

**Keynes' Chapter Twenty-Two:  
A System Dynamics Model**

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## **Keynes' Chapter Twenty-Two: A System Dynamics Model**

Financial crises are becoming more frequent events in the world economy. The broad-based move to increased capital market liberalization over the past few decades has not only contributed to the fragility exhibited, but also managed to make contagion more likely. The need to understand the logic of financial panics is greater than ever.

Though elements of his work have been incorporated into other's analyses (most notably, Minsky), we still see little reference to Keynes' full-scale trade cycle model in modern crisis theory. Indeed, his attempt to describe an economy in time in Chapter 22 of the **General Theory**, an effort that he claimed required "every element in our analysis...for its complete explanation" (Keynes 1964, p.313), has received comparatively little attention (Carlson and Keller 1982). This state of affairs is disappointing because what he presents there is a comprehensive, useful, and unique explanation of economic fluctuations. It would serve as an excellent framework into which many of the newer ideas could be placed.

The purpose of this paper is to illustrate the usefulness of Keynes' approach by modeling it using system dynamics. As this technique allows the researcher to place the analysis in time it is especially well suited to the task. It also allows us to see exactly which elements seem to create the characteristic shape of the business cycle and crisis.

### **Keynes' Chapter Twenty Two and Crisis Theory**

Keynes identifies five factors responsible for the trade cycle (Keynes 1964, pp.313-320):

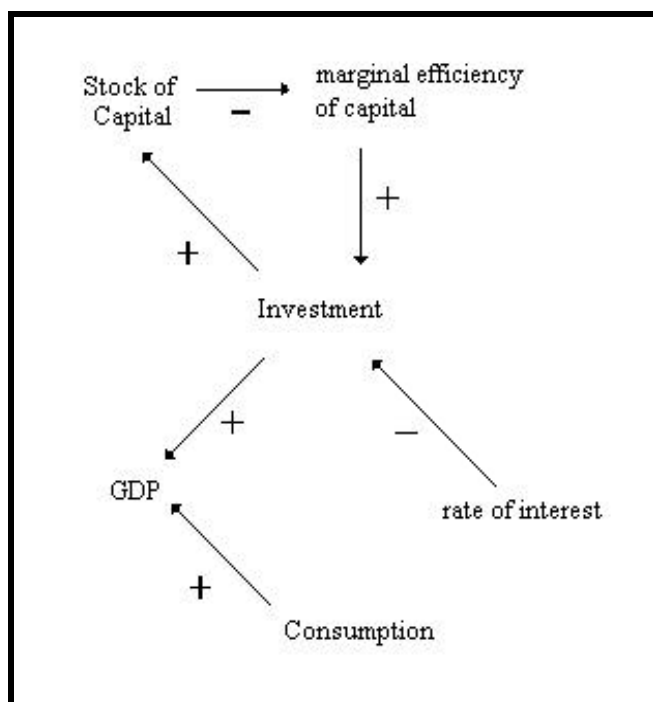
1. the negative impact of the rising stock of capital on the marginal efficiency of capital (mec);

2. the tendency of the rate of interest to rise over the expansion as the demand for financing begins to place pressure on supply;
3. the continuing upward pressure on the rate of interest once the collapse has begun (and agents scramble for liquidity);
4. the fall in the marginal propensity to consume (mpc) that will accompany the decline in the values of portfolios (assuming the bust brings with it a fall in asset values);
5. the manner in which agents form expectations of the future.

Of these, 3 and 4 make themselves felt once the turning point has been reached and the economy is in recession. 1 and 2 cause the expansion to tend to lose strength as it matures. But, as we shall see, it is 5 that gives the cycle its characteristic shape. Without it, the economy tends toward a

situation in which investment reaches a stable equilibrium (where gross capital formation just offsets depreciation).

