Eastern Economic Journal, Volume X, no. 4, October-November 1984

ENERGY PRICE SHOCKS, AGGREGATE SUPPLY DISPLACEMENT, AND MACROECONOMIC ACTIVITY

Ali Reza Nasseh*
and
Elyas Elyasiani**

1. Introduction

The economies of the world were so dominated in the 1970's by the effects of two oil crises that the period has been aptly named the OPEC decade[1]. The dramatic increases in energy prices that occurred when the Organization of Petroleum Exporting Countries (OPEC) quadrupled the world price of oil in 1973-1974, and again more than doubled it between the end of 1978 and early 1980, have had profound implications for the economies of all the industrialized countries. Other commodities have experienced rapid and substantial increases in price. The price of grain and other agricultural products, for example, has experienced price fluctuations on the order of 300 or 400 percent over years. Few people, however, would be as concerned about these events, or expect them to have anywhere near the impact on our standard of living that increases in the price of energy are likely to have. Higher energy prices have contributed to reduced economic growth in many countries, and in the longer-run may result in basic changes in lifestyles.

This study develops a model of short-run aggregate supply for two major oil consuming nations (U.S. and Canada) with explicit treatment of energy prices, and explores the effects of a change in the price of energy (oil) on the aggregate supply. The emphasis is on the supply side of the economy since important effects of energy on macroeconomic activity occur largely through relocation and rotation of aggregate supply. An increase in energy prices represents an increase in the cost of a major factor of production. Consequently, an increase in energy prices relative to other prices should result in a decline in the amount of goods and services supplied by the economy at any given level of prices, that is, the aggregate supply curve should shift to the left. An attempt is made to measure the extent to which the aggregate supply curve shifts to the left, at any level of output, due to higher energy prices. In addition, the aggregate supply may become flatter (or steeper) as price elasticity of output alters due to energy price shocks. The present paper also measures the magnitude of the changes in the slope of the aggregate supply resulting from the shocks.

According to the model developed here, the leap in energy prices in 1973 generated a sizable inflationary pressure in both the U.S. and Canada. The effects on labor productivity, real wages, capital utilization rate, and aggregate energy consumption were also found to be considerable and similar between the two countries. An interesting result concerning labor demand is that higher energy prices led to substitution of labor - intensive methods of production for energy-intensive ones, raising the labor/output ratio in both the U.S. and Canada.

* Department of Economics, St. Louis University
** Department of Economics, Temple University

In what follows in Section 2, a model of short-run aggregate supply is developed. In Section 3, the model is estimated, tested for dynamic stability and forecast accuracy, and then simulated to determine the magnitudes of the energy price effects of the 1973 shock on major macroeconomic variables and the change in the slope of the aggregate supply. Section 4 presents some concluding comments.

2. A Short-Run Model of Aggregate Supply

The aggregate supply framework developed here is a multi-sector model and accounts for interaction among all the sectors. Especially, this model has an advantage over the existing ones because it explicitly incorporates the demand and supply of energy into the analysis. The analytical form of the model is given on the next page. The components of the model, each of which will be described briefly below, are the following:

- A price determination equation which relates the price level to the wage rate and other input prices via some sort of mark-up.
- A wage rate equation or a short-run Phillips curve.
- A labor market model namely, a labor demand and a labor supply equation.
- A capital utilization rate equation (demand for capital).
- An energy sector namely, demand and supply of energy[2].

<u>The Price Equation</u>: In the aggregate supply model developed here, the price level (P) is assumed to be determined as a mark-up(m) on the minimum long-run average cost (AC) that is: $P = mAC$ [2,3]. . Given this mark-up relationship, and assuming a linearly homogenous Cobb-Douglas production function, the inflation rate ($\dot{P}$) can be easily determined by equation (1), where W is the wage rate, r and P_E are prices of capital and energy, and Z denotes the growth rate of the corresponding variable Z, $Z = P, m, w, r, P_E$.[3]

Equation (1), however, still has to be modified to incorporate the determinants of the mark-up factor (m). Following Ball and Duffy,(1) assume that short-run variations in m are determined by demand pressures, the latter being proxied by the ratio q of the industrial production to its exponential trend. Ball and Duffy's assumption, formulated as equation 2, is reasonable because when demand pressures are high the capacity of output will be close to being utilized fully, and hence the mark-up factor tends to be higher. The value of m determined by (2) can now be substituted in (1) and the price equation can be directly estimated.

