Education. (Philadelphia: I-in-A).

1969 "Patents, Compulsory Licensing, Prices and Innovation." In The Economics of Drug Innovation. (Washington, D.C.: American University, pp. 213-222).

1971 "The East-West dichotomy of Pennsylvania, (including the increase of Labor vs. capital-intensive industry)" in Pennsylvania Conference of Economists: Proceedings. (Lancaster, June 10).

1972 "Consumer Education for Adults" in AAUW Bulletin. Spring 1972 (Washington, D.C.: American Association of University Women).

--continued--

1972 "Statistical Data and Analysis for Conference on Edison Responsive Environment Machine's Contribution to Reading Readiness," in Department of Human Behavior and Development, Drexel University: Conference on Responsive Environments: Proceedings, April.

1972 "Analysis of Benefits of Educational Increments" in Department of Human Behavior and Development, Drexel University: Conference on Responsive Environments: Proceedings, April.

1972 "Economics of Consumption for a changing Society" Philadelphia,: Drexel University Press.

1973 "Communication and Feedback in the Technology of Consumption". VII the International Congresson Cybernetics.

1973 (Jointly with Steg, D.R.) "A General Theory of Adapting Behavior". VII The International Congress on Cybernetics.

1973 "Economic Significance of Pre-School Educational Technology". American Ortho-Psychiatric Association, Annual Meeting, N.Y.

Listing

Who's Who of American Women

Who's Who in the East

Who's Who in Commerce and Industry

Community Leaders of America

Consultation Work

1964-1969: Joint State Government Commission of the General Assembly of the Commonwealth of Pennsylvania:

December, 1964: The Iron and Steel Industry in Pennsylvania, 1940-1963: A Study of Comparative Regional Economic Factor Determinants.

April, 1965: Freight Transportation in Pennsylvania: An Evaluation of Selected Data Requirements and Availability, and Methods of Collection and Analysis.

March, 1966: Consumer Installment Credit: Economic and Legislative Background and Problems (with Commentary on House Bill No. 2117, Printer's No. 3085, Session of 1965).

April, 1966: Proposed Consumer Installment Credit Legislation: Analysis and Comparison of Senate Bill No. 10 (Printer's NO. 12) and House Bill No. 7 (Printer's No. 7) of the Special Session of 1966, The General Assembly of Pennsylvania.

October, 1968: Interindustry, Interregional Shift in Pennsylvania 1958-1963: A Study of Relative Coefficients of Growth and Ratio Measures of Industrial Performance.

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Bethlehem Steel Company, Shipbuilding Divison, and IUMSWA, AFL-CIO, Human Relations's Committee. Report prepared on Findings of Fact from 1967 Employment Statistics. 1969.

Smith, Kline & French - research requirements for the pharmaceutical industry. 1969.

Pilot Curriculum Development Program for School District of Phila.: "Guide to Consumer Education for Secondary School Students." Pamphlet on "Economic Concepts for Consumer Education." 1969-70.

Advisory Committeees

Advisory Committee to Bureau of Labor Statistics, 1943-64:

Subcommittee on Productivity
Subcommittee on Manpower
Subcommittee on Consumer Price Index
Subcommittee on City Worker's Family Budget
Subcommittee on Consumer Expenditure Survye
Subcommittee on Wages and Working Conditions
Subcommittee on Industrial Hazards

Statistical Advisory Committee to Division of Statistical Standards, Bureau of the Budget, 1943-1964.

1972: Member of Governor Shapp's Advisory Commission on Taxation.

1973: Board of Directors: Jewish Employment and Vocational Service

1972: Philadelphia Council for Equal Job Opportunity

Teaching Activities at Drexel
(other than regular courses in undergraduate and graduate Economic theory)

C-445: Economics of Demand and Consumption.

Analysis of demand and elasticity: Lancastrian characteristic vectors; psychological components of demand; advertising; techniques; comparison of private versus social goods; indifference analysis; Lorenz curves, Gini coefficients, and Pareto curves; patterns of consumption by income class and education of head of family.

C-421: Methods of Urban and Regional Economic Analysis, Terml. Regression; mational input-output; and systems analysis, including operations research, linear programming, and cost-benefit.

C-422: Methods of Urban and Regional Econmic Analysis, Term 2. Demogaphic and emplyment analysis; statistical and mathematical geography.

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C-423: Methods of Urban and Regional Economic Analysis, Term 3.
Area accounting systems; inter-regional input-output, economic base surveys.

C-424: Introduction to Urban Economics.
Income analysis and spatial patterns; theories of urban economic, economic growth, problems and cyclical change.

C-425: Industrial Location and Regional Development.
Theories of location and space economy; firm factor orientation and equilibrium; inter-relation of location and trade theory.

C-426: Urban Growth and Planning.
Development factors; systems of cities; metropolitan form; land and housing market; quantitative models; public policies.

C-427: Regional Economic planning.
Gravity and other models; multlpliers and inter-industry linkage; interregional trade; uses of social accounts; contraints.

C-428: Natural Resource Problems and Policy.
Problems of resource use allocation and trade alternatives; transportation modes; alternative marketing.

C-429: Economics of Social Production.
Social goods (inclusive of utilities) requirments; and accounting, transportation-location cost-benefit analysis; spatial structures of services; area construction analysis, education.

