H. Economicus: A Perceptual Control System Model of the Economy

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This paper describes a model of the economy that is based on Treval C. Powers' (1996) historical analysis of economic data found in the *Statistical Abstract of the United States*. T. C. Powers' analysis is surprisingly (and unintentionally) consistent with the perceptual control theory model of individual behavior developed by his son, William T. Powers (1973). Powers *pere* views the economy as a circular flow of money between producers and consumers. The behavior of this circular flow can be explained in terms of a perceptual control system model such as that described by Powers *fils*. A perceptual control system controls a perceptual representation of some aspect of environment that is shaped by the outputs of the system itself. The perceptual control theory model of the economy that is described in this paper controls a monetary representation of aspects of the economy that are shaped by the outputs of the model itself.

Circular Flow Analysis

T. C. Powers' analysis of the economy assumes that the basic economic process is a *circular flow* of money. Money flows between two composite entities: a *composite producer* and a *composite consumer*. The composite producer consists of all the people in the economy who are contributing to the production of goods and services. The composite producer is, thus, made up of everyone in the economy except those who are unable to contribute to the production of goods and services -- the very young, the very old and the infirm. The composite consumer consists of all the people in the economy who are contributing to the consumption of the goods and services that are being produced. The composite consumer is, thus, made up of everyone in the economy since everyone must consume at least some portion of all goods and services (such as the food portion) in order to survive.

To a first approximation, the composite producer and composite consumer are the same group of people: the entire population of people that makes up an economic entity such as the United States. The terms *composite producer* and *composite consumer* simply refer to two different roles -- production and consumption -- that are being carried out by the population of people that makes up this economic entity. Moreover, at the composite level, production and consumption can be thought of as occurring *simultaneously*: the composite producer is making cars while, as the composite consumer, it is driving home;

the composite producer is growing and packaging food while, as the composite consumer, it is eating; the composite producer is teaching computer science while, as the composite consumer, it is applying this knowledge to internet innovation.

The simultaneous interaction between composite producer and consumer is shown in Figure 1. The composite producer is producing goods and services, Q', and paying *itself*, in the role of composite consumer, for the work that produces Q'. The amount of dollars the composite producer pays itself, as composite consumer, is the average price (P) of all goods and services times the amount of goods and services produced (Q'). This payment is seen leaving the composite producer as an *output of dollars*, PQ'. The composite consumer receives these dollars as income; wage income (W), which includes both wages and profits, and capital income (K), which includes interest income and rent. Consumer income (W+K) represents buying power, B. The composite consumer uses this income to buy the goods and services that it was paid for producing them. This payment is shown being returned to the composite producer as *spent* purchasing power.

Figure 1 shows a circular flow of money going from composite producer to composite consumer and back to composite producer. It is important to understand that money is flowing in all parts of this circle simultaneously; money is flowing from the composite producer to the composite consumer as income *while* it is flowing from the composite consumer to the composite producer as payment. This flow is in equilibrium when the money flowing into the composite producer, in the form of payments for consumption of Q', is equal to the money flowing out of the composite producer in the form of wages and capital payments for production of that same Q'.