To better illustrate this, Keynes' model will be built in piecemeal fashion, beginning with the rather straightforward relationships shown in Figure 1. Eliminating the government and foreign sectors for simplicity, GDP is a positive function of investment and consumption (assuming a simple multiplier process). Investment in turn



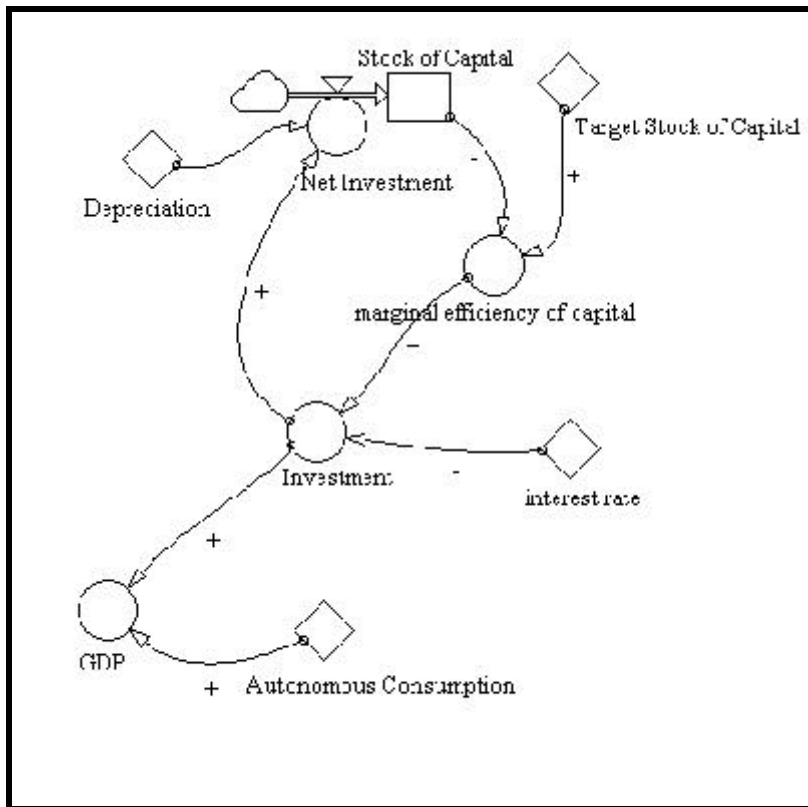
**Figure 1: Keynes' Basic Model.**

is driven by the mec and the rate of interest. The determinants of the mec are limited to the stock of capital to highlight the latter's impact in creating the trade cycle. As the stock of capital rises with net increases in investment, so the expectation of profit from future additions to the stock of capital will decline. Hence, a rise in investment inevitably (though not immediately) creates a fall as the economy works through the negative feedback loop show at the top of Figure 1:

$$[\text{investment} \propto [\text{stock of capital} \propto \text{mec} \propto \text{investment}.$$

The falling mec, rather than the rising interest rate as suggested in 2 creates the underlying dynamic and is, according to Keynes, the more “typical, and often the predominant” reason for collapse (Keynes 1964, p.315). Alone, however, it is no guarantee of a business cycle. This is illustrated below.

Using the equations listed

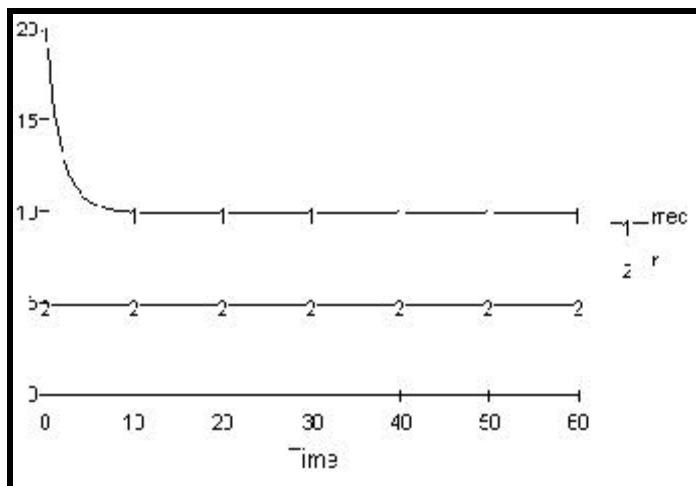


**Figure 2: Keynes' Basic Model in Powersim.**

in the Appendix, this simple system was modeled in Powersim. Figure 2 shows the schematic. Note that the negative feedback loop mentioned above still appears. Also note the addition of two new variables: Depreciation and Target Stock of Capital. The former is simply the rate at which existing capital decays, while the

latter is included on the assumption that the  $mec$  is a function of how much the existing stock of capital differs from some objectively-determined target level that would presumably satisfy current demand.