Memberships

AAUW

AAUP

AEA

ASA

IRRA

Regional Science Research Association

International Cybernectics Association

Philadelphia Orchestra Association

Philadelphia Museum Association

Philadelphi Ethical Society

World Affair Council of Philadelphia, (Board Member - 1963-1967)

Phi Beta Kappa

Beta Gamma Sigma

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

System Dynamics Group
Building E40-253

MEMO: D-2183

DATE: April 4, 1975

TO: Rockefeller Brothers Fund Group

FROM: William W. Behrens III

RE: Visit of Sherman Maisel, April 2-3, 1975

Sherman Maisel, past-Governor of the Federal Reserve System (1965-1972) and Professor of Economics at Berkeley, visited the System Dynamics Group on April 2-3, 1975. Our purpose in inviting Professor Maisel was to discuss with him the structure and objectives of the national model, with specific attention devoted to the monetary authority subsector. In addition to meetings with members of our own group, a luncheon discussion was held on April 2 with Franco Modigliani, MIT Professor of Economics; Abraham Siegel, Associate Dean of the Sloan School; and Walter Rosenblith, Provost of MIT. This memorandum summarizes the principal points covered in the two days of discussion.

(i) The importance of external shocks in creating cyclical behavior

Our discussions centered on the relationship between real economic activity (production, ordering of factors, inventories and backlogs) and financial variables (interest rates, money supply, prices).

A question arose as to whether business cycles are the result of the structure that relates inventories, backlogs, factor lifetimes, and factor ordering decisions, or are produced by international, fiscal, and monetary "shocks" to the economy. An example of a fiscal shock would be a sudden tax cut. Professor Maisel argued that the real economy has a natural tendency toward damped oscillation, but that the persistence of business cycles comes from shocks such as the Vietnam War and OPEC oil price increases. He was skeptical that a structure without these shocks would be capable of producing sustained cycles.

In the completed model, we should be sure to allow for the isolation of real phenomena from fiscal and monetary actions. Appropriate use of SWITCH functions would permit us to decouple the real production and ordering processes from the financial flows, and examine independently their behavior.

(ii) The discount rate and reserve ratio as instruments of monetary control

In discussing the functioning of the Federal Reserve in controlling the economy, Maisel pointed out that their principal instrument of control is open-market operations. In general, reserve requirements and the discount rate are not used to pursue policy objectives. He suggested that we might leave out the discount rate entirely, as it has little effect on the financial system and is not an active instrument of monetary

control. He also suggested that the reserve ratio could be left as an exogenous constant. We should consider these two variables as examples of elements that might be left constant for some policy experiments and dynamic for others. Since Maisel is the first to suggest that they be ignored, it is probably premature to remove both the reserve ratio and the discount rate at this time.

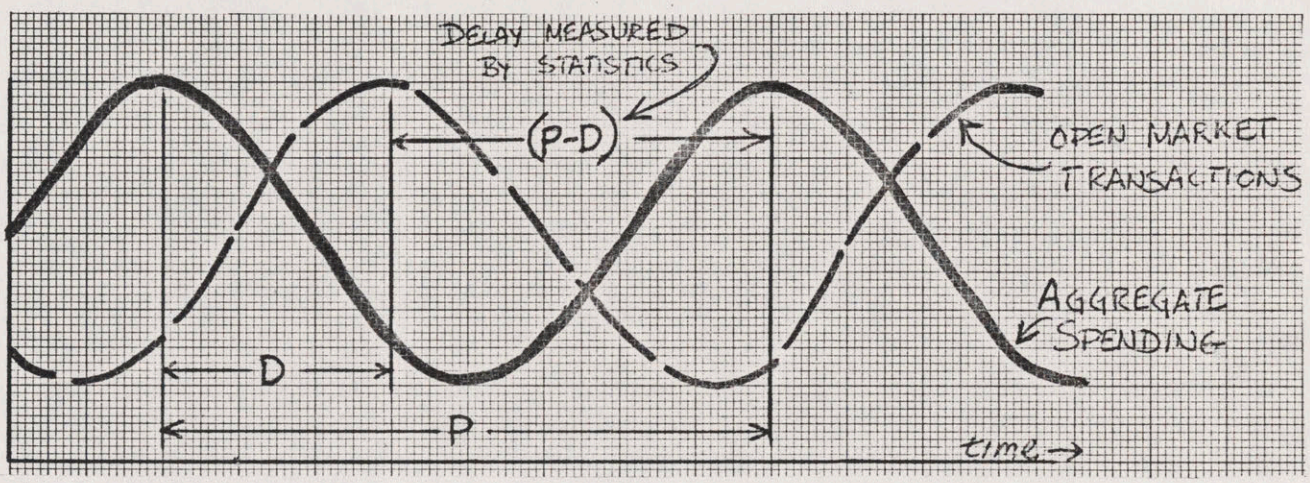
(iii) The goal structure of the monetary authority

Maisel thought that our use of monetary control goals that adapt to ongoing economic conditions (inflation, unemployment) was basically correct, but noted that the Fed's response to deviations from a goal was nonlinear. That is, their response to a 4% gap between actual inflation and their goal is more than twice as strong as their response to a 2% gap. This nonlinearity can be accommodated within the monetary authority structure as it already exists. Maisel also commented that the speed of adjustment of goals to actual conditions probably is itself a variable; incorporating this comment into the model will require some restructuring of the goal formation process as it currently appears in the financial sector.

(iv) Can the effect of open-market decisions on the economy be measured?