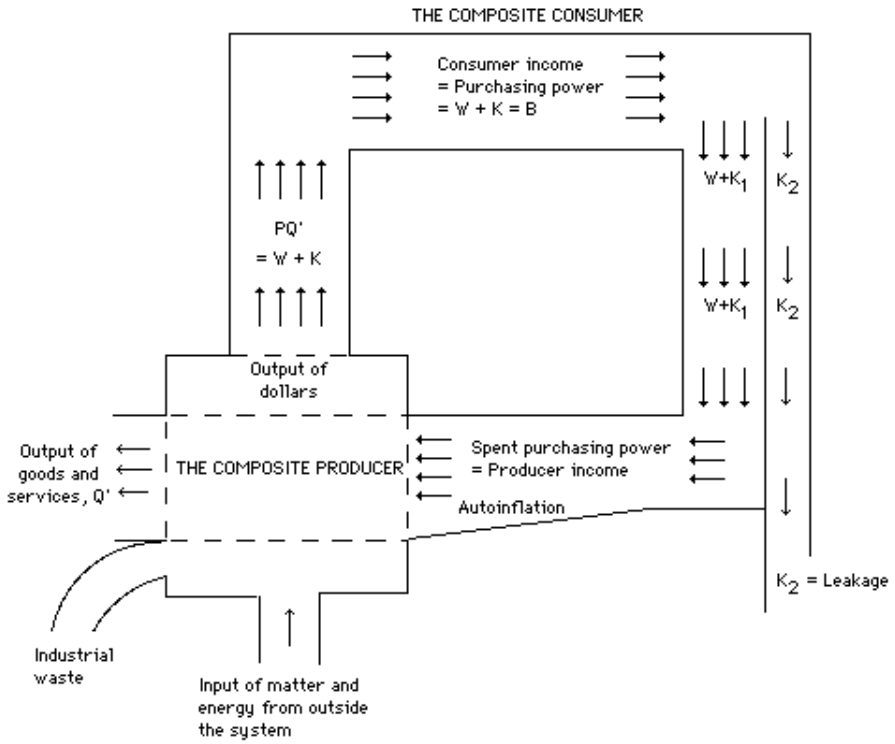

Figure 1. Circular flow analysis of the economy.

In circular flow analysis, there is a new law of supply and demand that operates at the composite level. PQ', the dollars paid for production of Q', is supply; W + K, the dollars available to purchase Q', is demand. The circular flow keeps the economy going only when supply equals demand such that the composite producer is being repaid exactly what it spent (and handed to the composite consumer as income) for producing Q'. Supply will not equal demand if money is lost from the circular flow. Money will be lost from the circular flow if it is received as income by the composite consumer but not used to purchase goods and services (Q'). Money that is lost from the circular flow in this way is called *leakage*.

Figure 1 shows that some proportion (K_2) of the total income (W + K) received by the composite consumer is being leaked away through the path on the right side of the figure, leaving only a portion of total income (W + K_1) to be returned to the composite producer as payment for Q'. Leakage creates a mismatch between supply and demand. This mismatch will reduce the circular flow because the composite producer is being forced to produce less (and, thus, spend less) in order to make up for the reduced income it receives. So the reduced circular flow resulting from leakage will produce an economic slow down (a recession or depression) unless money is pumped into the economy. This pumping process is called *autoinflation* in Figure 1 because the composite consumer is now spending more of its income (more than W + K_1) for the same quantity of goods and services, Q'.

The amount of money that is being paid by the composite producer for production of Q' (PQ' or W + K) is equivalent to a very important measure of economic performance that is a provided regularly in the *Statistical Abstract of the United States* (2000): *Gross National Product* or GNP. T. C. Powers' (1996) historical analysis of the economic data available in the *Statistical Abstract* shows that, over the last 100 years, the composite consumer has failed to return, on average, about 8% of its yearly income (GNP) to the composite producer. This means that the composite consumer spends 8% less on consumption than it receives as income. This unspent money is *not* savings. At the composite level, the amount of money being put into savings for future use is about equal to the amount being withdrawn from savings for current consumption. Powers (1966) presents evidence that this unspent income tends to be negatively related to economic growth and positively related to inflation, as predicted by circular flow analysis. In other words, unspent income acts like leakage.

T. C. Powers (1996) presents a considerable amount of evidence to support the circular flow analysis of the economy. What T. C. Powers does not do is propose a mechanism that keeps the circular flow flowing. For example, circular flow analysis describes no mechanism that keeps the outflow of dollars (PQ') from the composite producer matching the inflow of dollars (autoinflated W + K_1) into the composite produced when there is leakage. Nor does the analysis describe a mechanism that can account for the effect of leakage on economic growth (the growth of Q'). What is needed is a mechanism that will produce the behavior predicted by circular flow analysis. The

mechanism that will produce this behavior turns out to be the control system model of individual behavior developed by T. C. Powers' son, W. T. Powers.

H. Economicus

A control model that produces most of the economic behavior predicted by the circular flow analysis is shown in Figure 2. The model, called *H. Economicus*, consists of two control systems: the *composite manager* and the *composite GNP controller*. Each system controls a variable in the economic *environment*. The composite manager system controls the difference between the amount of money paid out for production of Q' (PQ' or GNP) and the amount returned as payment for Q', which is called *Producer income* in Figure 1 and P'Q' in Figure 2. P'Q' is what it costs the composite consumer to buy Q'. So P'Q' can be thought of as GNP seen from the point of view of the composite consumer while PQ' can be thought of as GNP seen from the point of view of the composite producer. PQ' is what it costs the composite producer to produce Q' (which is the same as the GNP measured by government economists); P'Q' is what it costs the composite consumer to purchase Q'. The composite GNP controller system controls just P'Q', which is GNP from the composite consumer's perspective.