Running this simulation shows that it does not create a cycle. Though it creates an underlying



**Figure 3: Linear Specification of  $mec$ .**

logic for the appearance of a turning point,

by itself the economy represented by

Figure 2 may actually yield a stable

equilibrium. The key is the specification of

the  $mec$ . If we give  $mec$  as a simple linear

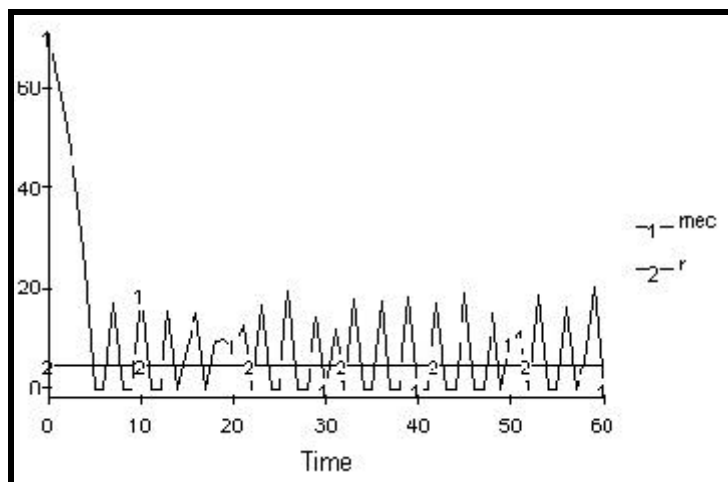
function, as in equation (5) in the

Appendix, then the economy seeks a point

where net investment will exactly offset

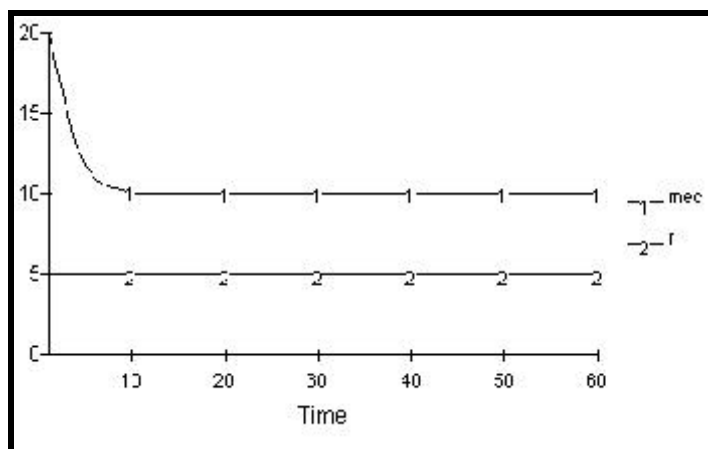
depreciation. This occurs in Figure 3, where  $mec$  fell as the gap between the target and actual stock of capital was filled, but then settled off as net investment came to rest at zero (which in this model occurs when  $mec$  exceeds interest by five percentage). For sake of brevity, plots of investment and GDP are not shown; but as the former is a function of the difference between the  $mec$  and the rate of interest and the latter varies directly with the former their patterns can be easily inferred.

A cycle can be created using the simple model, but it requires resorting to a convenient and not necessarily intuitive, respecification of the  $mec$ . Equation (5'), for example, shows  $mec$  equal to the square root of the difference between the actual and target stock of capital. This yields the pattern shown in Figure 4, which is much more like that we would expect. That we have no a priori reason to prefer (5') to (5), however, is a weakness of this approach.