The price equation: $$\dot{P}^* = \dot{m} + \alpha\dot{W} + \beta\dot{r} + \gamma\dot{P}_E - \delta t \qquad (1)$$

The mark-up behavior: $$\dot{m} = a_1 q - a_2 q_{-1} \qquad (2)$$

<u>The Labor Market:</u>

The Wage equation: $$\dot{W}^* = b_0 + b_1 U + b_2 \dot{U} + b_3 \dot{P}^e + b_4 \dot{LP} \qquad (3)$$

The demand for labor (man-hours): $$\ln L^* = A + \ln y - \beta \ln \frac{W}{r} - \gamma \ln \frac{W}{P_E} - \mu t \qquad (4)$$

Work-hour behavior: $$\ln Hr = e_0 + e_1 \ln y/y_{-1} + e_2 t \qquad (5)$$

Labor participation rate for primary labor: $$LPR_1 = l_0 + l_1 t \qquad (6)$$

Labor participation rate for secondary labor: $$LPR_2 = f_o + f_1 U_{-J} + f_2 LP + f_3 \frac{W}{P} + f_4 t \qquad (7)$$

<u>The Market for Capital:</u>

The short-run supply of capital: $$K = \bar{K} \text{ (fixed)} \qquad (8)$$

The demand for capital: $$\ln k = A + \ln y - \alpha \ln \frac{r}{W} - \gamma \ln \frac{r}{P_E} - \mu t \qquad (9)$$

The capital utilization rate $$K_{ur} = \ln K_t^u - \ln K_{t-1} \qquad (10)$$

<u>The Market for Energy:</u>

Demand for energy: $$\ln E^* = A + \ln y - \alpha \ln \frac{P_E}{W} - \beta \ln \frac{P_E}{r} - \mu t \qquad (11)$$

The short-run supply of energy $$P_E = \tilde{P}_E \text{ (fixed, set by the OPEC)} \qquad (12)$$

The Labor Market: The wage determination model, described by equation 3, relates the growth rates of wages ($\dot{W}$) to the rate of unemployment (U), the change in the unemployment rate ($\dot{U}$), the growth rate of labor productivity ($\dot{LP}$), and inflationary expectations ($\dot{P}^e$). Equation (3) cannot be directly estimated because data on $\dot{P}^e$ do not exist. To solve this problem, we postulate and estimate a rational expectation mechanism, $P_t^e = E(P_t Z_t)$, which produces forecasts of the future inflation rate over time. In this relationship, E is the mathematical expectation operator and Z_t indicates the set of variables used in forming inflationary expectations. For purposes of this paper, the variable set Z will be allowed to vary across the two countries so that the expectation mechanisms most suitable to each country can be determined by the data. This treatment is superior to an arbitrary choice of Z for both countries, an approach taken by some other authors.

The labor market equations also include an employment function (demand for labor) and a labor participation equation (supply of labor). It can be easily shown that the cost minimizing level of demand for labor, for our Cobb-Douglas production function, is given by equation (4), where A is a constant, L_t is the demand for labor in terms of man-hours, y is the output level, and $\frac{W}{r}$ and $\frac{W}{P_E}$ are the ratios of wages to prices of capital and energy respectively. t is a time index for technological progress. To derive the level of employment from the equation (4), the man-hours (L) has to be divided between the level of employment (M) and hours of work (H_r) where $L = H_r{*}M$.

The work-hour variable (Hr) follows a cyclical pattern. At times of economic expansion, there is a tendency for firms to increase the average hours of work, because it is often difficult to increase the number of employees quickly. As a result, the behavior of the variable H_r can be formulated as equation (5) where y is the level of output, $\ell n\, y/y_{-1}$ serves as an indicator of the business cycle, and again t is a time index.