P'Q' is a new variable that is not found in the circular flow analysis. What is new about P'Q' is P', which is the average cost of Q' to the composite consumer. P' is to be distinguished from P, which is the average cost of Q' to the composite producer. P and P' are not always the same because the cost of Q' to the consumer must sometimes be increased to make up for any loss of income to the producer due to leakage. So there are two controlled variables in the model of *H. Economicus*: PQ'-P'Q', which is controlled by the composite manager and P'Q' which is controlled by the composite GNP controller.

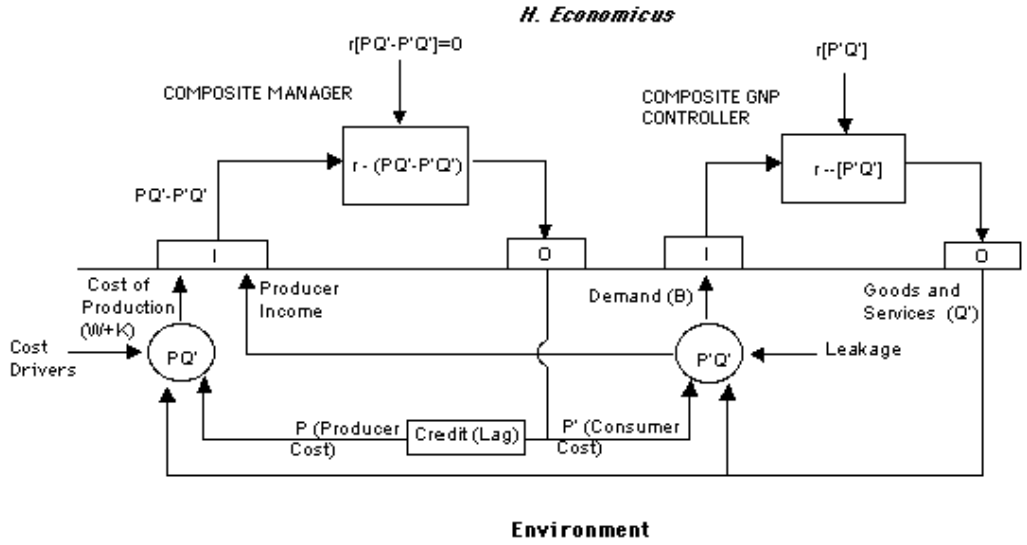

Figure 2. *H. Economicus*, a two control system model of the econony. One system controls PQ'-P'Q' and the other controls just P'Q'. PQ' is the cost to the composite producer of producing Q'; P'Q' is the cost to the composite consumer for purchase of Q'.

The composite manager component of *H. Economicus* does part of the job of the composite producer in circular flow analysis; it produces income (PQ') by paying the cost of production. But the composite manager does something that is not done in the circular flow model; it balances the books. The composite manager acts to keep the difference between production costs (PQ') and income from sales (P'Q') equal to a reference value (r[PQ'-P'Q']) that is set equal to zero. So the composite manager keeps output (PQ') matching input (P'Q'). It does this by raising or lowering the cost of goods and services (P') to compensate for disturbances to the controlled variable, PQ'-P'Q'. There are actually two disturbances to PQ'-P'Q': cost drivers, such as unpredictable variations in the availability of natural resources, that influence the cost of production (PQ') and leakage (variations in the amount of income that is not used for consumption) that influences the per item cost of goods and services.

The composite GNP controller component of *H. Economicus* fills the role of both the composite producer and composite consumer in circular flow analysis. It acts as a producer by working to make the goods and services (Q') it consumes; it acts as a consumer by consuming P'Q', the goods and services it produced. It works to produce Q' in order to keep the amount of goods consumed (P'Q'), perceived in terms of their dollar value, equal to a reference for the amount of goods and services desired (r[P'Q']). The composite GNP controller can compensate for disturbances to P'Q' (caused by leakage) only by varying the amount of goods and services (Q') produced. In fact, most of the composite GNP controller's efforts (in terms of production of Q') are aimed at keeping perceived GNP, P'Q', equal to an ever increasing reference level.