**Figure 4: Nonlinear Specification of mec.**

be highlighted (with a complete model presented at the end).



**Figure 5: Linear Specification of mec, Endogenous mpc.**

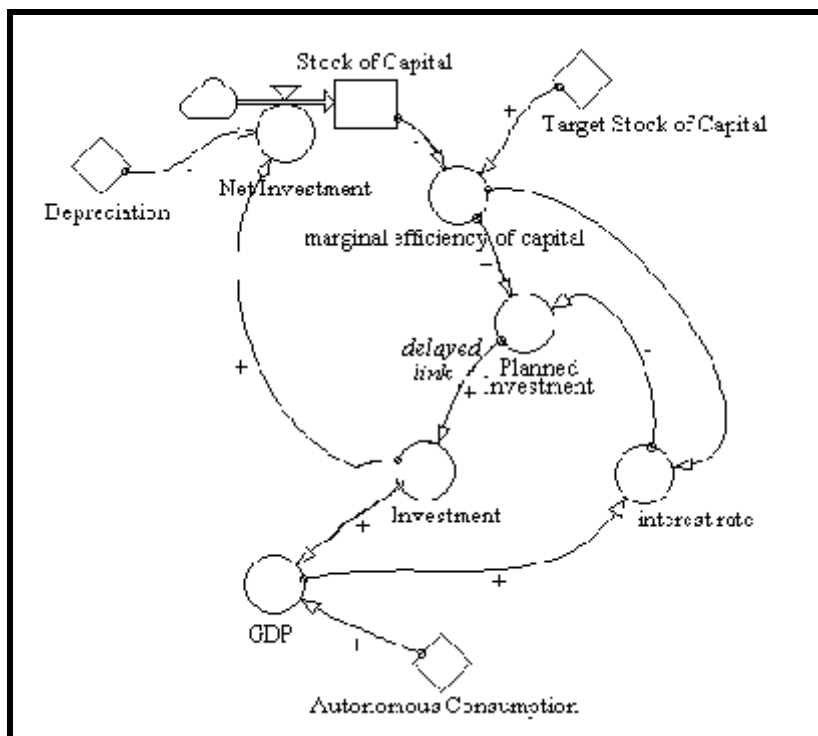
As space does not permit a demonstration of every other permutation of Keynes' five elements in a system dynamics format, I will now proceed by adding the others individually to the basic model shown in Figure 2 so that their contribution can

Figure 5 shows Keynes simple model (with a linear specification of mec), including the impact of a fluctuating mpc and income multiplier (4 from the above list). The two were modeled using equation (6) from the Appendix, where the multiplier (which had previously been exogenously determined as "two") is expressed as an inverse function the mec

(as a falling mec would tend to depress asset values; note also that making mpc endogenous required a slight respecification of equation (1), which now becomes (1')). As the only real difference between this economy and the one modeled in Figure 3 is in terms size of the multiplier effect on GDP, we see no difference in the plot of the mec and the rate of interest. Just as in Figure 3, the economy comes to

rest at the point where net investment is zero.

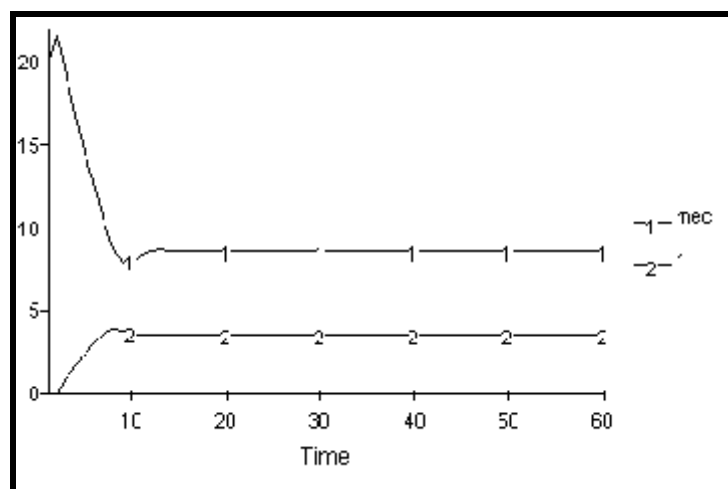
Modeling the interest rate endogenously (i.e., using both 2 and 3 from the above list) was