In discussing the delay between an action in the open market by the Federal Reserve and its ultimate impact on the economy, Maisel

commented that statistical correlation studies have estimated this delay to be on the order of 2-3 years. It is not clear that the statistical procedures can in fact recover the true delay, or even demonstrate a causal link between open-market operations and the economy. If open-market decisions are themselves responding with a delay D to aggregate spending (which is presumed to be affected by open-market operations), and aggregate spending is oscillating over the business cycle with period P, then the volume of open-market operations will be oscillating with the same period as aggregate spending. Therefore, a measure of the phase shift from open-market operations to aggregate spending may be measuring only (P - D), without there being any effect of open-market decisions on spending. Graphically, this phenomenon would appear as follows:



This specific case of statistical measurement yielding potentially incorrect results should be systematically examined as a separate piece of research. Does the measurement of lags between two oscillating variables yield any information about the direction of causation?

(v) Future cooperation with Maisel

Our discussions with Maisel were quite helpful in thinking about both model formulation and the communication of our efforts to practicing economists. Maisel's Washington experience has clearly left him more receptive to new ideas and approaches than a traditional academic economist. His comments were constructive, and he was quite willing to consider hypotheses that countered economic theory. He seemed interested in the project and wanted to keep in touch with our work. It should be helpful to meet again with Maisel when the multi-sector model with endogenous financial interactions is operative. At that time we could explore in more detail, and with reference to the actual performance of the model, the issues raised in the discussions of the past two days.

WWB/mt

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

System Dynamics Group
Building E40-253

MEMO: D-2183

DATE: April 4, 1975

TO: Rockefeller Brothers Fund Group

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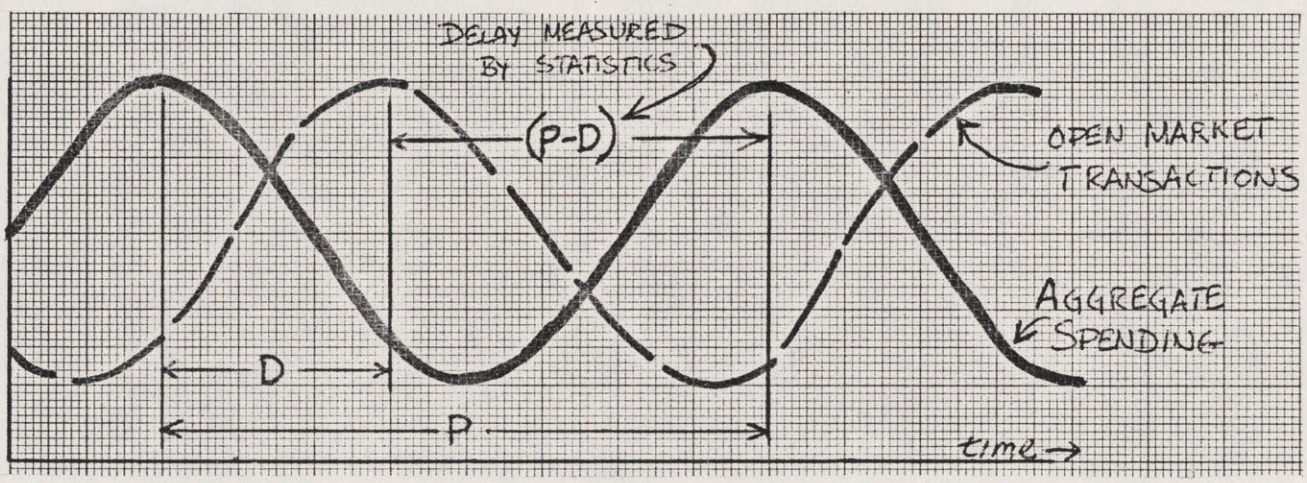

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WWB/mt

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

April 9, 1975

Jay W. Forrester
Germeshausen Professor

To: Carroll L. Wilson

From: Jay W. Forrester

Subject: Further Comments on the Letter of March 24 from Alfred Neal

In my March 31 memo I commented on several points raised by Alfred Neal. You have pointed out that I did not discuss his question about the long time span to which the model is addressed.

As I discussed before, this is not a statistical model drawn from only numerical data. It is a model that describes organization, information flows, and the policies that govern decisions. It generates from such a structure the interactions of people, agriculture, manufacturing, and technological change. It should produce the shifting balances between the different sectors of an economy.

The better the organizational structure and the policies represented in the model, the longer should be the time span over which it will show behavior similar to that of the real economy. There is no necessity for starting the model in the year 1800, it could be 1850 or 1900. However, the earlier it can be started while retaining reasonable behavior, the more persuasive will the model be. We think it is worth a try because little extra effort is involved in the longer time span.

One particular issue of possible importance does require the longer time horizon. As you know, there has been discussion at least since 1920 of a suggested long wave in the economy having some 50 years duration. This is usually called the Kondratieff cycle. The proposition has received little serious attention because it has been seen as a statistical phenomenon but with no hypothesis about underlying cause. We have already found in our new model in the way the capital sector operates a set of relationships capable of producing a strong 50-year cycle having many of the characteristics attributed to the Kondratieff cycle. If further examination points in the same direction, the results could be very important in terms of the possibility of repetition of an economic period like that in the 1930's. To be able to even examine questions of a 50-year disturbance requires a time horizon several times as long in the model.