Equations (4) and (5) can be used together to specify the demand for labor in terms of the number of workers (M). To determine the unemployment rate, we still need the supply side of the labor market which can be represented by some labor participation functions.

In the simplest case, we can break the labor force into a primary category (men 25-54) and a secondary category (women over 15, men 15-25). Tella's work (5), has established that the labor participation rate of the primary labor force ($LPR_1=LF_1/POP_1$) responds little to the business cycle and moves essentially along its time trend. The behavior of LPR_1 is described by equation (6) where LF and POP stand for labor force participation and population respectively, and t is the time trend.

The labor participation rate of the secondary labor force ($LPR_2=LF_2/POP_2$), however, does respond to economic factors other than the trend variable. These factors include the past unemployment rate (U_{-j}), labor productivity (LP), and real wages ($\frac{W}{P}$). The past employment rate, U_{-j} , has an effect on labor participation due to the "discouraged worker" phenomenon. Labor productivity (LP) enters into the equation, because increased productivity raises the families' income and is known to discourage labor participation.(4) Finally, higher real wages provide an additional incentive to work and hence increase labor participation. In sum, the labor participation rate $LPR_2 = LF_2/POP_2$ can be represented as equations (7).

Having the level of employment (M) determined by equations (4) and (5), and having the labor participation functions (6) and (7), the unemployment rate (U_t) can now be easily measured as:

$$U_t = \left(1 - \frac{M_t}{LF_{1t} + LF_{2t}}\right) * 100$$

The Market for Capital: The capital stock (supply of capital) may be taken as given (fixed) in the short-run (equation 8), while the optimal employment of capital is decided by firms according to the cost minimization procedure. For our Cobb-Douglas production function, this procedure leads to the demand function for capital services (K*) described by the equation (9). K* is the optimal level of capital. The actual level of capital used is assumed to adjust to the optimal level according to a partial adjustment mechanism. Once the level of utilized capital K^U is determined, the capital utilization rate can be easily obtained as K_{ur} defined by equation (10). K_{ur} is a measure for the rate at which the existing stock of capital is actually used.

The Market for Energy: Similar to labor and capital, the cost minimizing level of energy demand (E) can be easily derived as equation (11). The supply of energy for the period under consideration and for the countries included in the study, may be considered perfectly elastic. The price of energy during this period (1973-79) was essentially set by OPEC as the dominant producer of oil, while the oil consuming nations behaved as price takers. A horizontal supply and the demand function specified by equation (12) complete the specification of the energy sector. In the following section, the empirical estimates of the energy price effects based on this model will be discussed.

3. Empirical Results

The model developed in the previous section was estimated, tested for dynamic stability and simulated to evaluate its ability to replicate the real world data before its being used to examine the comparative static effects of higher energy prices. According to Theil's performance statistics, the model can forecast very accurately; the percentages of the forecast error due to bias and variance are very small as desired. In addition, despite its simplicity, the model is found to fit both the U. S. and Canada quite satisfactorily, and to be dynamically stable.

To measure the effects of higher energy prices, a counterfactual base case is developed and the performance of the respective economies in the base case and the actual case are compared. The base case is developed under the assumption that the price of energy continues to increase along its trend rate of the last five years immediately before the price shock. The trend rate was found to be 5% for the U. S. and 4% in Canada.

The deviations in values of the macro variables in the actual and base cases are displayed in Table 1-2. These deviations reflect the change in the macro variables over the period 1973-1979 due to the energy price shock of 1973. To isolate the energy price effects from scale effects, the level of output was held unchanged in the base case and the actual case simulations. Hence the results displayed in Tables 1-2 represent the energy price effects for a maintained output scale.

According to these results, the effects of the price shock were not limited to short-run once and for all disturbances, rather they lasted for quite a few years in both the U. S. and Canada. The inflationary pressures, due to the energy shock, were felt with a very short lag, reaching their peak rather quickly in both countries, and then falling while remaining significant for the whole period of the study (1973-79). The peak of the impact occurred in 1974. In this year the energy price shock contributed 4.75% to the U. S. inflation and a whopping 7.62% to the Canadian inflation rate.

