# THE USE OF 1130 CSMP SIMULATION TECHNIQUES FOR INVESTIGATING CYCLES IN MACRO-ECONOMIC ACTIVITY

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ABSTRACT

The failure of the U. S. economy to slow down as predicted, during the first three quarters of 1969, is indicative of the need for more reliable economic models. Current models utilize differential equations. The complexity inherent in formulation of differential equations denoting economic realism is competitive with the simplicity necessary for analytical solution. Thus, there is an obstacle to the generation of reliable macro-economic models of the business cycle.

In this paper the authors suggest that the use of 1130 CSMP simulation techniques can assist in overcoming this obstacle. In order to demonstrate this technique, a simple inventory accumulation model is modified to account for variations in savings behavior. The addition of this modification inhibits use of the usual techniques for analytical solution. A nonanalytical solution is presented in its implications for further macro-economic business cycle research are considered.

## INTRODUCTION

The problem motivating the research reported in this paper stems from the gap between the desired and the actual reliability levels of economic models employed in the investigation of business cycles (7). The magnitude of this gap was quantified in a recent report. It was indicated that the average prediction error for short run estimates was plus or minus one and one-half percent. In an economy generating a trillion dollar Gross National Product (GNP), the level which the U. S. is expected to generate in the near future, the error term could amount to 1.5 billion dollars. The three-quarter lag between the expected and actual rate of decline of GNP growth in response to the surtax of 1969 was further evidence as to the existence of the gap.

The objectives of this paper are: (1) to demonstrate the feasibility of utilizing the Continuous System Modeling Program (CSMP) simulation techniques in constructing business cycle models, and (2) to simultaneously indicate the potential of inter-disciplinary effort in business cycle research.

## BACKGROUND

The following background material is presented in order to acquaint the reader with the concepts and terminology of macro-economics and business cycle research. An economic model is an abstraction from reality that embodies the strategic components of the real world necessary to predict and explain phenomena concerning resource allocation. A mathematical formulation commonly is used. Macro-economics is the study of the overall system of economic activities, that is, those human interactions concerned with the allocation of scarce resources among diverse and competing ends. Macro-economics is concerned with such aggregates as average prices, total employment, total spending, and the value of all goods and services produced — the latter commonly measured in dollars and stated as Gross National Product (GNP) or as income. Fluctuations in GNP are called business cycles. By its very nature, macro-economics deals with the impact of government fiscal policy (spending and revenue raising) and monetary policy (supply of money and credit) on the aforementioned aggregates.

As mentioned, there is at the present time an absence of sufficiently reliable macro-economic models. Current models utilize differential equations. The complexity inherent in the formulation of equations denoting economic realism necessary for reliability is competitive with the simplicity required for analytical solution. This creates an obstacle to the generation of reliable macro-economic models of business cycle. The authors suggest that the use of the 1130 CSMP simulation techniques, designed originally for engineering research, can assist in overcoming this obstacle.

## PREVIOUS WORK

There is a substantial body of literature on business cycle theory. Since the purpose of this paper is to make a methodological rather than substantive contribution to the field, an exhaustive review is not presented. However, it should be indicated that:

1. The model used for illustrative purposes draws heavily on the work of Metzler (6).

2. Although the works of Goodwin (5) and Fisher (4) were constrained by the necessity for analytical solution of differential equations, they have made important inputs to the dynamic modeling of business cycles.

3. The application of nonanalytical solutions to business cycle differential equation models was pioneered by Phillips (8, 9).



## THE MODEL

In order to achieve the objective of demonstrating the feasibility of employing the CSMP simulation techniques in constructing more realistic macro-economic models a simple Metzler type inventory accumulation model is employed. This was developed and presented in differential equation format by R. G. D. Allen (1). It is modified herein to allow for increasing speed of producer response in meeting consumer demand and for variations in consumer saving (spending) behavior. These modifications incorporate aspects of economic realism, however, these additions inhibited the use of the usual techniques for analytical solution [1].