JWF*eac

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Jay W. Forrester
Germeshausen Professor

March 31, 1975

To: Carroll L. Wilson

From: Jay W. Forrester

Subject: Letter of March 24 from Alfred Neal

Thank you for sharing with me the letter of March 24 from Alfred Neal. It is most helpful to have a clear and explicit written reaction of this kind. Some of his points must be given more consideration in our modeling of social and economic change. Other points seem to arise from our not adequately conveying our meaning. The latter show where we must find better ways of presenting the nature of the new model and its objectives.

As became evident in connection with earlier published system dynamics models, criticisms by readers often mean something different to us than was intended by the critic. The same may happen here. The following comments may not be responsive to the questions that were intended. If so, I hope we can develop a continuing dialog with Neal until communication is solid enough that we can see if important differences remain.

Several comments in the letter suggest that Neal may be thinking more of the conventional econometric model than he is of a system dynamics model of the kind we are developing. His phrases "massive data manipulation," and "there are few consistent and meaningful sets of data," and "comprehensive collection and computer analysis of data" imply the kind of statistical data processing that has indeed shown rather limited effectiveness in guiding national policy. A system dynamics model is very different from an econometric model in source, structure, and use.

A system dynamics model is constructed from the same kind of descriptive information used by the business executive and political leader in reaching decisions. However, in a system dynamics model, more facets of the social system can be handled at once and the assumptions can be made more clear. Through computer simulation the future consequences of the assumptions can be determined with far greater certainty than through verbal debate. The system dynamics approach is an alternative to the econometric modeling commonly used at present.

The country is far from united on economic directions for the future. Most people hope for a better understanding of the national situation and better means of arriving at important decisions. In the present uncertainty, various alternatives should be pursued. The cost of several parallel, and quite different, approaches to understanding the economy is small compared to the magnitude of the national issues being debated. Although we believe we have a high probability of success with the present system dynamics project, even a chance of a few percent for achieving a better understanding of the processes of inflation, unemployment, energy shortage, and growth would seem like a good gamble.

Neal raises the question of exogenous events such as war. Of course, he is correct that important events can lie outside the processes described by the model structure. But I hope he is not implying the converse, namely, that the internal structure of the system is unimportant and without influence. If the latter were true, we would have no need for laws, a Federal Reserve, or Congress, because only accidents and random events would be shaping the future. I am sure he does not mean the internal structure is unimportant, but only that even the best conceivable structure leaves many "happenings" on the outside. He is right that this issue is not covered in the papers he read. The papers focus on the central structure one must have before one is in a position to consider the impact of exogenous events. For the multitude of small exogenous events, we include several random event generators in the model so the behavior of the system can be examined in the presence of uncertainty. For very large and unique events, such as war, the special condition can be imposed on the model to examine both the short-run and long-run reactions. The model we are now working on will have a military sector that engages people, purchases material and equipment, needs food, and interacts with most sectors of the economy. By exogenously imposing a high demand on this sector, it will be caused to draw its requirements from the rest of the economy for its expansion, as does a military mobilization. By watching such an impact on the model, and comparing the model responses with historical responses in the real economy, one can further evaluate the realism of the model and then use it as a tool for examining how the economy responds to such external events. On this matter of endogenous structure versus exogenous events, it would be helpful to discuss the matter with Neal in search of a better compromise than we have thus far chosen. In the past we have found that by putting more behavior into the endogenous structure we rapidly increase the realism and the usefulness of a model.

The comments about growth in my paper seem to disturb Neal. Perhaps this is because of the order in which the paper is arranged. Growth is discussed in the paper before the organization of the model,

maybe giving the impression that the discussion of growth dictates the model structure. The reverse is perhaps more correct. The model, built up from available knowledge about the country, should be used to examine the processes of growth and how growth depends on currently accepted facts and assumptions. For example, the model will contain a land area for the country and a distribution of land quality. As the best agricultural land is utilized, rising demand for food and the necessary use of poorer land would call for more capital investment (irrigation and machinery) and more purchased materials (fertilizer). Similarly, in the energy and resource sectors a plausible assumption (which can be easily changed when someone wants to try an alternative) would be that rising physical capital (equipment) is needed as the natural stocks are depleted and as one must search farther and mine deeper. Such seems usually to have been the case, and some people are now expressing concern that the country may not be able (or willing) to create the physical capital demanded by growing demands on the natural environment. Many people are now asking questions about growth, its processes, and its future. The model should serve for examining a variety of underlying assumptions and their consequences.

I read the question about GNP as a measure of growth as again suggesting that Neal is thinking of the statistical processes used in deriving an econometric model. A system dynamics model does not use time-series inputs, like GNP, as a basis for model construction. Instead, the model can generate, by any definition one likes, a GNP curve as output. The output of the model can then be compared with a correspondingly defined series from the economy. In other words, the real economy does not generate GNP in the same sense that it generates automobiles. GNP is a defined and calculated way of adding automobiles to electricity and to food to get a defined measure of the performance of the economy. In the same way one can combine capital goods, consumer goods, etc., in the model to get a defined measure. GNP may well be a poor measure, but one might still want to define it the same way in the model so there would be a comparable output curve from the model to evaluate against the curve now being computed as a measure of real economic activity. Faster than one can change any such measure in the real economy, one can change the corresponding definition in the model. In the model, as in the measure of the real economy, one only has to specify which of the model variables are to be added up to get the measure.