Higher energy prices also had major impacts on the level of employment and capital utilization rate. Investigation of the magnitudes of these impacts, and the consequent knowledge of substitutability (or lack of substitutability) between energy and non-energy inputs are very important in policy decisions. If energy resources are rather limited and they must be technically employed in a fixed or almost fixed proportions with other factors of production, future economic growth will be critically dependent on availability and the growth rate of energy resources. On the other hand, if energy is a substitutable factor of production, a slackening supply of it should not be taken as a major impediment to economic growth. It immediately follows that information about technical substitutability between energy and labor and capital is essential for rational planning of private and government concerning foreign trade and allocation of revenues for development of alternative energy resources.

Intuitively, it may seem that labor and energy are complements so that an increase in the price of energy should lead to a decline in employment. But according to our results, the opposite is true. The results in Table 1-2 reveal that higher energy prices indiced more labor-intensive methods of production, in effect leading to substitution of labor for energy and an increase in employment for a given level of output. The effect on employment was similar between the two countries and grew larger and larger from 1973 to 1979 as labor-intensive methods of production were adopted to a larger and larger extent over time.

Capital, however, did act as a complement to energy. Higher energy prices lowered the capital utilization rate (K_U) both in the U. S. and Canada. The largest decline in K_U occurred within the first 2-3 years after the shock. In the U. S. the maximum decline in K_U was only 2.76% and occurred in 1975, while in Canada the corresponding figure was as high as 7.74% and occurred a year earlier (1974).

Labor productivity and real wages also fell victim to the energy price shock. The results in Tables 1-2 indicate that productivity declined by bigger and bigger amounts in every year between 1973 and 1979, reaching a maximum decline of 9.25% in the U. S. and 7.94% in Canada. Naturally, the decline in real wages followed the lower productivity resulting from higher energy prices. In the U. S. real wages fell as much as 8.33% in 1974 due to the price shock. In Canada the maximum decline in real wages was 9.76% and occurred in 1975.

TABLE 1

DEVIATION FROM BASE CASE FORECASTS, U.S.A.

	ABS. DIF. $\dot{P}$ (%)	ABS. DIF. $\dot{W}$ (%)	% DIF $\frac{W}{P}$	% DIF LP	ABS. DIF. M (1000)	ABS. DIF. U (%)	% DIF E	% DIF K_{UR} (%)
1973	0.50	-0.27	0.0	-.77	581	-.43	-.54	-.21
1974	4.75	1.86	-2.61	-4.71	3365	-2.43	-3.30	-1.50
1975	2.79	1.24	-5.13	-5.88	4214	-2.99	-5.19	-2.76
1976	1.07	0.33	-5.00	-6.26	4584	-3.18	-6.20	-1.97
1977	0.74	-0.36	-6.50	-7.11	5424	-3.66	-7.20	-1.63
1978	0.04	-0.48	-6.30	-7.39	5803	-3.83	-7.76	-1.28
1979	1.71	0.02	-8.33	-9.25	7461	-4.80	-9.19	-2.25

where
LP = Labor Productivity (Output Per Manhour)
M = Total Employment
P_E = Price of Energy
U = Unemployment Rate
E = Energy Demand (Consumption)
K_{UR} = Capital Utilization Rate (Defined as: $K_{UR} = \ln K_t - \ln K_{t-1}$)
$\frac{W}{P}$ = Real Wage