The reference for P'Q' (r[P'Q']) is equivalent to the composite GNP controller's *demand* for GNP as perceived in terms of its cost (P'). In the *H. Economicus* model, increases in the reference for perceived GNP are the driving force behind economic growth. With P' relatively constant, the composite GNP controller must continuously increase Q' in order to keep P'Q' equal to a constantly increasing r[P'Q']). However, if there is leakage, increases in P' will offset increases in Q', leading to lower levels of production of goods and services; the composite GNP controller gets growth in P'Q' but this growth is a result of increases in P' (cost) as well as Q' (production of actual goods and services). The composite GNP controller's efforts to counter the effects of leakage on P'Q' by reducing output, is the mechanism that accounts for the effect of leakage on the productive capacity of *H. Economicus*.

The Behavior of *H. Economicus*: Leakage and Inflation

The *H. Economicus* model was implemented as a dynamic spreadsheet simulation. When the simulation was run, the reference for P'Q' (r[P'Q']) was automatically increased at a rate equivalent to 13% per year. The reference for PQ'-P'Q' remained equal to zero. At the beginning of each simulation run the user could enter a value for the rate of leakage. At the end of a simulation run (which lasted the equivalent to 20 years) the spreadsheet calculated three measures of economic performance: the relative output of

goods and services produced by the economy (Q'/Q), the rate of economic growth (dQ'/dt) per year and an index of inflation. Relative output is the ratio of actual economic output (Q') to the economic output that *would have* been produced if there were no leakage. Rate of growth is the percentage change in Q' in one year. The index of inflation is the ratio of the actual average cost of consumer goods (P') to what the average cost of consumer goods *would have* been without leakage.

Table 1. Effect of leakage on Q'/Q, growth rate and inflation for circular flow analysis and *H. Economicus model.*

Leakage %	Relative Output Q'/Q %		Rate of Growth % per year		Index of Inflation	
	CF	*H. Econ.*	CF	*H. Econ.*	CF	*H. Econ.*
0	100	100	13	13	100.0	100.1
2	98	98	11	13	102.0	102.1
4	96	96	9	13	104.2	104.3
5	95	95	8	13	105.3	105.9
6	94	94	7	13	106.4	106.4
7	93	93	6	13	107.5	107.3.
8	92	92	5	13	108.7	108.4
9	91	91	4	13	109.9	109.5
10	90	90	3	13	111.1	111.2
11	89	89	2	13	112.3	112.8
12	88	88	1	13	113.6	113.6
13	87	87	0	13	114.9	115.1
14	86	86	-1	13	116.3	116.2
15	85	86	-2	13	117.6	117.4
16	84	84	-3	13	119.0	118.5

The control systems that make up *H. Economicus* were not designed to produce particular values of Q'/Q, growth rate or inflation. The values obtained are side effects of the operation of the control systems. They are the values of Q'/Q, growth rate and inflation that result when the control systems act to protect the variables they are controlling (PQ'-P'Q' and P'Q') from disturbances, in this case, from the disturbance caused by different levels of leakage.

The fact that the *H. Economicus* model produces values of Q'/Q and inflation that are very close to the predictions of circular flow analysis for all values of leakage is a reassuring indication that the mechanism of the *H. Economicus* model is able to capture the important aspects of the behavior of the circular flow analysis. The small differences between the predictions of the circular flow and *H. Economicus* model result from the fact that the P'Q' variable in the *H. Economicus* model includes a portion of Q' that represents unsold inventory.

The glaring difference between circular flow analysis and the *H. Economicus* model occurs in the results for rate of growth (columns 4 and 5 in Table 1). The circular flow

analysis predicts a large effect of leakage on rate of growth but the rate of economic growth produced by *H. Economicus* is not affected by leakage at all. The reason for this discrepancy is clear when one takes a closer look at the circular flow analysis. In circular flow analysis the dependence of growth rate on leakage is simply assumed to exist; it is not derived from the interaction of variables in the circular flow, as was the case with Q/Q' and inflation. Rather, the effect of leakage on growth rate is taken as an axiom in circular flow analysis. That is, the effect is *assumed* (Powers, 1996, equation 2-29, p 101) rather than *predicted*.