The model is specified in Table 1. Essentially, it depicts producers reacting in a lagged manner to consumer demand subject to the constraint of maintaining a desired stock of inventory. The momentum of the system is generated by the business sector's desire to simultaneously meet consumer demand for goods and to close the gap between desired and actual inventory levels. The satisfaction of consumer demand is a moving target in that the process of producing goods generates income which, in turn, results in an increasing desire on the part of consumers for goods. (See equation 2, Table 1.) Thus, there is a feedback effect. After differentiating with respect to time and making appropriate substitutions the model is next expressed in terms of equation 5, Table 1. The assumptions pertinent to the model are:

Table 1. Metzler Inventory Accumulation Model*

| | | |
|---|---|---|
| Demand | $Z = C, C = cY$ | (1) |
| | Z = Total Demand for Goods | |
| | C = Consumption | |
| | $c = \frac{dC}{dY}$ | |
| Output: | $y = (k - k) = \frac{\lambda}{D+\lambda} Z$ | (2) |
| | k = Stock of consumer goods (Inventory) | |
| | k = Desired inventory | |
| | $\lambda = 1$ = Time constant of Lag (Lundbeogian) | |
| | $D = \frac{d(?)}{dt}$ | |
| | $\frac{1}{T} = \frac{1}{To -\alpha t}$ | (3) |
| | t = Years | |
| | $\alpha = 0.01$ | |
| | $To = 4$ | |
| | $DK = Y - cY = sY$ | (4) |
| | $s = 1 - c$ | |
| Final Model: | $D^2Y = -s(1 + \lambda) DY - s\lambda Y$ | (5) |

*This presentation was adapted from R. G. D. Allen (1, pp. 166-168).

[1]It is recognized that the simplified model of the economy being used will not generate predictions of the time path of GNP amenable to reliability testing. This results from the impossibility of depicting the multisector U. S. economy with a two-sector model.

1. Entrepreneurs have adequate inventories so that at any time the discrepancy between output and consumer demand may be met by inventory fluctuations rather than by price change.

2. Output in a given period is based upon the sales of the preceding period.

3. Consumer goods are produced entirely in anticipation of sales and/or to replace inventory.

4. Income is equal to the production of consumer goods.

5. Consumption within the sales-output period depends upon the income of the same period.

6. There is no business savings (6).

## THE RESULTS

Solutions to four different computer runs of the model were obtained. Each successive run embodied modifications which were hypothesized to reflect more realistic consumer behavior. These modifications focused on "s," the change in saving with respect to income (the marginal propensity to save). Following Allen (2) values and for $a$ and $T_0$ were arbitrarily chosen.

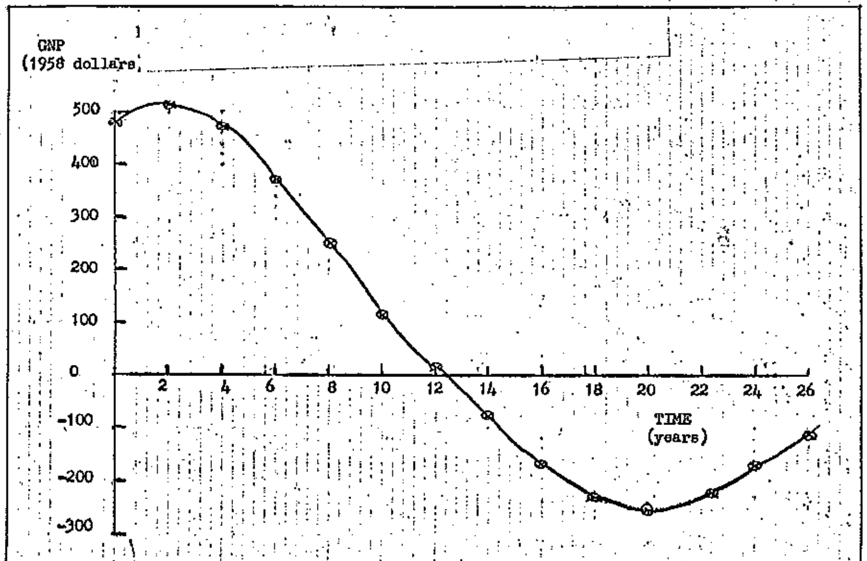


Figure 1

CYCLE ACHIEVED WHEN "s" IS CONSTANT (0.122)