TABLE 2

DEVIATION FROM BASE CASE FORECASTS, CANADA

	ABS. DIF. $\dot{P}$ (%)	ABS. DIF. $\dot{W}$ (%)	% DIF. $(\frac{W}{P})$	% DIF. LP	ABS. DIF. M (1000)	ABS. DIF. U	% DIF. E	% DIF. K_{UR} (%)
1973	2.29	-.12	-2.63	-.97	63	-.54	-1.83	-2.38
1974	7.62	1.72	-7.50	-3.73	259	-2.03	-6.82	-7.74
1975	5.04	2.90	-9.76	-5.14	360	-2.47	-8.75	-7.56
1976	3.95	3.83	-9.52	-6.20	435	-2.92	-10.02	-6.41
1977	4.06	4.80	-9.52	-7.05	509	-3.38	-11.30	-6.70
1978	3.27	5.31	-7.14	-7.58	556	-3.62	-11.93	-4.70
1979	3.93	6.26	-4.88	-7.94	616	-4.01	-12.93	-4.34

where LP = Labor Productivity (Output Per Manhour)
M = Total Employment
P_E = Price of Energy
U = Unemployment Rate (% of Civilian Labor Force)
E = Energy Demand (Consumption)
K_{UR} = Capital Utilization Rate
(Defined as: $K_{UR} = \ln K_t - \ln K_{t-1}$)
$\frac{W}{P}$ = Real Wage

What happened to energy consumption? Was the demand for energy price elastic? Did consumers cut their consumption of energy in response to higher energy prices? According to our results, consumers responded very strongly to higher energy prices in both the U. S. and Canada. Especially, the decline in energy consumption grew larger and larger over the 1973-79 period as people gradually formed new energy consumption habits and adopted alternative energy sources. In the U. S. the cut in energy consumption was only .54% in 1973, but this figure grew to 9.19% in 1979, reaching a maximum in this year. In Canada, the initial effect was larger, 1.83% in 1973, and it also rose faster to reach a maximum decline of 13% in energy consumption in 1979.

Finally, it is interesting to investigate whether the energy price shock affected the price elasticity of output, or equivalently, the slope of the aggregate supply curve. Simulations of our model in the actual and base cases revealed that in the U. S. the aggregate supply curve did indeed rotate due to higher energy prices, becoming flatter as a result. The numerical value of the price elasticity of output rose in the U. S. from 7.867 to 10.167 indicating a much stronger sensitivity of the real sector to the price level changes. In Canada, however, the slope of the aggregate supply remained unchanged according to our results.

4. Conclusion

This paper measures the magnitudes of the effects of the 1973 energy price shock on some major macroeconomic variables such as inflation, unemployment, productivity, real wages, and capital utilization rate for a maintained output scale. Simulations of our aggregate supply model in the presence and absence of the energy price shock show that these effects were substantial and lasted for the whole period of the study, 1973-79. The effects on the U. S. and Canada were similar in direction and pattern but differed in magnitude.

One note of caution is that these effects are the absolute or overall effects and should be distinguished from the marginal effects. The differences in overall effects between the U. S. and Canada are influenced by the fact that energy prices rose at different rates in the two countries. To eliminate this influence, the relative or marginal effects of a one-unit increase in energy prices should be investigated in a further study. The tremendous effects of higher energy prices on the economic variables should also serve as a warning about the serious nature of the energy problem and should encourage research on alternative sources of energy.

Appendix 1

Empirical Estimates of the Model

Tables A11-A12 display the estimated form of the model. There are eight equations for each country:

1. The inflation rate determination equation.
2. The wage equation.
3. The demand for labor function.
4. The man-hour behavior of the employed labor.
5. The labor participation function for the primary category of labor.
6. The labor participation function for the secondary category of labor.
7. Demand for capital.
8. Demand for energy.

The performance of the model and its ability to replicate the actual data for each country is analyzed in Appendix 2.

TABLE A11 - The Coefficient Estimates of the Aggregate Supply Model For the U.S.

$$\dot{p} = -.014 + 220\dot{p}_{t-1} + .582\dot{w} - .022\dot{r} + .084\dot{p}_E - .020\dot{q} + .011\dot{q}_{t-1} + .0003t \qquad (A1)$$
$$\qquad (1.33) \quad (3.33) \quad (.74) \quad (3.64) \quad (.55) \quad (.28) \quad (.99)$$
$$\bar{R}^2 = .90 \quad F(7,21) = 37.23 \quad \text{Durbin } h = 1.53$$