Neal raises an interesting question about productive versus unproductive activity. But this does not affect the structure of the model, it relates more to how one wishes to interpret the behavior of the economic system and of the model. In the model, for example, the agricultural sector produces food, the durable goods sector produces such things as refrigerators and automobiles, and the government sector produces, without their being separately specified, laws, peace, services, and tax collection. Whether these raise the standard of living as much as

heat and food is a matter of personal interpretation. Much of government expense would seem to be like pollution-control equipment--it is not so much a good in its own right as it is a compensation for a "bad" being produced elsewhere in the system. For example, if crime increases, the cost of law enforcement is a compensation that cancels the "bad" resulting in no net gain in social well being for the two but does result in higher cost. Several published studies show that the per capita cost of running a city rises as the population and population density increase. Neal himself makes the same point when he writes, "there can be genuine concern about the lag in productivity growth in some sectors of government." For some sectors a productive net contribution to quality of life may be intrinsically unlikely.

I see most of the points above as arising from failure to communicate adequately. Yet there may be some important issues being raised that we have not fully appreciated.

A system dynamics model is never frozen. I anticipate that we will engage in continuous improvement for a long time. Enough progress has now been made that we have a foundation for good use of suggestions and criticisms. I hope that you can persuade Neal to spend some time in helping us make the present effort more effective. He may be skeptical; certainly past efforts at economic modeling have left many questions unanswered. But, if he will give us the benefit of the doubt until he can spend some time with a new approach, I believe he will find we can help fill many holes in present understanding of important issues.

JWF:mu

September 1, 1973

Professor Jay W. Forrester
Room E52-454C
M.I.T.

Dear Jay:

Recently in looking at the OECD OBSERVER it occurred to me that the data which they have after many years decided are the most relevant concerning the OECD member countries I thought it might be interesting to you. I know you are assembling a lot of material of various kinds and I merely send this forward to be added to other things. Over the past twenty years the OECD countries have arrived at various measures of their economic vitality and condition and these are now summarized in the kind of tables I am sending. This is the 1973 edition and is the 9th year of this series.

I saw Bill Deitel's letter to you written just before he went on holiday. I assume a high priority will be to select your panel which he also rates of great importance in the project. It also appears that he regards the national model exercise as the introduction to getting wider support for system dynamics.

The scheme of Workshops on Alternative Strategies I mentioned not long ago seems to be taking shape and I'll probably be spending half of my time on this over the next couple of years to get one workshop well underway involving North America, Europe and Japan. Probably the subject will be energy options from the 1980's.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosure

from . . .
Jay W. Forrester

C. Wilson

Mar. 1 '73

Thank you for
all you did in
arranging &
carrying through
the trip to Colorado.

Jay

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

FOLLOW-UP	
FILE	

TO Carroll Wilson DATE February 21, 1973

FROM Jay W. Forrester

SUBJECT Technical Report (The Limits to Growth)

You might want to phone Dennis Meadows and follow up on your letter of January 12th to him. My latest information from Meadows was that he has finished five of the seven chapters to the third draft stage. That means two more chapters before the xerox copies are ready for those who ordered them. It means still another revision before the manuscript is ready for the final book.

From various indirect information, I have the impression that Dennis is spending a large amount of time traveling and giving lectures. It would seem that the Technical Report is not getting undivided attention.

JWF*eac
Dictated by Professor Forrester, not read

Room E40-253

January 8, 1973

Professor Jay W. Forrester
Room E52-454C
M.I.T.

Dear Jay:

When I was at NCAR at Boulder in October Will Kellogg, who was one of the key people in both SCEP and SMIC, gave me the enclosed from SCIENCE concerning World Dynamics. I'm sure you have seen this. It goes very much to a central criticism which also it seems to me has shown up in the seminar record on model validation--the sensitivity of some of the key parameters to changes in value.

I am sure that the attached has been circulating at NCAR and is well known to Gilbert White and probably to Boulding. You will, therefore, want to have in mind the appropriate response when you visit Boulder.

I would be very much interested myself in your comments on the points the author makes. It seems to me inescapable that the designer of models introduces his own concepts of reality and that these need to be explicit and acknowledged. I don't think they necessarily invalidate the model but they do indicate some of the basic assumptions that go into it and these indeed determine how the model eventually runs.

It also touches on the point which came up the other day in our discussions with Mr. Morris and others concerning the change in behavior with the change in certain inputs. Your point was that wide changes in many of the inputs do not substantially affect the behavior of the model. The enclosed is an indication that another view is held and in some ways if the model is not sensitive to certain changes in behavior it raises questions as to whether it really is something to rely on.

Sincerely,

Carroll L. Wilson

CLW:F
cc: Professor Meadows

Room E40-253

January 7, 1973

Professor Jay W. Forrester
Room E52-454C
M.I.T.

Dear Jay:

I don't know whether you have closely looked at two papers by Herman Daly relating to the steady state economy. I enclose a copy of each. The one on "The Fallacies of Growth" I think you will find especially interesting if you haven't seen it because he takes a sharp poke at Probins and Nordhouse in various places. I am wondering whether Daly would be a suitable person on your economic advisory panel. He is obviously not very popular with many of his economist colleagues but I think he's a perfectly competent economist and one who finds many things in common with Boulding.

Sincerely,

Carroll L. Wilson

CLW:F

Enclosures

MASSACHUSETTS INSTITUTE OF TECHNOLOGY *CAMBRIDGE, MASSACHUSETTS 02139*
E40-159

February 9, 1979

Forrester's proposal is simple to understand and administer and contains specific and potentially attractive benefits for everybody. It involves applying to all oil and gas (domestic and imports) a tax of $5/barrel oil equivalent in year 1, $10/b in year 2, $15/b in year 3, etc., at the wellhead or as a duty on imports.