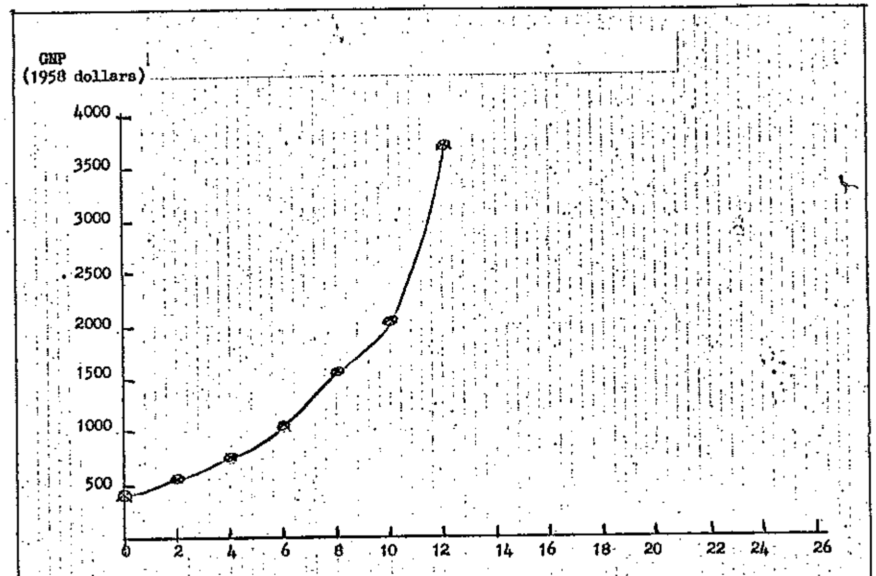


Figure 2

CYCLE ACHIEVED WHEN "s" IS CONSTANT (-0.122)

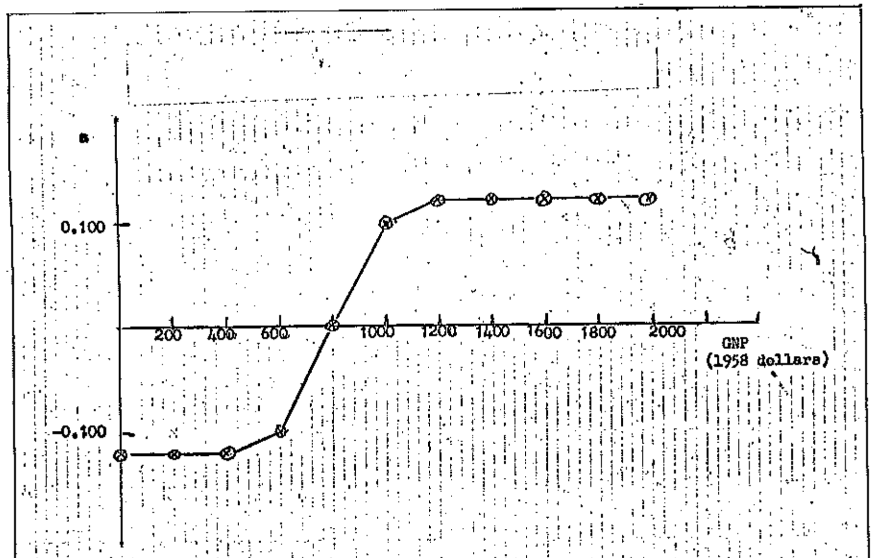


Figure 3

FUNCTION GENERATOR SPECIFICATIONS FOR "s"

In the first run, s was set equal to 0.122, the 1955-68 computed trend value. The time path of Gross National Product (GNP) generated is approximated in Figure 1. It should be noted that since gross income can never be negative, only the downward trend during the first twelve year period has economic relevance. This downward trend can be interpreted as being representative of the sluggishness of the economy from the middle 1950s through the early 1960s (10).

In the second run s was set equal to -0.122 – its value for 1967-68. The negative marginal propensity (which indicates that as income increases, saving decreases) is indicative of consumers' inflationary expectations. Such consumer behavior engendered an explosive upward time path of GNP. (See Figure 2.)

In the third run a major modification was introduced[2]. Here, s was changed from a parameter to a function of income (GNP). This modification was incorporated in order to account for the real world phenomon of differential saving response to changes in income at different levels of income (3). The function generator specifications are depicted in Figure 3. As GNP increases from zero to 2000 billion, s moves from -0.122 to 0.122. This function represents increased saving (or decreased spending) for an increment to income as the level of income increases. An income oscillation of greater amplitude than that computer run one (but with positive GNP values throughout its range) resulted from the modification. (See Figure 4.)

In the fourth computer run, s was expressed as a function of time. This modification was introduced to account for the real world situation in which short run s approaches long run s (3). Thus, s was allowed to vary between 0.60 and 0.10. (See Figure 5.) The result of this change was a damped oscillation of lesser amplitude (and more indicative of the usual movements of the economy) than for any of the three previous runs. However, the problem of negative income reappeared. (See Figure 6.)

## SUMMARY AND CONCLUSIONS

It was demonstrated in this paper that it is feasible to use CSMP simulation techniques (designed originally for engineering research) in the modeling of business cycles. Starting with a simple second order differential equation business cycle mode, the authors showed how modifications to incorporate realistic aspects of consumer behavior can be added without sacrificing solvability. The capacity to add realistic aspects of behavior to business cycle models should facilitate the construction of more complex reliable models for macro-economic predition and explanation.

[2]Prior to this run, the specified model was amenable to analytical solution. This was not the case for the third and fourth computer runs.



## ACKNOWLEDGMENTS

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