$.499\dot{w}_{-1}$

$$\dot{w} = .026 + .429\dot{w}_{-1} + .0005U - .008\dot{U} - .114L\dot{P} + .413\dot{p}^e, \quad \bar{R}^2 = .68 \quad F(5,22) = 12.47 \quad DW = 1.96 \qquad (A2)$$
$$\qquad (2.96) \quad (.39) \quad (2.58) \quad (.76) \quad (3.04)$$

$$\ln L = 12.882 + .681 \ln Y - .026 \ln\left(\frac{W}{r}\right) - .104 \ln\left(\frac{W}{P_E}\right) + .079 \ln L_{-1} - .012t \qquad (A3)$$
$$\qquad (9.33) \quad (1.87) \quad (6.51) \quad (.83) \quad (4.43)$$
$$\bar{R}^2 = .99 \quad F(5,22) = 562.36 \quad DW = 1.32$$

$$\ln Hr = 3.712 + .131\dot{y} - .004t, \quad \bar{R}^2 = .98 \quad F(2,25) = 645.92 \quad DW = 1.78 \qquad (A4)$$
$$\qquad (5.09) \quad (7.86)$$

Table A11 - continued

$$LPR1 = .995 - .002t, \quad \bar{R}^2 = .99 \quad F(1,26) = 2001.6 \quad DW = .86 \qquad (A5)$$

(10.72)

$$LPR2 = .462 - .002U - .023LP + .034(\tfrac{W}{P}) + .008t, \qquad (A6)$$

(2.46) (2.34) (.38) (4.99)

$\bar{R}^2 = .99$ $F(4,23) = 453.26$ $DW = 1.57$

$$\ln E = -1.231 + .527 \ln Y - .066 \ln(\tfrac{P_E}{W}) - .003 \ln(\tfrac{P_E}{r}) + .447 \ln E_{-1} - .001t \qquad (A7)$$

(4.02) (1.61) (.21) (3.62) (.25)

$\bar{R}^2 = .99$ $F(5,23) = 1217.13$ Durbin $h = .91$

$$\ln K = -.964 + .264 \ln Y + .001 \ln(\tfrac{r}{P_E}) - .006 \ln(\tfrac{r}{W}) + .897 \ln K_{-1} - .006t \qquad (A8)$$

(5.56) (.13) (.41) (11.15) (1.47)

$\bar{R}^2 = .999$ $F(5,22) = 19926$ $DW = 1.59$

Table A12: The Coefficient Estimates of the Aggregate Supply Model For Canada

$$\dot{p} = -.002 + .329\dot{p}_{-1} + .0005\dot{w} - .022\dot{r} + .231\dot{p}_E + .035\dot{q} + .105\dot{q}_{-1} + .001t \qquad (A9)$$

(1.20) (.002) (1.03) (2.95) (.35) (1.00) (1.52)

$\bar{R}^2 = .82$ $F(7,16) = 16.22$ $DW = 1.78$

$$\dot{w} = .056 + .524\dot{w}_{-1} - .008U - .005\dot{U} + .271LP + .522\dot{p}^e \qquad (A10)$$

(3.56) (3.82) (1.05) (1.28) (3.31)

$\bar{R}^2 = .80$ $F(5,13) = 19.89$ Durbin $h = 1.36$

$$\ln L = 4.305 + .683 \ln Y - .013 \ln(\tfrac{W}{r}) - .104 \ln(\tfrac{W}{P_E}) + .270 \ln L_{-1} - .020t \qquad (A11)$$

(8.64) (1.56) (6.73) (2.67) (6.14)

$\bar{R}^2 = .99$ $F(5,18) = 548.3$ Durbin $h = .63$

$$\ln Hr = 3.77 + .130\dot{y} - .008t \qquad (A12)$$

(3.23) (36.01)