The full amount of tax collected would be applied to a reduction of individual, corporate and/or social security taxes. An approximation of the numbers is shown below:

Year	Tax Rate/b	U.S. Use Oil & Gas Billions of barrels oil equiv. (1977 rate)		G & O Billions b/yr	Tax Yield $ billions	1978 Tax $ billions		
		Oil	Gas			Ind	Corp	Soc S.
1	$5	7	3	10	50	181	60	102
2	$10	7	3	10	100	181	60	102
3	$15	7	3	10	150	181	60	102

If applied entirely to reducing individual income taxes, reductions could be 27% in 1979, 55% in 1980, and 82% in 1981.

It might be more equitable and easier for more people to feel the effects on take-home pay if applied to social security tax reduction. Such taxes could be cut 50% in year 1 and 100% in year 2.

The intent of the proposal is to price oil and gas where they should be and to use the full tax collected to reduce other taxes thus avoiding inflationary effects.

Since the purpose is to reduce the use of oil and gas the 10 billion barrel useage will decline and thus the tax base will decline.

I hope you find this as interesting as I do.

Sincerely,

Carroll L. Wilson

Enclosures

February 9/79

Forrester letter/speech sent to:

Anthony Paresi - The New York Times

Daniel Yergin - Harvard Business School

Katherine Graham - The Washington Post

Hedley Donovan - Time Inc.

Thornton Bradshaw - Atlantic Richfield

Grenville Garside - Senator Jackson's office

Frank Potter - Representative Dingell's office

Charlotte Saikowski - Christian Science Monitor

Howard Johnson - Chairman, MIT Corporation

Robert Seamans - Dean, MIT School of Engineering

A.J. Meyer - Center for International Studies, Harvard

William Dietel - RBF

Year	Tax Rate/b.	U.S. Use of Oil & Gas Billions of barrels oil equiv. (1977 rate) Oil	Gas	G&O Billions b/yr

Year	Tax Rate/b	U.S. Use Oil & Gas Billions of barrels oil equiv. (1977 rate) Oil	Gas	G & O Billions b/yr	Tax Yield $billions	1978 Tax $ Billions Ind	Corp	Soc S

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February 7, 1979
Volume 23
Number 23

TECH TALK

Massachusetts Institute of Technology

Forrester Advocates High Oil, Gas Taxes

The government should impose heavy taxes on oil and gasoline to drive prices up to realistic levels consistent with demand, and thereby encourage conservation, MIT professor Jay W. Forrester, the father of "system dynamics," told a Washington audience Tuesday, Feb. 6.

Professor Forrester said that under his plan the high taxes on oil and gas use would be fully compensated by reducing other taxes "to avoid imposing an additional burden on an economy that is already taxed at a dangerously high rate."

Increasing oil and gas taxes, while lowering income, Social Security and other taxes, would attack the underlying causes of the energy shortage and the resulting economic problems, rather than the symptoms, Professor Forrester said in his keynote address at the annual meeting of the American Institute of Aeronautics and Astronautics in Washington, D.C.

The major objections to high oil and gas taxes likely would be based on questions about personal hardships and inequities, Professor Forrester said.

"But hardships from a tax should be less than hardships from not taxing," he said. "If an oil and gas tax is compensated by reduction in other taxes, the total tax load remains constant. Prices for other services and goods should decline relative to energy. The cost of living need not be affected. Energy and products with a high energy content would rise in price, but products with a high labor content would fall in price. There would be a shift of incentives toward conserving energy but there should be no increase in hardship. To the contrary, the standard of living should rise as we reduce OPEC claims on our industrial output and increase the opportunites for employment."

Professor Forrester said he is convinced that the public is ahead of its leadership and wants "a fundamental solution that is good for the long term."

"Stopping inflation and solving the energy problem have come to be seen as conflicting goals rather than two faces of the same challenge," Professor Forrester said. "The public has been confused by a government that first likened the oil situation to a wartime crisis, then recommended a massive array of trivial and ineffective legislation, and lastly has offered a State of the Union message in which energy was given nine words."

Dr. Forrester, the Germeshausen Professor at MIT, directs the System Dynamics Program at the Institute's Alfred P. Sloan School of Management. The field of system dynamics has been created since 1956 under Professor Forrester's leadership to evaluate how alternative policies affect growth, stability, fluctuation and changing behavior in corporations, cities and countries.

Professor Forrester

"System dynamics" operates on the theory that major economic and social stresses arise from long-term processes in society, meaning that the origins of present difficulties have been taking shape for decades.

"In the recent past, energy consumption per capita has been higher than ever before in history," Professor Forrester said, "and probably higher than ever again in the future. But human memory is so short that we have accepted the recent aberration of excess energy as being the normal condition.

"During the oil and gas era that is now drawing to a close," he con-

(Continued on page 3)

Forrester Advocates High Oil, Gas Taxes

(Continued from page 1)

tinued, "energy has been available in too great a supply and at too low a price. Even today, after the price of energy has increased, gasoline sometimes still costs less than water. Oil is brought from the Middle East, refined into gasoline, trucked to the corner filling station, and put in an automobile for less than the price of a gallon of local spring water at the grocery store.

"Easy availability, wide distribution of energy supplies and low costs of production have induced excessive substitution of energy and capital equipment for labor," he said. "The result has become an internal imbalance in patterns of living and production."

The imbalances that have arisen from an excessive supply of energy, Professor Forrester said, "now permeate homes, businesses, social structure, and government organization.