**Figure 6: Keynes' Basic Model plus Liquidity Preference in Powersim.**

slightly more complicated, but gave the same essential result. To begin, making the interest rate a function of both demand for cash for finance purposes and as a hoard meant linking it to mec (which impacts negatively on the rate of interest, as falling mec implies sinking optimism and a flight to cash) and GDP (where rising GDP raises interest rates). In terms

of modeling the latter link caused a problem since the current rate of interest could not, in this sort of system, be simultaneously a function and a determinant of (through investment) GDP. This is an economy in time where there must exist a *sequence* of events. However, this was solved as shown in Figure 6. Here, today's investment is a result of yesterday's mec and rate of interest, which implies that firms made profit projections and secured funding one period ahead of actual spending. Hence the *delayed link* between planned investment and investment.



**Figure 7: Linear Specification of mec, Liquidity Preference.**

in this case reaches equilibrium at 3.69%). Still, no cycle is generated when the specification of mec is linear.

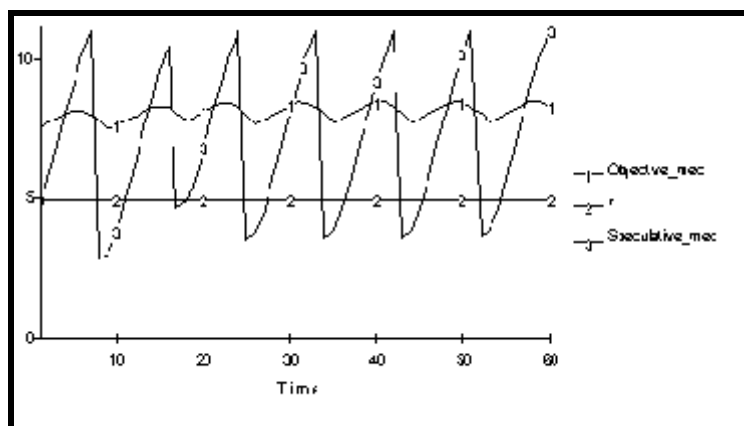
It is only when the particular way expectations are formed is taken into account that we see a real trade cycle. Agents in Keynes' **General Theory** form their forecasts in an environment of uncertainty. This leads those forecasts to be a) held with little confidence and b) based largely on the agent's impressions of what others believe the market will do (reliance on conventional wisdom in the face of individual ignorance). But agents are also inherently optimistic, and it is this optimism, combined with investors being too busy forecasting market sentiment (which would of late been bullish) and not industry conditions, that leads to them to continue to expect positive returns well beyond the point that the increasing size of the stock of capital and rising costs of production would suggest. Once reality sets in (as realized profits are compared with prior projections), the flimsy foundation of the expectations means that the re-evaluation is "sudden and even catastrophic" (Keynes 1964, p.316).

To model this, the useful dichotomy employed by Keller and Carlson (1982) was adopted.

All this made little difference in the end, as interest rates and the mec once again came to rest at a point where the latter was 5 percentage points above the former (this is shown in Figure 7). The only difference is that now the rate of interest is not set exogenously at 5%, but is determined by GDP and mec (and

There, they distinguish between an *objective* mec, which “reflects a yield based on a fundamental rate of return,” and a *speculative* mec, or one derivative of “individual businessmen’s calculation of yields which reflect predictions of majority opinion in the marketplace” (Keller and Carlson 1982, p.406). In the system dynamics model, the old linear specification of mec was used for the objective mec, while the speculative one required a series of new equations. Modeling expectations necessitated the following adjustments:

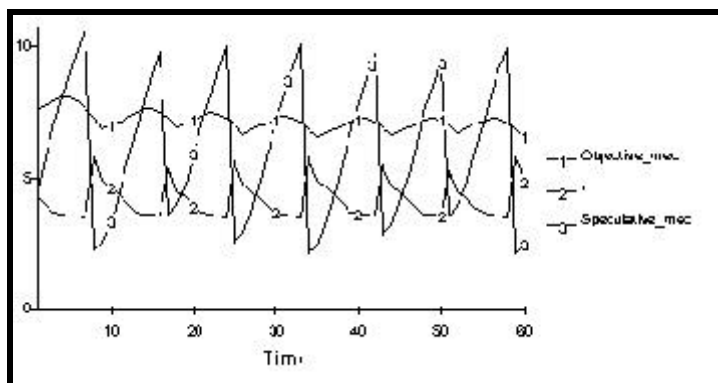
- i. investment is affected by the speculative mec and not mec;
- ii. a bandwagon effect occurs such that consecutive positive values for objective mec contribute a “bonus” to speculative mec—these accumulate up to the point of crisis;
- iii. a similar, though less powerful, bandwagon works in reverse (such that depressed expectations beget depressed expectations);
- iv. a crisis in expectations occurs whenever there are three consecutive periods during which the speculative mec exceeds the objective one—at that point there is a collapse in the speculative mec.



**Figure 8: Linear Specification of mec, Expectations Modeled.**

Finally, a trade cycle is created, as shown in Figure 8 (note that this model leaves the multiplier and interest as exogenous and adds only expectations to the basic model).

Just as one would expect, the fall is much steeper than the climb and the



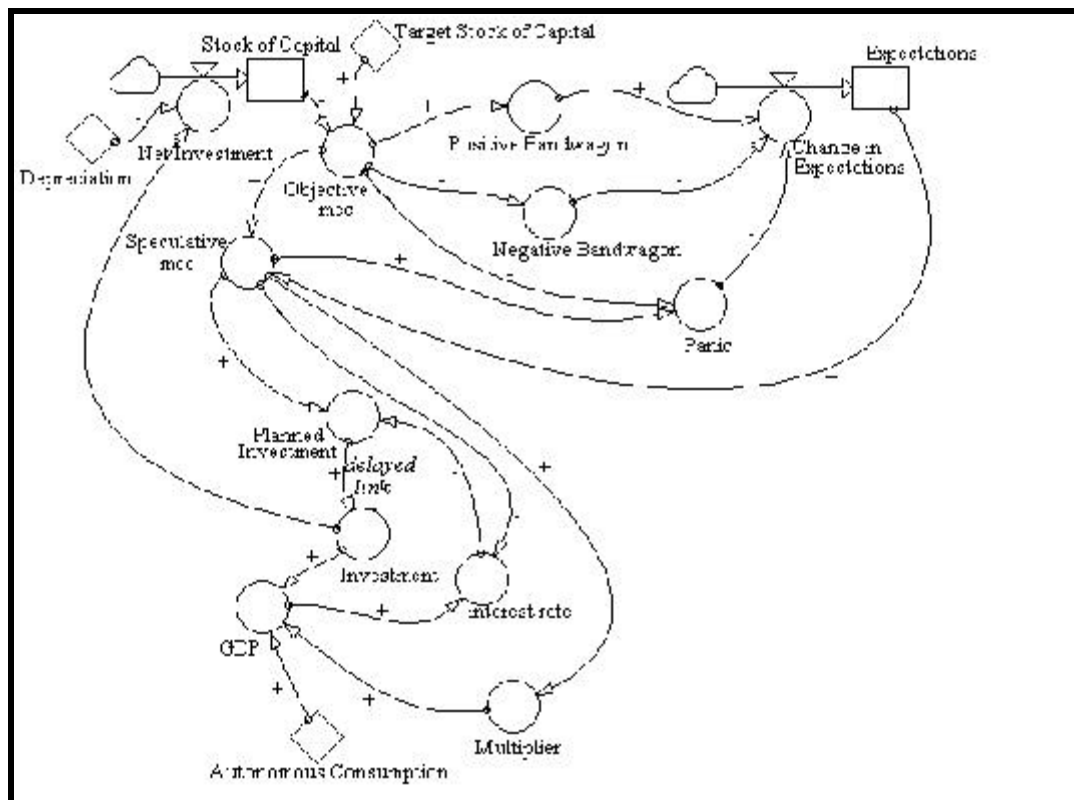
**Figure 9: Linear Specification of mec, Expectations Modeled, Liquidity Preference, and Endogenous mpc.**

speculative mec shows much more volatility than the objective.