$\bar{R}^2 = .99$ $F(2,20) = 1518.09$ $DW = 1.93$

Table A12 (continued)

$$LPR1 = .984 - .001t \qquad (A13)$$
$$\quad (190.92) \quad (5.37)$$
$$\bar{R}^2 = .95 \quad F(1,21) = 419.6 \quad DW = 1.49$$

$$LPR2 = .358 - .002U_{-1} - .008LP - .867(\frac{W}{P}) + .011t \qquad (A14)$$
$$(1.81) \quad (.45) \quad (.53) \quad (4.40)$$
$$\bar{R}^2 = .99 \quad F(4,18) = 568.69 \quad DW = 1.91$$

$$\ln E = -3.434 + 1.082 \ln Y - .205 \ln (\frac{P_E}{W}) + .008 \ln (\frac{P_E}{r}) + .115 \ln E_{-1} - .017t \qquad (A15)$$
$$(5.54) \quad (4.40) \quad (.45) \quad (.85) \quad (2.42)$$
$$\bar{R}^2 = .99 \quad F(5,18) = 1416.43 \quad \text{Durbin } h = -.11$$

$$\ln K = -.103 + .154 \ln Y + .015 \ln (\frac{r}{P_E}) - .024 \ln (\frac{r}{W}) + .676 \ln K_{-1} + .008t \qquad (A16)$$
$$(3.03) \quad (1.29) \quad (1.73) \quad (5.39) \quad (1.04)$$
$$\bar{R}^2 = .99 \quad F(5,17) = 33414 \quad DW = 1.02$$

Notations

P	Price Level
m	Mark-up Factor
W	Wages
r	Cost of Capitol
	Price of Energy
t	Time
q	The ratio of industrial production to its exponential trend
U	Unemployment Rate
	The Change In U
	The Expected Rate of Inflation
LP	Labor Productivity
L	Labor Quantity (man-hours)
y	Output
	Hours of Work
	Capital Stock
	Utilized Capital
	Capital Utilization Rate
E	Energy
Z	Growth Rate of

Appendix 2

Performance Measures of the Aggregate Supply Model

To evaluate the model's performance and its ability to replicate the data, the closeness of simulated and actual values should be examined. One measure often used for this purpose is the root-mean-square error (RMSE) which can be decomposed into a "bias," a "variance," and a "covariance" components U^M, U^S, U^C. These components are known as Theil's statistics:

$$RMSE = \sqrt{\frac{1}{n} \sum (y_t^s - y_t^a)^2}$$

$$U^M = (\bar{y}^s - \bar{y}^a)^2 / \frac{1}{n} \sum (y_t^s - y_t^a)^2$$

$$U^S = (\sigma s - \sigma a)^2 / \frac{1}{n} \sum (y_t^s - y_t^a)^2$$

$$U^C = 2(1-\rho)\sigma s\ \sigma a / \frac{1}{n} \sum (y_t^s - y_t^a)^2$$

In these relations Y_t^s is the simulated and y_t^a is the actual value of the variable y_t, n is the number of periods in the simulation. $\bar{y}^s$, $\bar{y}^a$, σ_s, and σ_a are the means and the standard deviations of the series y_t^s and y_t^a respectively, and ρ is their correlation coefficient. U^M, U^S and U^C are called the "bias," the "variance," and the "covariance" proportions of the error respectively. The bias proportion U^M is an indication of systematic error. The variance proportion U^S indicates the ability of the model to replicate the degree of variability in the variable of interest. Finally, the covariance proportion U^C represents the remaining error after deviations from average values and average variabilities are accounted for. The ideal values for Theil's statistics are $U^M = U^S = 0$ and $U^C = 1$. Tables A21-A22 display the RMSE and Theil's statistics for the two countries.

TABLE A21

RESULTS OF HISTORICAL SIMULATION FOR U.S.A.