"Such imbalances are not static," he adds. "They have been decades in the making. Their correction will take time. The imbalances are dynamic with changing and recurring patterns."

Professor Forrester charged in his speech that governmental energy policies thus far adopted are self-defeating because they establish conflicting motivations. "Congress has legislated energy conservation policies while maintaining incentives for continued use of excessive energy."

Effective policy, he said, should be simple and should radiate strong motivation to all sectors of the economy, while addressing underlying causes.

A heavy tax on oil and gas would meet these requirements, he said, because a tax on petroleum energy, if high enough, would motivate conservation.

"The price umbrella thus created would also motivate private development of alternative energy sources," he explained. "A tax on petroleum at the well or the dock would be easy to administer. There would be nothing complicated to defy understanding."

Professor Forrester said the best procedure probably would be to apply the oil and gas tax in steps to test the degree of response and allow time for the economy to adjust.

"But time is of the essence," he warned. "A decade appears much too long for initiating effective action. A best compromise may be to increase the oil and gas tax at a rate of $5 per barrel-equivalent per year until it becomes clear that the necessary responses are occurring."

It may evenutally be necessary to impose an additional US tax of $20 to $30 per barrel of oil or equivalent in gas, Professor Forrester said. "When the price of energy from oil and gas becomes high enough to cause people to change their consumption and living habits, incentives for conservation will have permeated society."

The MIT researcher said that such a high tax would be non-inflationary if balanced by tax reduction elsewhere. "Through favorable effects on balance of trade, value of the dollar, and domestic employment, a high tax might even lower the pressures that now sustain inflation," he said.

Professor Forrester also said that an oil and gas tax must not become an excuse for higher government expenditure. "The tax should not be used to support energy-related government programs because that would defeat the objective of shifting energy decisions away from government and toward consumers and businesses in the private sector," he said.

A general tax reduction to compensate for the oil and gas tax probably would be concentrated in the income tax," he said. "A $20 per barrel tax on oil would substitute for about half of the total collected in corporate plus individual income tax," he explained. "With a very substantial reduction of income tax, and maybe Social Security tax, a high tax on oil should become politically acceptable."

Massachusetts Institute of Technology
Alfred P. Sloan School of Management
50 Memorial Drive
Cambridge, Massachusetts, 02139

Jay W. Forrester
Germeshausen Professor

System Dynamics Group
E40-253

October 31, 1979

Professor Carroll Wilson
Building 1-143
M.I.T.

Dear Carroll:

You asked that I comment on recent monetary policy from our vantage point in working with the System Dynamics National Model. We have not yet put our work on inflation into formal papers, but I will summarize the emerging results.

1. Control of money supply is central to the control of inflation.

2. The "Phillips-Curve" concept of a tradeoff between inflation and unemployment is too simplistic and a poor guide to policy.

3. There are two economic modes of behavior that cause price to change--the short-term business cycle, and a much longer dynamic mode resulting from changes in Federal Reserve policy.

4. The 3-to-7-year business cycle mode arises from within the private economy mostly as a result of inventory and employment policies. It is not tightly coupled to either investment or monetary policy.

5. A change in monetary policy initiates responses that may take 15 years or more to run their course.

6. Inflation has two components. One is the long-term rise in prices caused by excessive increase in the money supply. The second is the rise and fall of prices induced by the business cycle.

   a. The two components of inflation are superimposed.

   b. At the end of a business cycle expansion, as has recently occurred, the two components of price rise add together.

c. High combined rate of price rise just before an impending recession induces the Federal Reserve to take anti-inflation action at the very time that it is most vulnerable to being accused of causing the recession that would have occurred anyway.

7. Past statistical analyses that have been interpreted as showing a tight coupling between money supply and real activity in the economy have led to incorrect conclusions because of failure to realize that there are two different modes of behavior causing prices to change. Money supply is more important in determining prices and less important in determining real activity than is commonly believed.

Regarding the recent action of the Federal Reserve:

1. It is in the right direction. Money must be controlled, not interest rates.

2. Interest rates must rise to perhaps 6 percent above the inflation rate before there is any chance of stopping borrowing for speculative purposes, with the consequent increase in money supply.

3. There will probably be a rather immediate effect in areas where speculation in anticipation of further price rise has dominated economic behavior. But we believe there will not be serious consequences in the main stream of the economy from the recent monetary action.

4. Results in controlling inflation will be slower than most people expect. It could take a decade.

5. The greatest danger is that government and the Federal Reserve will falter in the present correct move to halt inflation. Failure to carry through would undermine the credibility of any future effort.

6. The Federal Reserve is vulnerable to unjustified criticism because a recession will probably occur independently of Federal Reserve action. Furthermore, the end of the capital-investment boom of the 1950s and 1960s is producing major stresses that, again unjustifiably, could cause criticism of the Federal Reserve.

I am greatly encouraged by the recent actions led by Paul Volcker. I hope he will be allowed to hold to his convictions long enough to produce results.

Enclosed is a brief summary of our preliminary work on inflation, a folder on the System Dynamics National Project, and an article discussing some of our work on cyclic behavior in the economy.