Circular flow analysis does not suggest a mechanism to explain the dependence of growth rate on leakage and such dependence does not exist in *H. Economicus*. However, simulations using the *H. Economicus* model did reveal a surprising dependence of growth rate on *rate of change* in leakage (increasing rates of change in leakage lead to decreasing rates of change in economic growth). But it is difficult to tell whether this aspect of the behavior of *H. Economicus* is consistent with the economic data.

The effect of leakage on inflation that is found in both *H. Economicus* and the circular flow analysis in Table 1 (columns 6 and 7) was also found in the economic data. One of the main causes of leakage is the Federal Reserve's discount rate policies; the higher the discount rate the greater the leakage. Based on the results in Table 1, one would expect to find a positive relationship between discount rate (leakage) and inflation rate in the economic data. This is precisely the opposite of the effect expected by conventional economists. But Figure 3 shows that the data fit the prediction of circular flow analysis as implemented in the *H. Economicus* model rather than the conventional expectation. In fact, the results shown in Figure 3 are exactly what would be expected if the Federal Open Market Committee (which sets discount rates with the aim of keeping inflation in check) is in a positive feedback relationship with respect to the variable it is trying to control: inflation. The positive feedback comes from the fact that discount rates, which are being raised with the aim of decreasing inflation, are actually increasing it. Small fluctuations in inflation would be emphasized by this positive feedback process resulting in the large swings in inflation rate seen in Figure 1.

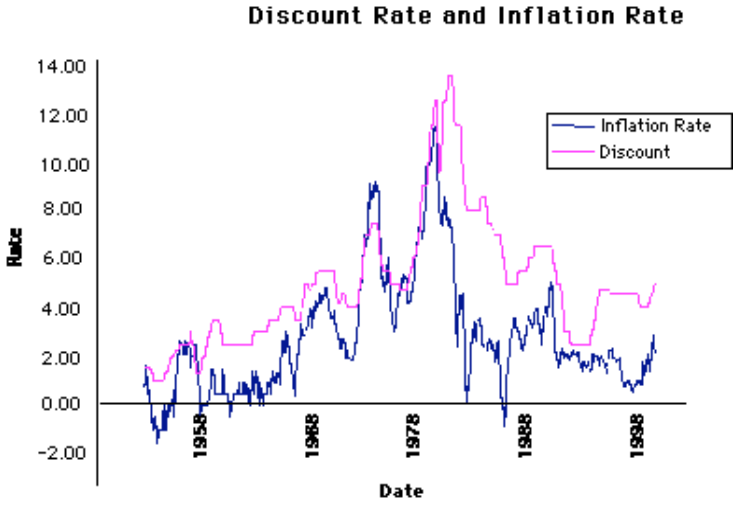

Figure 3. Relationship between Fed discount rate (leakage) and inflation over time.

Apparently, economists at the Federal Reserve who formulate the policy in which discount rate is used to control inflation are aware of the relationship shown in Figure 3 (Canterbery, 2000). Nevertheless, increases in discount rate are still thought to decrease inflation, but after a long delay. Unfortunately, the facts contradict even this hopeful interpretation of the data. The correlation between discount rate and inflation is still positive (and large) even when the discount rate from as much as a year earlier is correlated with current inflation rate. Apparently, the belief in the negative effect of discount rate on inflation persists because there is no way, using conventional economic models, to explain why increases in the discount rate (which decreases the amount of money in circulation) would lead to increases in inflation. Current economic models say that increases in the discount rate *should* decrease inflation. The *H. Economicus* model described in this paper does explain why increases in the discount rate would lead to increased inflation. Now that this phenomenon is explained, perhaps economists at the Federal Reserve will accept the data in Figure 3 as a representation of real phenomenon and act accordingly.

Conclusion

The *H. Economicus* model of the economy explains some of the most important observed economic phenomena in terms of collective control of monetary variables. The model suggests that some of our basic assumptions about what makes an economy function well may have to be revised. In the *H. Economicus* model, the economy functions best (low inflation, high productivity) when leakage (unspent consumer income) is low. Leakage is influenced by the monetary policies of the Federal Reserve Bank and by the distribution of income received by the composite consumer (when a small portion of the composite consumer receives a larger share of GNP than it can use to purchase Q' there is unspent income; leakage). If these influences on leakage can be controlled, a well functioning economy -- one that works best for all its members -- can be readily achieved and maintained.