	$\dot{p}$	$\dot{w}$	LP	U	lnL	lnE	lnK
MEAN	3.53	6.04	6.34	5.23	18.64	3.99	6.51
RMSE	.80	1.10	.068	.84	.011	.021	.041
THEIL M (U^M)	.0053	.0472	.2479	.1683	.2021	.0724	.0052
THEIL S (U^S)	.0620	.0624	.1786	.2668	.1100	.0042	.2221
THEIL C (U^C)	.9327	.8904	.5735	.5650	.6880	.9233	.7728

TABLE A22

RESULTS OF HISTORICAL SIMULATION FOR CANADA

	$\dot{P}$	$\dot{W}$	LP	U	lnL	lnE	lnK
MEAN	4.17	7.46	5.10	5.87	16.27	8.43	4.96
RMSE	1.36	1.48	.07	.69	.012	.020	.007
THEIL M (U^M)	.0222	.0388	.0718	.0155	.0330	.0394	.0003
THEIL S (U^S)	.0581	.1543	.3592	.0582	.2798	.3423	.3088
THEIL C (U^C)	.9197	.8069	.5691	.9263	.6872	.6183	.6909

ENDNOTES

[1] This was the title of a special review of the World Economy in the 1970's which was published in The Economist, December 29, 1979.

[2] For a more elaborate analysis of aggregate supply modeling, see any modern advanced macro textbook.

[3] For derivation of equations 1, 4, 9 and 11, see any micro textbook.

BIBLIOGRAPHY

1. Ball, T., and Duffy, M. "Price Formation in European Countries." The Econometrics of Price Determination. 1970.

2. De Menil, G. "Aggregate Price Dynamics." Review of Economics and Statistics, (May 1974), 129-40.

3. Gordon, R. "The Effects of Aggregate Demand on Prices." Brooking Papers on Economic Activity, (1975), 613-22.

4. Suits, D., et. al. "Birth Control in an Econometric Simulation." International Economic Review, (February 1975), 22-111.

5. Tella, A. "Labor Force Sensitivity to Employment by Age, Sex." Industrial Relations, (February 1965), 69-83.

Eastern Economic Journal, Volume X, no. 4, October-November 1984

THE INTERNATIONAL GOLD STANDARD: A NEW PERSPECTIVE

Joseph Salerno

1. Introduction

As early as 1923, John Maynard Keynes declared that the choice of an international monetary regime involved an unpleasant dilemma. Keynes argued that "If ... the external price-level lies outside our control, we must submit either to our own internal price-level or to our exchange being pulled about by external influences. If the external price-level is instable, we cannot keep *both* our own price level *and* our exchanges stable. And we are compelled to choose .... " choose ..."[1]

The most significant practical implication of Keynes' contention is, of course, that a nation must choose either to maintain "fixed" exchange rates between its own and foreign currencies by participating in the international gold standard or to maintain reasonable stability in domestic levels of prices, output, and employment. Following Keynes, most economists today are inclined to accept the view that the operation of the gold standard tends to be inconsistent with the maintenance of domestic macroeconomic stability. Indeed, this is one of the major considerations that led many economists and informed economic policymakers during the Bretton Woods era to conclude that a regime of fluctuating exchange rates is superior to a fixed exchange-rate system.

In this paper, I shall suggest that the generally accepted explanation of the impact of the international gold standard on the stability of an individual nation's domestic economy rests on an overly aggregative approach to monetary and balance-of-payments theory. This approach tends to obscure rather than elucidate important issues whose understanding is vital in assessing the relative merits of competing international monetary systems. The issues in question include: 1. The type of price variations that are necessary to adjust balance-of-payments disequilibria under the gold standard; 2. The meaning of the terms "inflation" and "deflation" in the context of an "open" national economy; and 3. The international transmission of business cycles or "macroeconomic instability" under fluctuating exchange rates.

In addressing these issues below, I shall attempt to rehabilitate and extend the approach of a number of economists writing in the 1930's who pioneered the development of a micro-oriented "process analysis" of monetary and balance-of-payments phenomena[2]. These writers include the prominent monetary economists, Ralph Hawtrey[3], Friedrich A. Hayek[4], and Lionel (later Lord) Robbins[5], and the less well-known Michael A. Heilperin[6] and F. W. Paish[7].

2. Price Changes and Balance-of-Payments Adjustment under the Gold Standard

The belief that there exists a dilemmatic tradeoff between fixity of exchange rates and stability of domestic economic activity can be traced partly to the conventional explanation of how disequilibria in the balance of payments are normally