Sincerely yours,

Jay

JWF/cdk

enc: "Summary of Research on Inflation," System Dynamic Group, October 27, 1979, D-3160.
"Changing Economic Patterns," Jay W. Forrester, Technology Review, August/September 1978.
The System Dynamics National Model descriptive brochure

October 27, 1979

SUMMARY OF RESEARCH ON INFLATION

SYSTEM DYNAMICS GROUP

Alfred P. Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

(Taken from the report on the
Sponsors Meeting of November 1, 1978)

The System Dynamics Group at M.I.T. is studying inflation and changes in economic activity using the System Dynamics National Model. Various assumptions are being examined regarding money supply, union pressures, and wage and price controls. The following summary presents preliminary results.

Model simulations suggest that:

(1) continued money growth is a necessary condition for sustained inflation;

(2) wage and price controls at best achieve only short-term price stability at the expense of a resurgence of inflation later;

(3) stopping money growth should not have the severe effect on unemployment that many people assume;

(4) other alleged causes of inflation, like union demands to boost wages and rising oil price, cannot in themselves create sustained inflation but do result in adverse consequences, such as tight liquidity and increased unemployment, that induce governments to increase money growth and thereby cause inflation;

(5) increasing money supply has only a temporary benefit in increasing employment, and;

(6) increasing money supply can eventually worsen liquidity by causing prices to advance ahead of the increasing supply of money.

The time over which changes in money policy work themselves out in the model extend through two decades. Although future revisions of the model may shorten those times somewhat, consequences of changing the money supply appear much longer and more gradual than the two or three years implied by most discussions of the unemployment-inflation tradeoff.

The model assembly used thus far to study inflation consists of a durable goods production sector, a household sector, a labor mobility sector, and a channel for increasing money. In the early tests, credit and interest rates were constant, as was total population. The goods sector used variable labor but, for ease of analysis, held capital constant (with capital replacements obtained at a price proportional to the variable wage). Allowing capital to vary, a condition that we have tested, does not alter the main conclusions. These restrictions are being removed in the most recent model now being tested.

Operation of the model can be explained through the well-known money equation of exchange, MV=PT, in which money M multiplied by velocity of money V equals price P times real transactions T. Behavior of the National Model demonstrates exchanges between money, velocity of money, prices, and transactions that are very different during different time intervals after a change in policy controlling money supply.

In current inflation debates, there is general agreement that an increase in money produces a proportionate increase in price over the long term, rather than a sustained change in velocity of money or a sustained increase in real transactions. But disagreement lies in the initial timing of responses in the various components of the money equation and the length of the long term before inflation absorbs an increase in money. The

National Model can be used as a laboratory economy to test the sequence of time responses under a variety of policy assumptions.

Four model simulations were made to study the effects of changes in the availability of money. The first model simulation showed the result of a continuing money growth. Money was added to the household sector to represent money increase through fiscal channels. At first, increased money at the household leads to a higher adequacy of money. Adequacy of money is the ratio of the money stock to that desired to support the current money flow as determined by price multiplied by transactions. Higher adequacy of money initially encourages more purchases and is followed by some increase of employment for a few years. But as prices begin to rise, inflation expectations drive prices and wages ahead of the increase in money. As a result, even with steadily increasing money, demand for money to handle transactions eventually moves ahead of money (because of rising prices) and adequacy of money declines below its initial value. After 20 to 30 years, during which there was a continuous increase in money, money became less adequate for handling transactions; prices and wages were rising steadily in response to the increasing money; and employment had fallen below its initial value. The behavior supports the view that the benefits of an increasing money supply are temporary but that the resulting inflation is continuing.

A second computer simulation showed consequences of suddenly stopping a steady growth in money after 15 years. Prices and wages continued to coast up for several years before peaking, after which they subsided enough to become consistent with the money that had accumulated during the 15 years of money growth. Employment returned to its original value after dipping only slightly below the level to which it had fallen in the first simulation as a consequence of the continued rise of money. Unemployment rose after the termination of money increase to a fraction of a percent above the initial value it had before money increase was started and then fell back to the initial value. The behavior suggests that

stopping inflation probably will not lead to the high unemployment that is usually assumed in politics and the press. But more than a decade may be required for the inflation-induced stresses to subside from the economic system.

In a third simulation, money supply was increased continuously and price controls were imposed in the 20th through 24th years. Controls slowed the rise of prices and wages temporarily, but, when controls were removed, prices and wages accelerated to overtake the rising money supply. The end result was the same as without controls.

A fourth simulation was used to examine union bargaining pressure for wage increase. From an initial equilibrium condition, labor was given an upward force on wages, in addition to any upward or downward pressures that might develop. At first, wages begin to rise, and prices follow. Higher prices and wages mean higher money flows, and the adequacy of money falls (money is not being increased). Prices and wages cannot continue to rise without limit, or money would become entirely inadequate. Forces must arise within the system to oppose and counterbalance the extra upward pressure being exerted on wages. One counteracting force arises from the falling adequacy of money in the production sector, which makes management more resistant to wage increase. A second counteracting force on wages comes from the rising unemployment resulting from falling adequacy of money in the household, less ordering of goods, and less production. In response to the increased upward bias on wages, prices rise, adequacy of money declines, orders for goods fall, production falls, profits decline, standard of living falls, and unemployment increases. These are the pressures that would usually signal to government the need for increased money. But more money only adds inflation to the other symptoms.

The above four model simulations indicate the direction of current research on inflation now being undertaken by the System Dynamics Group. As the research continues, findings from a more comprehensive model will

lead to a series of papers on the slow response to monetary policy, why the slow response is consistent with evidence that has usually been interpreted to imply a fast response, the relative independence of monetary policy from business-cycle behavior, and a reinterpretation of the Phillips-Curve literature.