Furthermore, Keynes argument that over-investment in a strict sense is not the cause of the cycle is supported since the objective mec never falls below the artificial floor created by the rate of

interest, and certainly not below zero.

The picture is even clearer in Figure 9 which, at last, gives the complete model, with expectations modeled and interest and the mpc/multiplier treated as endogenous (interest, incidentally, is now linked to the speculative mec and not the objective one). The story is basically the same as that shown in Figure 8, but with interest fluctuating in a manner that makes economic recovery even more difficult. Figure 10 shows the complete model.



**Figure 10: Complete Model in Powersim.**

## Conclusions

By placing Keynes' Chapter Twenty Two into a system dynamics framework it can be demonstrated that he offered a viable explanation of crisis over half a century ago. It also becomes clear that key to panic and collapse is the means by which agents form expectations, with other factors adding vital elements (including especially the fluctuating objective mce). His Chapter Twenty Two offers an excellent base for more complex theories of cycle and crisis.

## APPENDIX

### Specification of the Simple Keynes-Style Trade Cycle

This model consisted of five equations, four constants, and an initialization value.

Equations:

- (1)  $GDP = 2 * (Investment + Autonomous\ Consumption)$
- (2)  $Investment = 100 * (marginal\ efficiency\ of\ capital - interest\ rate)$
- (3)  $Net\ Investment = Investment - Depreciation$
- (4)  $Stock\ of\ Capital = Previous\ Stock\ of\ Capital + Net\ Investment$
- (5)  $marginal\ efficiency\ of\ capital = ((Target\ Stock\ of\ Capital - Stock\ of\ Capital) / Stock\ of\ Capital) * 100$
- (5')  $marginal\ efficiency\ of\ capital = (Target\ Stock\ of\ Capital - Stock\ of\ Capital)^{0.5}$

Constants:

Autonomous Consumption = 2250;

Depreciation = 500;

interest rate = 5;

Target Stock of Capital = 30000;

Stock of Capital initial value = 25000.

In addition, Investment was limited so that it could vary only from 100 to 1600.

### Adding Marginal Propensity to Consume/Multiplier

- (6)  $multiplier = 1.8 + mec/35$

$$(1') \quad \text{GDP} = \text{multiplier} * (\text{Investment} + \text{Autonomous Consumption})$$

### **Adding Liquidity Preference**

$$(7) \quad \text{rate of interest} = 2 + \text{GDP}/1200 - \text{mec}/3$$

Note that making the rate of interest endogenous requires lagging investment.

### **Adding Expectations**

Space does not permit an explanation of this aspect of the model beyond what is offered in the text.

However, the author is happy to forward a copy of the model and its component equations to interested readers.

**REFERENCES**

Keller, Robert R. and J. Lon Carlson. "A Neglected Chapter in Keynes' *General Theory*." **Journal of Post Keynesian Economics**, vol.4, no.3, Spring 1982, pp.404-412.

Keynes, John Maynard. **The General Theory of Employment, Interest, and Money**. New York: Harcourt Brace Jovanovich, Publishers, 1964.

Kindleberger, Charles. **Manias, panics, and crashes : a history of financial crises**. New York: Wiley, 2000.

Minsky, Hyman. **Stabilizing an Unstable Economy**. New Haven : Yale University Press, 1986.

\_\_\_\_\_. **Can "It" Happen Again? : Essays on Instability and Finance**. Armonk, N.Y. : M.E. Sharpe, c1982.

Wolfson, Martin. **Financial Crises : Understanding the Postwar U.s. Experience**. Armonk, N.Y. : M.E. Sharpe, c1994.